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**THE SYSTEM OF INTERNATIONAL COMPARISONS OF REAL DOMESTIC  
PRODUCT AND PURCHASING POWER**

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UN ECONOMIC AND SOCIAL COMMISSION  
FOR WESTERN ASIA

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\* The views expressed in this paper are those of the author and do not necessarily reflect the views of the Economic and Social Commission for Western Asia.

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## PREFACE

Ever since its Statistics Unit was first established, the Economic and Social Commission for Western Asia (ESCWA) has maintained contact with a number of statistical organizations in the countries of the region with a view to apprising them of the International Comparison Project (ICP).

In November 1978, at a training course on price statistics and index numbers held in Damascus and organized by the Arab Institute for Training and Research in Statistics (Baghdad), the Commission presented a number of lectures on the methodologies used by ICP which were subsequently issued as its first publication (in Arabic) on international comparisons of real domestic product and purchasing power. The contents of that publication were as follows: I. The International Comparison Project (covering Phases I-III, when the benchmark years were 1970-1973, and the plan for Phase IV, with the benchmark year of 1980); II. The principal results of the International Comparison Project (during Phases I and II); III. The organization of basic data; IV. Methods of binary comparison; V. Multilateral comparisons. The publication also contained a sample comparison of notional prices and quantities of foodstuffs in the ESCWA countries over the period 1973-1975 using the binary comparison method only. In November 1980, ESCWA published a second study supplementing the calculation of foodstuff prices and quantities for those countries using the Geary-Khamis (G-K) multilateral method together with a simplification of the mathematical formulae used.

When it became known that representatives of the central statistical organizations of the ESCWA region might be meeting at the end of 1985 in order to formulate a plan for the co-ordination of their major statistical programmes, it was considered appropriate that a new study should be prepared on the methodologies to be used during Phase V (benchmark year 1985), which will include international comparisons for between 60 and 70 countries. Two kinds of comparison will be required: regional comparisons between the countries of each region separately, such as regional comparisons for the ECA region, the ECE region, the ESCAP region, etc; and core-country comparisons, linking the results of the various regional comparisons in order to make it possible to establish a comparison at the world level.

Part one of the paper presents a simplified theoretical study of the basic methodology employed by ICP. Part two deals with the implementation of Phases III and IV and preparations for Phase V.

It is hoped that the representatives of the central statistical organizations of the ESCWA countries will adopt a positive attitude towards making a substantive contribution to Phase V with a view to establishing comparisons of real domestic product for the countries of the region on a more rational basis than that involving a mere comparison of nominal GDP evaluated at official exchange rates. The Syrian Arab Republic is, of course, the only ESCWA country to have participated in ICP with effect from Phase III.

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Abbreviations

CP	Category parity
CPO	Country-product--dummy (method)
DA	Domestic absorption
ESA	European System of Integrated Economic Accounts
GDP	Gross domestic product
GDY	Gross domestic income
ECA	Economic Commission for Africa
ECE	Economic Commission for Europe
ECLAC	Economic Commission for Latin America and the Caribbean
EEC	European Economic Community
EKS	Elteto, Koves and Szulc (method)
ESCAP	Economic and Social Commission for Asia and the Pacific
ESCWA	Economic and Social Commission for Western Asia
EUROSTAT	Statistical Office of the European Communities
G-K	Geary-Khamis (method)
ICP	International Comparison Project
ICU	International currency unit
NFB	Net foreign balance
OECD	Organization for Economic Co-operation and Development
PPP	Purchasing-power parity
SNA	United Nations System of National Accounts
UNSO	Statistical Office of the United Nations



## Part One

### BASIC METHODOLOGY OF THE INTERNATIONAL COMPARISON PROJECT

The gross domestic product (GDP) of a country, as defined in the United Nations System of National Accounts (SNA), is the monetary amount expressed in the currency of that country corresponding to the goods and services produced by that country for all purposes, whether domestic consumption, capital formation or export. Real GDP is a global quantity of goods and services produced. The purpose of ICP is to devise a standard of measurement appropriate for all countries by means of which a comparison can be made of the global quantities that go to make up overall GDP, or its components, for each country. Such a standard must be able to bring about: a ranking of countries according to the magnitude of the global quantities involved (an ordinal comparison); and a computation of global quantities for countries in such a manner as to make it possible for an estimate to be made of the amount by which the quantities for a particular country exceed or fall short of those for all other countries (a cardinal comparison).

The quantitative calculation of the GDP of a particular country can be made on the basis of the production process (the output method) or of the use of the goods and services produced (the final-use method), corresponding to the two definitions of the monetary value of GDP given in SNA. The "output method" deals with the various elements of GDP, namely the producers' value of the gross outputs of resident producers, including the distributive trades and transport, less the purchasers' values of their intermediate consumption, while the "final-use" method addresses itself to expenditure on GDP, that is to say on the final uses of the domestic supply of goods and services less imports of goods and services.

For ICP purposes, comparisons of real value of GDP must be made in accordance with both output method and final-use method at one and the same time. However, the methodologies required are different, each method gives rise to considerable difficulties and there are considerable differences in the costs involved.

An evaluation was carried out at the end of 1960 and it was decided, in the light of available allocations and of the need to obtain results as quickly as possible, that ICP should begin by focusing its efforts on devising methodologies for the calculation of real GDP on the basis of the final-use method. The calculation of real GDP in accordance with the output method will be introduced at a future stage for which the time is not yet ripe.

Using the method applied by ICP, chapter I will present a simplified comparison where real expenditure on fully specified items can be compared within a clearly defined group of countries and where prices are available for all items. Non-intervention on the part of governments in price fixing is assumed.

Chapter II will present the aggregation formulae used by ICP.

I. THE GENERAL ICP FRAMEWORK

A. Elements of the comparison

For comparisons of the kind in question, it is assumed that the following elements are present:

(a) The countries to be compared;

(b) The goods and services (items) to be compared, together with identification of their nature (e.g. automobiles) and of their use (e.g. capital formation);

(c) The producers and consumers of such goods and services (establishments, households, etc.);

(d) The year for which comparisons are being made.

It is also assumed that each item is defined by a set of specifications, that the list of items provides full details, that there is perfect correspondence between each item for one country and its counterpart in the other countries, and that the list includes every item purchased from at least one country included in the comparison in the course of the year.

Let us assume that the list contains the four items a, b, d, and e, that the comparison is to be made between the four countries A, B, D, and E, and that the quantities purchased by each country are as they appear in the following table:

Item	Country				Total
	A	B	D	E	
a	14	12	8	8	42
b	16	14	6	4	40
d	12	10	8	0	30
e	10	8	0	0	18

The quantity of item d purchased by country E is nil, and the quantity of item e purchased by countries D and E is also nil. All of the quantities purchased by country A are greater than those purchased by countries B, D and E, and the quantities purchased by country B are greater than those purchased by countries D and E. For countries D and E, the quantities of item a are the same. The quantity of item b purchased by country D is greater than the quantity of the same item purchased by country E, and the same is true of item d. It is therefore possible to make the direct inference that the global purchases of country D will be greater than those of country E. On the basis of such observations, the four countries can be ranked in accordance with the magnitude of the global quantities purchased by them in the order A, B, D and E. Comparisons of such a kind are known as ordinal comparisons.

Each country having been ranked in accordance with global quantities purchased, ICP sets out to establish a set of figures such that each figure

corresponds to one of the four countries. It is then possible to establish numerical comparisons and to answer such questions as: Within the group of four countries, A, B, D and E, how much greater are the global quantities purchased by country A than those purchased by country D? In order to convey some idea of the difficulty of this question, let us suppose that the group is made up of two countries only, country A and country B. From the quantities purchased by them, the following can be derived:

Item	Ratio of quantity purchased by country A to quantity purchased by country B
a	1.167
b	1.143
d	1.200
e	1.250

The logical conclusion to be drawn is that the ratio of the global quantities purchased by country A to those purchased by country B lies somewhere between 1.143 and 1.250. There is however no definite answer, that is to say no single figure.

#### B. Computation of theoretical prices

The method proposed for establishing a numerical comparison of the real values of global quantities purchased by a group of countries in the course of a year is that of devising a single set of standardized prices (rarely the prices of one of the countries included in the comparison) and applying it to the various quantities purchased by each country in order to assign values to those quantities. The set of prices to be devised should be as neutral as possible, that is to say that the prices of one of the countries included in the comparison should not have undue preponderance over those of the others. In order to avoid confusion with the prices currently prevailing within the group of countries to be compared, the term "theoretical prices" is applied to the standardized prices ICP seeks to establish.

It should be noted that such theoretical prices can be characterized as neutral only for the group of countries included in the comparison. If another country is added to the group, then the theoretical prices forfeit their neutral character and the search must begin again for another set of theoretical prices. In particular, if a numerical comparison is to be made between two countries within the framework, say, of ESCWA or of the League of Arab States, for example Kuwait and Qatar, then the result of the comparison will differ according to the framework selected. Any comparison between Kuwait and Qatar will obviously be affected by the figures for the other countries in the group selected. The comparison must convey an idea of the position of the two countries either within the ESCWA group of countries or within that of the League of Arab States. If, however, an independent comparison is to be made between Kuwait and Qatar disregarding their inclusion in the framework of any regional or international organization, then it will be possible to use only the figures for the two countries in question.

C. Some properties of theoretical prices

Let us assume that the list of goods and services contains only the two items a and b, that only three countries are included in the comparison, A, B and D, and that the quantities purchased are as follows:

Item	Country			Total
	A	B	D	
a	10	6	14	30
b	20	24	8	52

Let us also assume that the theoretical prices of a and b are 8 and 4 respectively. The true values for the total quantities purchased by each country will, accordingly, be as follows:

$$\text{Country A: } V_A = (8 \times 10) + (4 \times 20) = 160$$

$$\text{Country B: } V_B = (8 \times 6) + (4 \times 24) = 144$$

$$\text{Country D: } V_D = (8 \times 14) + (4 \times 8) = 144$$

The figures show that the real value of the purchases made by country B is the same as that for country D. Since the theoretical prices are the same for both countries, the global quantity purchased by country B is equal to the global quantity purchased by country D. The global quantities purchased by countries A, B and D are in the following ratios:

$$\frac{V_A}{V_B} = \frac{V_A}{V_D} = \frac{160}{144} = 1.11$$

If we now assume that the theoretical prices of items a and b are one half of the those previously assumed, that is to say 4 and 2 respectively, then the real values of the quantities purchased will be as follows:

$$V'_A = (4 \times 10) + (2 \times 20) = 80$$

$$V'_B = (4 \times 6) + (2 \times 24) = 72$$

$$V'_D = (4 \times 14) + (2 \times 8) = 72$$

The global quantity purchased by country B will still be equal to the global quantity purchased by country D and the global quantities purchased by countries A, B and D will remain in the same ratios as before:

$$\frac{V'_A}{V'_B} = \frac{V'_A}{V'_D} = \frac{80}{72} = 1.11$$

This result can be generalized; if all of the theoretical prices are multiplied or divided by one figure, then the values of the quantities

purchased by each country will be multiplied or divided by the same figure and the ratios between the values for any two countries will remain constant and unchanged.

Obviously, for such theoretical prices to be meaningful, they must be expressed in the same unit of currency. Likewise, the absolute value of such prices is not very meaningful and it is the structure of the theoretical prices that is crucial. This means that the unit of currency in which the theoretical prices are expressed will not affect the outcome of the comparisons of the global quantities purchased as long as the structure of the theoretical prices remains unchanged (and by the "structure of the theoretical prices" is meant the ratios of the theoretical price of item b to those of items d, e, etc). We can therefore postulate that theoretical prices can be expressed in a theoretical currency unit which, as long as the theoretical prices preserve their structure, can be the unit of currency of one of the countries in the comparison. One of the properties of theoretical prices is that the theoretical price of a particular item should be related to the prices of that item within the group of countries being compared. It is, in fact a kind of mean average of those prices. The familiar, conventional method is to convert the prices into the unit of currency of one of the countries using the exchange rate and then to calculate averages. This method is, however, vitiated by error, since the structure of such prices differs from that of the theoretical prices, particularly since exchange rates (such as those of the dollar) fluctuate from day to day, rising and falling in accordance with economic and political considerations. In order to obtain theoretical prices whose structure is unaffected by random fluctuations in rates of exchange, ICP has endeavoured to develop other methods, as set out hereunder.

#### D. Definition of purchasing-power parities

Let us assume, for the purposes of this second simplified example, that the group consists of the three countries A, B and D, that the list of goods and services is made up of the four items a, b, d and e, and that each country has a separate unit of currency designated as follows:

Country	Unit of currency
A	A-C
B	B-C
D	D-C

For the theoretical prices, T-C represents the theoretical unit of currency. The units of quantity used for all goods and services are the same in all three countries. The quantities purchased are as follows:

Item	Units of quantity	Quantities purchased			Total
		A	B	D	
a	Millions of bushels	0	10	10	20
b	Millions of hectolitres	32	0	8	40
d	Millions of barrels	40	40	0	80
e	Millions	20	0	80	100

and the expenditure of each country on each item in millions of national currency units is:

Item	Country		
	A A-C	B B-C	D D-C
a	0	40	80
b	160	0	40
d	200	160	0
e	40	0	80
<hr/>			
Total country expenditure (V)	400	200	200

Prices can then be obtained by dividing expenditure values by quantities and a table established showing prices expressed in the units of currency of each country. Prices that cannot be determined are indicated by an asterisk.

Item	Unit of quantity	Country		
		A A-C	B B-C	D D-C
a	Bushels	*	4	8
b	Hectolitres	5	*	5
d	Barrels	5	4	*
e	Units	2	*	1

Let us now assume that theoretical prices expressed in the theoretical unit of currency have been computed in accordance with the Geary-Khamis method, to be explained in chapter II, as follows:

Item	Theoretical price (in T-C, the theoretical unit of currency)
a	704
b	505
d	534
e	124

As stated above, theoretical prices can be multiplied or divided by the same number without changing the results of comparisons of global quantities purchased. Accordingly, when divided by 10, for example, the theoretical prices will, without altering the results of the comparison, be as follows:

Item	Theoretical price (T-C)
a	70.4
b	50.5
d	53.4
e	12.4

Real values for the purchases of each country can now be calculated by applying the initial set of theoretical prices above. The purchases of countries A, B, and D in units of theoretical currency will be as follows:

$$V'A = (704 \times 0) + (505 \times 32) + (534 \times 40) + (124 \times 20) = (T-C)40000$$

$$V'B = (704 \times 10) + (505 \times 0) + (534 \times 40) + (124 \times 0) = (T-C)28400$$

$$V'D = (704 \times 10) + (505 \times 8) + (534 \times 0) + (124 \times 80) = (T-C)21000$$

These figures show that  $A^Q_B$ , the ratio of the global quantities purchased by country B to those purchased by country A, is 0.71, as can be seen from the following calculation:

$$A^Q_B = \frac{V'_B}{V'_A} = \frac{28400}{40000} = 0.71$$

Likewise,  $A^Q_D$ , the ratio of the global quantities purchased by country D to those purchased by country A, is 0.525:

$$A^Q_D = \frac{V'_D}{V'_B} = \frac{21000}{40000} = 0.525$$

Each country's expenditure on a set of goods and services has thus been calculated to yield two values: the prices of each country in its national unit of currency give a value for country A of A-C 400; and the theoretical prices in the theoretical unit of currency give a value for country A of T-C 40000. The exchange rate for the conversion of the theoretical currency into the unit of currency of country A can therefore be calculated as 400/400000 or 0.01, that is to say that one theoretical unit of currency is equivalent to one hundredth of the unit of currency of country A. For country B, the exchange rate for each theoretical unit of currency will be 200/28400 or 0.0070422, and, likewise, the exchange rate for country D will be 200/21000 or 0.0095238.

The ratio of a country's expenditure on goods and services at domestic prices to its expenditure on the same goods and services at theoretical prices is called the purchasing-power parity (PPP) of that country's unit of currency in relation to the theoretical unit of currency. Values for PPP will, of course, vary with the set of goods and services selected.

If the value of the PPP of country A in relation to the theoretical unit of currency is represented as  $.PPP_A = 0.01$ , then  $.PPP_A$  (A-C) represents the value required in country A to purchase a set of goods and services costing one unit of theoretical currency, or T-C 1, at theoretical prices. By dividing  $V_A$ , the expenditure of country A denominated in the units of currency of country A, by  $.PPP_A$ , a value at theoretical prices,  $V'A$  can be obtained. For the example given, the following results can be obtained:

Country	Total expenditure at domestic prices (V)	Purchasing-power parity (PPPs)	Total expenditure of each country at theoretical prices (real values of expenditure) (V'S (T-C))
A	A-C 400	0.01	40000
B	B-C 200	0.0070422	28400
D	D-C 200	0.0095238	21000

The indices for the global quantities purchased within the group of countries in question, selecting country A as benchmark country for purposes of comparison, are as follows:

$${}^A Q_A = \frac{V'_A}{V'_A} = \frac{40000}{40000} = 1$$

$${}^A Q_B = \frac{V'_B}{V'_A} = \frac{28400}{40000} = 0.71$$

$${}^A Q_D = \frac{V'_D}{V'_A} = \frac{21000}{40000} = 0.525$$

E. Some properties of PPPs

If all the theoretical prices are multiplied (or divided) by a common factor, then the values for .PPPs relative to the theoretical currency will be divided (or multiplied) by the same factor. If .PPPA is selected as a factor multiplying the theoretical prices, all the PPPs will be divided by the factor .PPPA, as follows:

$$(1) \frac{.PPP_A}{.PPP_A} = \frac{0.01}{0.01} = 1$$

$$(ii) \frac{.PPP_B}{.PPP_A} = \frac{0.00070422}{0.01} = 0.70422$$

$$(iii) \frac{.PPP_D}{.PPP_A} = \frac{0.0095238}{0.01} = 0.95238$$

After multiplication by factor .PPPA, the real values are as follows:

$$(i) \widetilde{V}'_A \text{ --- } 40000 \times 0.01 = \text{T-C } 400$$

$$(ii) \widetilde{V}'_B \text{ --- } 28400 \times 0.01 = \text{T-C } 284$$



$$(iii) \quad \widetilde{V}'_D \text{ --- } 2100 \times 0.01 = \text{T-C } 210$$

The indices for the quantities in question do not change:

$${}^A Q_A = \frac{\widetilde{V}'_A}{V'_A} = \frac{400}{400} = 1$$

$${}^A Q_B = \frac{\widetilde{V}'_B}{V'_B} = \frac{284}{400} = 0.71$$

$${}^A Q_D = \frac{\widetilde{V}'_D}{V'_D} = \frac{210}{400} = 0.525$$

In the present case, we note that there is parity and equivalence between the unit of currency of country A and the theoretical unit of currency, that is to say that A-C = T-C, and that  $V'_A = V_A$ . This does not however mean that the new theoretical prices are the same as those prevailing for such items in country A. For, in the example given, the new theoretical prices, obtained by multiplying the initial theoretical prices by the PPP of country A (.PPP<sub>A</sub> = 0.01), give figures that differ from the original prices of the items in question in country A, as will be noted from the following table of correspondence between original prices and new prices in country A:

Item	Original price and type of currency	New theoretical price and type of currency
a	A-C *	T-C 7.04
b	A-C 5	T-C 5.05
d	A-C 5	T-C 5.34
e	A-C 2	T-C 1.24

As for the quantity indices, which are unaffected by the multiplication of the theoretical prices by .PPP<sub>A</sub>, given that:

$$\widetilde{V}'_A = V_A$$

$$\widetilde{V}'_B = V'_B \times .PPP_A$$

$$\widetilde{V}'_D = V'_D \times .PPP_A$$

the quantity index formulae will be:

$${}^A Q_A = \frac{\widetilde{V}'_A}{V'_A} = 1$$

$${}^A Q_B = \frac{\widetilde{V'_B}}{\widetilde{V'_A}} = \frac{V'_B}{V_A} = \frac{V'_B}{V_A} \times .PPP_A$$

$${}^A Q_D = \frac{\widetilde{V'_D}}{\widetilde{V'_A}} = \frac{V'_D}{V_A} = \frac{V'_D}{V_A} \times .PPP_A$$

$${}^A Q_B = \frac{V'_B}{V_A} \times .PPP_A = \frac{V_B}{V_A} \times \frac{.PPP_A}{.PPP_B}$$

$${}^A Q_D = \frac{V'_D}{V_A} \times .PPP_A = \frac{V_D}{V_A} \times \frac{.PPP_A}{.PPP_D}$$

Given the PPPs of countries B and D relative to the currency unit of country A:

$${}^A PPP_B = .PPP_B / .PPP_A$$

$${}^A PPP_D = .PPP_D / .PPP_A$$

the quantity indices are written in accordance with the following formulae, where  ${}^A Q_A = 1$ :

$${}^A Q_B = \frac{V_B/V_A}{{}^A PPP_B} = \frac{V_B/V_A}{.PPP_B/.PPP_A}$$

$${}^A Q_D = \frac{V_D/V_A}{{}^A PPP_D} = \frac{V_D/V_A}{.PPP_D/.PPP_A}$$

From these formulae it is clear that:

- (a) The quantity index is the ratio of the expenditure of country B, converted into the unit of currency of country A by using the purchasing-power parity  ${}^A PPP_B$ , to the original value of the expenditure of country A;
- (b) The quantity index is obtained by dividing the original expenditure  $\frac{1}{}$  of country B by the original expenditure of country A and then dividing the result by the above purchasing-power parity  ${}^A PPP_B$ , previously defined as follows:

$${}^A PPP_B = .PPP_B / .PPP_A ;$$

- (c) Not only country A, but any other country in the group can be selected as benchmark country for purposes of the comparison;

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$\frac{1}{}$  By the "original value" for country S is meant its expenditure denominated in the unit of currency of country S.

- (d) The choice of a country as benchmark country for the comparison, say country S, does not mean that the prices of country S are also the theoretical prices;
- (e) In order to avoid any confusion and in order to stress the fact that the choice of country S as benchmark country is for purely practical reasons and does not affect the quantitative results of comparisons, country S is termed the "numeraire country";
- (f) In order to avoid any confusion between the unit of currency of the numeraire country and the theoretical unit of currency, ICP, in publishing the results of Phases I, II and III and having selected the United States of America as numeraire country, assigned the term "international dollar" to the theoretical unit of currency.

F. The single item and the complex item

In considering the various stages of the aggregation of data, the concept of the "complex item" will be used since the operations connected with the data on such an item are a generalization of those applied to the single item.

1. The single item

Let us assume that the set of goods and services selected comprises a single item purchased by the group of countries included in the comparison, as follows:

Single item	Country		
	A	B	D
Quantity	$Q_A$	$Q_B$	$Q_D$
Unit of national currency	A-C	B-C	D-C
Value of expenditure	$V_A$	$V_B$	$V_D$
Price	$P_A$	$P_B$	$P_D$
Theoretical unit of currency	T-C	T-C	T-C
Theoretical price	$\overline{TT}$	$\overline{TT}$	$\overline{TT}$

The real values corresponding to the theoretical prices are, accordingly, as follows:

$$V'_A = \overline{TT} \times Q_A$$

$$V'_B = \overline{TT} \times Q_B$$

$$V'_D = \overline{TT} \times Q_D$$

The quantity indices will be as follows:

$${}^A Q_A = \frac{V'_A}{V'_A} = \frac{\overline{P} \times Q_A}{\overline{P} \times Q_A} = 1$$

$${}^A Q_B = \frac{V'_B}{V'_A} = \frac{\overline{P} \times Q_B}{\overline{P} \times Q_A} = \frac{Q_B}{Q_A}$$

$${}^A Q_D = \frac{V'_D}{V'_A} = \frac{\overline{P} \times Q_D}{\overline{P} \times Q_A} = \frac{Q_D}{Q_A}$$

The PPP for each country relative to the theoretical unit of currency is:

$$.PPP_A = \frac{V_A}{V'_A} = \frac{P_A \times Q_A}{\overline{P} \times Q_A} = \frac{P_A}{\overline{P}}$$

$$.PPP_B = \frac{V_B}{V'_B} = \frac{P_B \times Q_B}{\overline{P} \times Q_B} = \frac{P_B}{\overline{P}}$$

$$.PPP_D = \frac{V_D}{V'_D} = \frac{P_D \times Q_D}{\overline{P} \times Q_D} = \frac{P_D}{\overline{P}}$$

Examination of these formulae reveals the following:

(a) In the case of the single item, the quantity indices are independent of the theoretical price and are equivalent to the ratios of the quantities purchased in the various countries to the quantity purchased by the comparator country;

(b) In the case of the single item, the PPP of each country is equivalent to the ratio of the price in that country to the theoretical price;

(c) In the case of the single item, if country A is selected as numeraire country, the value of each PPP is as follows:

$${}^A PPP_A = \frac{.PPP_A}{.PPP_A} = 1$$

$${}^A PPP_B = \frac{.PPP_B}{.PPP_A} = \frac{P_B / \overline{P}}{P_A / \overline{P}} = \frac{P_B}{P_A}$$

$${}^A PPP_D = \frac{.PPP_D}{.PPP_A} = \frac{P_D / \overline{P}}{P_A / \overline{P}} = \frac{P_D}{P_A}$$

This is to say that the PPP for each country, when country A is selected as numeraire country, is equivalent to the ratio of the price in that country to the price in the numeraire country;

(d) We have stated that multiplying the theoretical prices by any numerical factor will not alter the results of the theoretical comparisons. If the theoretical price  $\bar{P}$  is multiplied by the factor  $1/\bar{P}$  the value of the new theoretical price is 1. We thus obtain the following results:

$$.PPP_A = P_A$$

$$.PPP_B = P_B$$

$$.PPP_D = P_D$$

Furthermore:

$$V_A = P_A \times Q_A = .PPP_A \times Q_A$$

$$V_B = P_B \times Q_B = .PPP_B \times Q_B$$

$$V_D = P_D \times Q_D = .PPP_D \times Q_D$$

## 2. The complex item

The complex item M is made up of a basket of goods and services, very like a basket of fruit containing oranges, apples and grapes. It is assumed that the theoretical prices of all the goods and services included in this basket are known and that the PPP for the basket can be calculated:

$$.PPP_A(M)$$

$$.PPP_B(M)$$

$$.PPP_D(M)$$

We also assume that we know the original values for the expenditure of each country on purchases made from the basket:

$$V_A(M) \quad V_B(M) \quad V_D(M)$$

The true values for the complex item can thus be calculated:

$$V'_A(M) = V_A(M) / .PPP_A(M)$$

$$V'_B(M) = V_B(M) / .PPP_B(M)$$

$$V'_D(M) = V_D(M) / .PPP_D(M)$$

$$AQA(M) = 1$$

$$A^{QB(M)} = V'_B(M) / V'_A(M)$$

$$A^{QD(M)} = V'_D(M) / V'_A(M) \quad \underline{1/}$$

G. Computation of PPPs and quantitative comparisons

In reality, no country in the world yet has complete information on the values expended on or the quantities purchased of all single items included in the list of goods and services over a period of time. In general, the only data available are for the values expended on the various categories contained in the list of goods and services and the prices of certain items in each category. Proceeding on the basis of the available data, the PPP of each basket and the PPP of all goods and services (that is to say of all categories) must therefore be calculated or estimated.

We have already stated that, in the case where the category contains one single item, the PPP and the quantitative comparisons can be calculated in accordance with the following formulae:

$$A^{PPP_B} = P_B / P_A$$

$$A^{PPP_D} = P_D / P_A$$

$$A^{Q_B} = \frac{Q_B}{Q_A} = \frac{V_B/P_B}{V_A/P_A} = \frac{V_B}{V_A} \cdot \frac{1}{A^{PPP_B}}$$

$$A^{Q_D} = \frac{Q_D}{Q_A} = \frac{V_D/P_D}{V_A/P_A} = \frac{V_D}{V_A} \cdot \frac{1}{A^{PPP_D}}$$

Given that:

$$V_A = P_A \times Q_A$$

$$V_B = P_B \times Q_B$$

$$V_D = P_D \times Q_D$$

---

1/ The indices  $A^{QB(M)}$  and  $A^{QD(M)}$  are no more than the global quantities of countries B and D in terms of the global quantity of country A. Despite the lack of an absolute value for these global quantities, the indices can be established in terms of the magnitudes  $Q_A(M)$   $Q_B(M)$   $Q_D(M)$ , which can be expressed in the following formulae:

$$A^{QA(M)} = Q_A(M) / Q_A(M)$$

$$A^{QB(M)} = Q_B(M) / Q_A(M) = V'_B(M) / V'_A(M)$$

$$A^{QD(M)} = Q_D(M) / Q_A(M) = V'_D(M) / V'_A(M)$$

and given that each category contains a number of items, say, for example, the three items a, b and d, that their respective prices in country A are, say,  $P_{aA}$ ,  $P_{bA}$  and  $P_{dA}$ , that the quantities purchased by country A are  $Q_{aA}$ ,  $Q_{bA}$  and  $Q_{dA}$ , and that the theoretical prices are  $\overline{P}_a$ ,  $\overline{P}_b$  and  $\overline{P}_d$ , then  $V_A$ , the theoretical value of the expenditure on this category by country A in the unit of currency of that country, will be as follows:

$$V_A = (P_{aA} \times Q_{aA}) + (P_{bA} \times Q_{bA}) + (P_{dA} \times Q_{dA})$$

If we assume that  $Q_A(M) = V'_A(M)$ , we can establish the remaining magnitudes,  $Q_B(M)$  and  $Q_D(M)$ , as follows:

$$\begin{aligned} Q_B(M) &= V'_B(M) \\ Q_D(M) &= V'_D(M) \end{aligned}$$

Given that:

$$\begin{aligned} V'_A &= V_A(M) / .PPP_A(M) \\ V'_B &= V_B(M) / .PPP_B(M) \\ V'_D &= V_D(M) / .PPP_D(M) \end{aligned}$$

then:

$$\begin{aligned} \hat{Q}_A(M) &= V_A(M) / .PPP_A(M) \\ \hat{Q}_B(M) &= V_B(M) / .PPP_B(M) \\ \hat{Q}_D(M) &= V_D(M) / .PPP_D(M) \end{aligned}$$

and consequently:

$$\begin{aligned} V_A(M) &= .PPP_A(M) \times \hat{Q}_A(M) \\ V_B(M) &= .PPP_B(M) \times \hat{Q}_B(M) \\ V_D(M) &= .PPP_D(M) \times \hat{Q}_D(M) \end{aligned}$$

These formulae show that  $.PPP_S(M)$  consists of the prices of a unit of the global quantities of country S expressed in the currency of that country. These are called the global basket or category prices. The expression:

$$\hat{Q}_A(M); \hat{Q}_B(M); \hat{Q}_D(M)$$

may be written as follows:

$$\begin{aligned} V'_A(M) &= 1 \times \hat{Q}_A(M) \\ V'_B(M) &= 1 \times \hat{Q}_B(M) \\ V'_D(M) &= 1 \times \hat{Q}_D(M) \end{aligned}$$

which shows that the theoretical price corresponding to complex item M is 1. Such a basket of goods and services is called a complex item.

Let us assume that expenditure on the purchase of item a,  $P_{aA} \times Q_{aA}$ , represents the greater part of expenditure on the entire category or  $V_A$ . The value of real expenditure (i.e. at theoretical prices) on this category in country A will be:

$$V'_A = \pi_a Q_{aA} + \pi_b Q_{bA} + \pi_d Q_{dA}$$

where real expenditure on item a in country A,  $\pi_a Q_{aA}$ , accounts for the greater part of its total real expenditure on the category.

Assuming that the situation with regard to country A is similar to that with regard to countries B and D, an approximation of the quantity indices can be obtained as follows:

$$\begin{aligned} {}^A Q_B &= \frac{V'_B}{V'_A} = \frac{\pi_a Q_{aB} + \pi_b Q_{bB} + \pi_d Q_{dB}}{\pi_a Q_{aA} + \pi_b Q_{bA} + \pi_d Q_{dA}} \\ &\# \frac{Q_{aB}}{Q_{aA}} = \frac{V_{aB}/P_{aB}}{V_{aA}/P_{aA}} = \frac{V_{aB}/V_{aA}}{P_{aB}/P_{aA}} \\ &= \frac{V_{aB}}{V_{aA}} \cdot \frac{1}{{}_A PPP_{aB}} \end{aligned}$$

where  $V_{aA} = P_{aA} \times Q_{aA}$  is the value of the expenditure of country A on the purchase of item a, and  $V_{aB} = P_{aB} \times Q_{aB}$  is the value of the expenditure of country B on the purchase of the same item. On the supposition that  $V_B/V_A \# V_{aB}/V_{aA}$ , the formula for the quantity index for country B in terms of country A will be:

$${}^A Q_B \# \frac{V_{aB}}{V_{aA}} \cdot \frac{1}{{}_A PPP_{aB}} \# \frac{V_B}{V_A} \cdot \frac{1}{{}_A PPP_B}$$

In the same way, the formula for the quantity index for country D in terms of country A will be:

$${}^A Q_D \# \frac{V_D}{V_A} \cdot \frac{1}{{}_A PPP_D}$$

Thus we reach the following conclusion: the quantity index for country B in terms of country A for a set or category of goods and services, when expenditure on one of the items in the set represents the greater part of expenditure on the category as a whole, is approximately equal to the ratio of the expenditure of country B expressed in the units of currency of that country to the expenditure of country A expressed in the units of currency of country A divided by the purchasing-power parity  ${}_A PPP_{aB}$ , in accordance with the following formula:

$${}^A Q_B \# V_B/V_A \times 1/{}_A PPP_{aB}$$

$${}^A Q_D \# V_D/V_A \times 1/{}_A PPP_{aD}$$



There are, in reality, few cases in which expenditure on a single item represents, in all of the countries included in the comparison, the greater part of expenditure on the category to which the single item belongs. We can nevertheless substitute the complex item for the single item within the category and assert that total expenditure on a set of selected items in the category is representative of total expenditure on the category as a whole. The approximate formula for the quantity index of country B relative to country A will be:

$$AQB \# V_B/V_A \cdot 1/A^{PPP B^M}$$

where M is the complex subitem.

II. AGGREGATION METHODS USED BY ICP

The present study will restrict itself to a presentation of the aggregation methods currently used by ICP, without entering into a discussion of their advantages or the caveats with which they are hedged about and without dwelling at length on proofs of the mathematical formulae involved, using extremely simplified examples.

We shall begin by introducing the basic Geary-Khamis method. The formula used in the method will then be transformed in order to show how data obtained at the category level or that of complex item subgroups can be used to obtain overall PPPs. An estimation factor for the PPP of the category will be calculated by using a geometric mean of the price ratios for selected items. Then, the country-product--dummy (CPD) method will be taken up and used to estimate missing prices for certain countries by making use of all country data. Finally, the CDP method will be used to estimate the PPP for a specific category when no prices whatever for that category are available for a particular country.

A. The basic Geary-Khamis method

We shall assume that all items for all countries included in the comparison have been covered, that is say that there has been no selectivity among the items under consideration. We shall also assume, for the purposes of the present study, that quantities and expenditure values for each item included in the list of goods and services are known for all countries without exception. It might however happen that a particular item included in the list of goods and services has not been purchased by one or more of the countries.

Let us assume that countries A and B are being compared and that the list of goods and services is made up of the three items a, b and c. The following tables show expenditure expressed in the national currency of each country and quantities purchased.

Expenditure values (V)

Item	Country	
	A	B
	(A-C)	(B-C)
a	8	6
b	12	10
c	12	8
Total	32	24

Quantities purchased (Q)

Item	Country		Total
	A	B	
a	2	6	8
b	4	2	6
c	6	4	10

Accordingly:  $V_A$ , the total value of the expenditure of country A in the unit of currency A-C, is 32;  $V_B$ , the total value of the expenditure of country B in the unit of currency B-C, is 24;  $Q_a$ , the total quantity of item a purchased, is 8;  $Q_b$ , the total quantity of item b purchased, is 6; and  $Q_c$ , the total quantity of item c purchased, is 10.

It is to be noted that no comparison of global quantities can be made unless the theoretical prices ( $\overline{P}$ ) are known. If we begin by arbitrarily establishing all such theoretical prices at 1:

$$\overline{P}^0_a = 1; \overline{P}^0_b = 1; \overline{P}^0_c = 1$$

we shall see how such theoretical prices can be developed by applying the round-iteration method of computation. On the basis of the initial theoretical prices, transformed or real values can be obtained for each country:

$$\begin{aligned} V'_A &= \overline{P}_a Q_{aA} + \overline{P}_b Q_{bA} + \overline{P}_c Q_{cA} = (1 \times 2) + (1 \times 4) + (1 \times 6) = 12 \\ V'_B &= \overline{P}_a Q_{aB} + \overline{P}_b Q_{bB} + \overline{P}_c Q_{cB} = (1 \times 6) + (1 \times 2) + (1 \times 4) = 12 \end{aligned}$$

We thus obtain transformed values for expenditure, and it is to be noted that  $V'_A = V'_B$ , i.e. that the global quantities for countries A and B are the same :

$$A^{QB} = V'_B / V'_A = 1.00000$$

The PPP for each of the countries can be calculated in terms of the theoretical unit of currency:<sup>2/</sup>

$$.PPP_A = V_A / V'_A = 32 / 12 = 8 / 3 = 2.66667$$

$$.PPP_B = V_B / V'_B = 24 / 12 = 2.00000$$

These PPPs can then be used to transform the original expenditure of each of the two countries on the purchase of each of the three items so as to obtain the corresponding transformed values, as follows:

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<sup>2/</sup> The purchasing-power parity (PPP) is calculated in accordance with the formula:

$$PPP_j = \frac{\sum_{i=1}^m P_{ij} Q_{ij}}{\sum_{i=1}^m \overline{P}_i Q_{ij}}$$

Source: Irving B. Kravis et al., A System of International Comparisons of Gross Product and Purchasing Power (Baltimore and London, The Johns Hopkins University Press, 1975), p. 68.

Item	Country				Total transformed expenditure (T-C)
	A		B		
	.PPP <sub>A</sub> = 2.6667		.PPP <sub>B</sub> = 2.00000		
	Expenditure by unit of currency				
	Theoretical National (A-C)	Theoretical (transformed) National (T-C)	Theoretical National (B-C)	Theoretical (transformed) National (T-C)	
a	8	3.0000	6	3.0000	6.00000
b	12	4.5000	10	5.0000	9.50000
c	12	4.50000	8	4.0000	8.50000

By dividing total transformed expenditure on each item by the quantity of the item purchased, new theoretical prices can be obtained, as follows:<sup>3/</sup>

Item	Total transformed expenditure (T-C)	Total quantity	New theoretical price (T-C)
a	6.0000	8	0.75000
b	9.5000	6	1.58333
c	8.5000	10	0.85000

These new round-one prices differ from the initial arbitrary theoretical prices. Recalculating the PPPs, the quantity index and the theoretical prices in round two, we obtain new values for PPPs, as follows:

Item	Country A			Country B		
	Quantity	New theoretical price	New transformed value	Quantity	New theoretical price	New transformed value
a	2	0.75000	1.5000	6	0.75000	4.5000
b	4	2.58333	6.33332	2	1.58333	3.16666
c	6	0.85000	5.10000	4	0.85000	3.40000
Total			12.93332			11.06666
Original value			32			24
PPP			2.47423			2.16867

<sup>3/</sup> In accordance with the formula:

$$\overline{P}_i = \frac{1}{\sum Q_{ij}} \sum_{j=1}^n \frac{P_{ij} Q_{ij}}{PPP_j}$$

Source: Kravis et al., op.cit., p.69

The new quantity index is thus:

$${}^A Q_B = \frac{V'_B}{V'_A} = \frac{11.06666}{12.93332} = 0.85567.$$

Using the following table, we obtain a new transformed expenditure:

Country					
A			B		
.PPP <sub>A</sub> = 2.47423			.PPP <sub>B</sub> = 2.16867		
Expenditure according to unit of currency					
Item	Original expenditure (A-C)	Transformed expenditure (T-C)	Original expenditure (B-C)	Transformed expenditure (T-C)	New total transformed expenditure (T-C)
a	8	3.23333	6	2.76667	6.00000
b	12	4.85000	10	4.61112	9.46112
c	12	4.85000	8	3.68888	8.5388

And finally, the second-round theoretical prices are established as follows:

Item	Total transformed expenditure	Total quantity	Second-round theoretical price
a	6.0000	8	0.75000
b	9.46112	6	1.57685
c	8.5388	10	0.85389

If, in order to obtain PPPs and new prices, we were to proceed to further rounds of calculation, we would obtain new results. On the basis of an arbitrary assumption concerning the initial theoretical prices, all the computation operations can be summarized as follows:

	Purchasing-power parity values		Theoretical prices for items		
	Country A	Country B	a	b	c
Prior arbitrary assumption			1.00000	1.00000	1.00000
First round	2.66667	2.00000	0.75000	1.58333	0.85000
Second round	2.47428	2.16867	0.75000	1.57685	0.85389

(Table continued)

	Purchasing-power parity values		Theoretical prices for items		
	Country A	Country B	a	b	c
Third round	2.47472	2.16817	0.75000	1.57687	0.85387
Fourth round	2.47472	2.16817	0.75000	1.57687	0.85388
Fifth round	2.47472	2.16817	0.75000	1.57687	0.85388

It can be seen from the table that there is a correspondence between the results obtained in rounds four and five and that the PPP of country B relative to that of country A is:

$$\overline{A^{PPP_B}} = \overline{.PPP_B} / \overline{.PPP_A} = 2.16817/1.47472 = 0.87612.$$

The ratios of the final theoretical prices of items b and c to those of item a are:

$$\overline{TT_b} / \overline{TT_a} = 1.57687/0.75000 = 2.10247$$

$$\overline{TT_c} / \overline{TT_a} = 0.85388/0.75000 = 1.13850$$

Let us now, for the purpose of calculating PPPs, begin with the following set of initial theoretical prices:

$$\overline{TT_a}^0 = 6 ; \overline{TT_b}^0 = 2 ; \overline{TT_c}^0 = 2$$

We then carry out a number of round-iterations, as follows:

	Purchasing-power parity values		Theoretical prices for items		
	Country A	Country B	a	b	c
Prior arbitrary assumption			6.00000	2.00000	2.00000
First round	1.00000	0.50000	2.50000	5.33333	2.80000
Second round	0.74189	0.65099	2.50000	5.25602	2.84639
Third round	0.74242	0.65045	2.50000	5.25623	2.84626
Fourth round	0.74242	0.65045	2.50000	5.25623	2.84626

In the case of the second assumption, the rounds are fewer in number and the PPP of country B relative to country A is:

$$A^{PPP_B} = 0.65045/0.74242 = 0.87612$$

This is the same value as that obtained on the basis of the first assumption. The ratios of the theoretical prices of items b and c to that of item a are, likewise:

$$\overline{P}_b / \overline{P}_a = 5.25623/2.50000 = 2.10249$$

$$\overline{P}_c / \overline{P}_a = 2.84626/2.50000 = 1.13850$$

or the same as those obtained on the basis of the first assumption. We can, accordingly, conclude that whatever values we select for the initial theoretical prices ( $\overline{P}_i$ ), the results of the round-iteration method will yield identical values for PPPs, if one particular country in the group under consideration is chosen as the numeraire country, and an identical structure of final theoretical prices.

The question now is whether, if we were to assign arbitrary initial values to PPPs instead of theoretical prices, we would obtain the same results by applying the round-iteration method. Let us assume that the initial PPP values in the above example are:

$$.PPP_A^0 = 1 ; .PPP_B^0 = 1$$

The transformed values can now be computed:

Item	Country				Total transformed value
	A		B		
	Original value	Transformed value	Original value	Transformed value	
	.PPP <sub>A</sub> =1		.PPP <sub>B</sub> =1		
a	8	8	6	6	14
b	12	12	10	10	22
c	12	12	8	8	20
Total	32	32	24	24	56

The first-round calculations for theoretical prices can then be carried out:

Item	Transformed value	Quantity	Theoretical price (T-C)
a	14.00000	8	1.75000
b	22.00000	6	3.66667
c	20.00000	10	2.00000

Then, using the initial theoretical prices, new first-round PPP values can be calculated, as follows:

First round

Item	Country			
	A		B	
	Quantity	Transformed value	Quantity	Transformed value
a	2	3.50000	6	10.50000
b	4	14.66667	2	7.33333
c	6	12.00000	4	8.00000
Total transformed value		30.16667		25.83333
Total original value		32		24
PPP		1.06077		0.92903

On the basis of the new PPP values, the second-round theoretical prices can be calculated:

Second round

Item	Country				Total transformed value
	A		B		
	Original value	Transformed value	Original value	Transformed value	
	.PPP <sub>A</sub> =1.06077		.PPP <sub>B</sub> =0.92903		
a	8	7.54167	6	6.45833	14.0000
b	12	11.31250	10	10.76388	22.07638
c	12	11.31250	8	8.61112	19.92362
Total	32	30.16667	24	25.8333	56.0000
Item	Transformed value		Quantity	Theoretical price	
a	14.00000		8	1.75000	
b	22.07638		6	3.67940	
c	19.92362		10	1.99236	

Thus, the second-round PPPs will be:



Item	Country			
	A		B	
	Quantity	Transformed value (T-C)	Quantity	Transformed value (T-C)
a	2	3.50000	6	10.50000
b	4	14.71760	2	7.35880
c	6	11.95416	4	7.96944
Total transformed value		30.17176		25.82824
Total original value		32		24
PPP		1.06059		0.92922

Proceeding to the third round, since the figures for subsequent rounds do not change, we obtain the following final results:

$$\overline{.PPP}_A = 1.06059 \qquad \overline{.PPP}_B = 0.92921$$

$$\begin{aligned} \overline{TT}_a &= 1.75000 \\ \overline{TT}_b &= 3.67936 \\ \overline{TT}_c &= 1.99238 \end{aligned}$$

If country A is adopted as numeraire country, the PPP for country B relative to country A will be:

$$\overline{A}PPP_B = \overline{.PPP}_B / \overline{.PPP}_A = 0.92921 / 1.06059 = 0.87612$$

The ratios of the theoretical prices will be:

$$\begin{aligned} \frac{\overline{TT}_b}{\overline{TT}_c} / \frac{\overline{TT}_a}{\overline{TT}_a} &= 3.67936 / 1.75000 = 2.10249 \\ \frac{\overline{TT}_c}{\overline{TT}_c} / \frac{\overline{TT}_a}{\overline{TT}_a} &= 1.99238 / 1.75000 = 1.13850 \end{aligned}$$

We thus arrive at the same results as those obtained in assuming arbitrary theoretical prices for use in the round-iteration procedure. The results obtained from the example can therefore be assessed as follows: when one of the countries is chosen as numeraire country, any figures assigned either to theoretical prices or to values for the PPP factor in applying the round-iteration method will yield the same final theoretical prices relative to the numeraire country and the same PPP values.

In connection with the basic G-K method, the final values for theoretical prices and PPPs verify the following:

$$\begin{aligned} \overline{TT}_a &= \frac{1}{[Q_{aB} + Q_{aA}]} \left[ \frac{V_{aA}}{\overline{.PPP}_A} + \frac{V_{aB}}{\overline{.PPP}_B} \right] \\ \overline{TT}_b &= \frac{1}{[Q_{bA} + Q_{bB}]} \left[ \frac{V_{bA}}{\overline{.PPP}_A} + \frac{V_{bB}}{\overline{.PPP}_B} \right] \\ \overline{TT}_c &= \frac{1}{[Q_{cA} + Q_{cB}]} \left[ \frac{V_{cA}}{\overline{.PPP}_A} + \frac{V_{cB}}{\overline{.PPP}_B} \right] \end{aligned}$$

If:

$$\bar{Z}_A = \frac{1}{.PPP_A} ; \quad \bar{Z}_B = \frac{1}{.PPP_B}$$

then:

$$\bar{Z}_a = 1 / .PPP_A = \left[ \bar{T}_a Q_{aA} + \bar{T}_b Q_{bA} + \bar{T}_c Q_{cA} \right] / (V_{aA} + V_{bA} + V_{cA})$$

$$\bar{Z}_b = 1 / .PPP_B = \left[ \bar{T}_a Q_{aB} + \bar{T}_b Q_{bB} + \bar{T}_c Q_{cB} \right] / (V_{aB} + V_{bB} + V_{cB})$$

We thus obtain five first-order linear equations and five unknowns. However, one of the equations can be determined on the basis of the others and the number of independent equations is therefore four. The solutions can be obtained in a single operation, rather than by having recourse to the round-iteration method, by adopting one of the unknowns, say  $\bar{Z}_A = 1 / .PPP_A$ , as a parameter. For the above example, the set of equations for the figures contained in the table of values will be as follows:

$$\bar{T}_a = (1/8)(8\bar{Z}_a + 6\bar{Z}_B)$$

$$\bar{T}_b = (1/6)(12\bar{Z}_A + 10\bar{Z}_B)$$

$$\bar{T}_c = (1/10)(12\bar{Z}_A + 8\bar{Z}_B)$$

$$\bar{Z}_A = (1/32)(2\bar{T}_a + 4\bar{T}_b + 6\bar{T}_c)$$

$$\bar{Z}_B = (1/24)(6\bar{T}_a + 2\bar{T}_b + 4\bar{T}_c)$$

Given that the number of independent equations is four, the final equation can be deleted and the following solutions obtained on the basis of  $\bar{Z}_A = 1 / .PPP_A$ :

$$\bar{Z}_B = 1.14139 \bar{Z}_A$$

$$\bar{T}_a = 1.85604 \bar{Z}_A$$

$$\bar{T}_b = 3.90231 \bar{Z}_A$$

$$\bar{T}_c = 2.11311$$

If we assume that  $.PPP_A = 1$ , i.e. that  $\bar{Z}_A = 1$ , then:

$${}_A PPP_B = .PPP_B / .PPP_A = \bar{Z}_A / \bar{Z}_B = 1 / 1.14139 = 0.87612$$

and the theoretical price ratios will be:

$$\bar{T}_b / \bar{T}_a = 3.90231 / 1.85604 = 2.10249$$

$$\bar{T}_c / \bar{T}_a = 2.11311 / 1.85604 = 1.13850$$

These results are the same as those obtained by using the round-iteration method. The G-K method can also be applied when all items have not been purchased by all countries. Applying the method to the second example, we obtain the following set of equations:

$$\overline{P}_a = 1/20(40\overline{Z}_B + 80\overline{Z}_D)$$

$$\overline{P}_b = 1/40(160\overline{Z}_A + 40\overline{Z}_D)$$

$$\overline{P}_d = 1/80(200\overline{Z}_A + 160\overline{Z}_B)$$

$$\overline{P}_e = 1/100(40\overline{Z}_A + 80\overline{Z}_D)$$

$$1/.PPP_A = \overline{Z}_A = 1/400(32 \overline{P}_b + 40 \overline{P}_d + 20 \overline{P}_e)$$

$$1/.PPP_B = \overline{Z}_B = 1/200(10 \overline{P}_a + 40 \overline{P}_d)$$

$$1/.PPP_D = \overline{Z}_D = 1/200(10 \overline{P}_a + 8 \overline{P}_b + 80 \overline{P}_e)$$

If .PPP<sub>A</sub> is selected as a parameter, we obtain the following solutions:

$$.PPP_B = 0.95238 \times (.PPP_A)$$

$$.PPP_D = 0.70423 \times (.PPP_A)$$

$$\overline{P}_a = 7.04/.PPP_A ; \overline{P}_b = 5.05/.PPP_A$$

$$\overline{P}_d = 5.34/.PPP_A ; \overline{P}_e = 1.24/.PPP_A$$

If we assume that .PPP<sub>A</sub> = 1, then:

$$.PPP_B = 0.95238$$

$$.PPP_D = 0.70423$$

$$\overline{P}_a = 7.04 ; \overline{P}_b = 5.05 ; \overline{P}_d = 5.34 ; \overline{P}_e = 1.24$$

These theoretical prices have the same structure as those assumed for the purposes of the example given in chapter I (page 9) and the same results can be obtained by applying the round-iteration method. If we assume that the figures for the initial prices are  $\overline{P}_a^0 = 700$ ,  $\overline{P}_b^0 = \overline{P}_d^0 = 500$  and  $\overline{P}_e^0 = 100$ , then the same results can be obtained after a series of round iterations.

## B. Transformation of the basic method

### 1. The present method

The two basic sets of equations for the G-K method are:

$$\overline{P}_i = \frac{1}{\sum_{J=1}^n Q_{iJ}} \sum_{J=1}^n \frac{P_{iJ} Q_{iJ}}{.PPP_J}$$

$$.PPP_J = \frac{\sum_{i=1}^m P_{iJ} Q_{iJ}}{\sum_{i=1}^m \overline{P}_i Q_{iJ}}$$

where  $P_{iJ}$  is the price of item  $i$  in country  $J$ ;  $Q_{iJ}$  is the quantity of item  $i$  purchased by country  $J$ ; and  $.PPP_J$  is the purchasing-power parity relative to the theoretical unit of currency.  $V_{iJ}$ , the value of the original expenditure of country  $J$  on the purchase of item  $i$  in the unit of currency of that country is,  $P_{iJ} Q_{iJ}$ ; and  $V_{iJ}$ , the value of the real expenditure of country  $J$  on the purchase of item  $i$  at the theoretical price  $\pi_i$ , is  $\pi_i Q_{iJ}$ . Accordingly, the two sets of equations can be written in terms of expenditure and prices only, assuming that all items have been purchased by all countries so that all quantities can be obtained by means of the equation  $Q_{iJ} = V_{iJ}/P_{iJ}$ , given that  $V_{.J} = V_{1J} + V_{2J} + \dots + V_{mJ}$ :

$$\pi_i = \frac{1}{\sum_{J=1}^n \frac{V_{iJ}}{P_{iJ}}} \cdot \sum_{J=1}^n \frac{V_{iJ}}{.PPP_J}$$

$$.PPP_J = \frac{\sum_{i=1}^m \frac{V_{iJ}}{P_{iJ}}}{\sum_{i=1}^m \frac{\pi_i V_{iJ}}{P_{iJ}}} = \frac{V_{.J}}{\sum_{i=1}^m \frac{\pi_i V_{iJ}}{P_{iJ}}}$$

If country A is adopted as numeraire country, then the PPP of country J in terms of country A relative to item  $i$  will be:

$$A^{PPP_J^i} = P_{iJ}/P_{iA}$$

$$P_{iJ} = P_{iA} \times A^{PPP_J^i}$$

and thence:

$$\sum_{J=1}^n Q_{iJ} = \sum_{J=1}^n \frac{V_{iJ}}{P_{iJ}} = \sum_{J=1}^n \frac{V_{iJ}}{P_{iA} \times A^{PPP_J^i}}$$

$$= \frac{1}{P_{iA}} \sum_{J=1}^n \frac{V_{iJ}}{A^{PPP_J^i}}$$

$$\sum_{i=1}^m \pi_i Q_{iJ} = \sum_{i=1}^m \pi_i \frac{V_{iJ}}{P_{iJ}} = \sum_{i=1}^m \frac{\pi_i}{P_{iA}} \cdot \frac{V_{iJ}}{A^{PPP_J^i}}$$

The two sets of equations are thus transformed as follows:

$$\pi_i = \left[ 1 / \frac{1}{P_{iA}} \sum_{J=1}^n \frac{V_{iJ}}{A^{PPP_J^i}} \right] \cdot \sum_{J=1}^n \frac{V_{iJ}}{.PPP_J}$$

$$.PPP_J = \frac{V \cdot J}{\sum_{i=1}^n \frac{\overline{P}_i}{P_{iA}} \cdot \frac{V_{iJ}}{A^{PPP}_i}}$$

If we assume that  $\sigma_i = \overline{P}_i / P_{iA}$ , then:

$$\overline{P}_i = \sigma_i P_{iA} = \frac{1}{\frac{1}{P_{iA}} \sum_{J=1}^n \frac{V_{iJ}}{A^{PPP}_J}} \sum_{J=1}^n \frac{V_{iJ}}{A^{PPP}_J}$$

$$\frac{1}{.PPP_J} = \frac{1}{V \cdot J} \cdot \sum_{i=1}^n \sigma_i \frac{V_{iJ}}{A^{PPP}_J}$$

and finally:

$$\sigma_i = \frac{\sum_{J=1}^n \frac{V_{iJ}}{A^{PPP}_J}}{\sum_{J=1}^n \frac{V_{iJ}}{A^{PPP}_J}}$$

$$\frac{1}{.PPP_J} = \frac{\sum_{i=1}^m \sigma_i \frac{V_{iJ}}{A^{PPP}_J}}{\sum_{i=1}^m V_{iJ}}$$

From the fact that these formulae can be used initially for simple items, they can also be applied to categories of goods and services. If sub-categories are represented by M, then the formulae can be written as follows:

$$\sigma_M = \frac{\sum_{J=1}^n \frac{V_{iJ}^{(M)}}{A^{PPP}_J^{(M)}}}{\sum_{J=1}^n \frac{V_{iJ}^{(M)}}{A^{PPP}_J^{(M)}}}$$

$$\frac{1}{.PPP_J} = \frac{\sum_M \sigma_M \frac{V_{iJ}^{(M)}}{A^{PPP}_J^{(M)}}}{\sum_M V_{iJ}^{(M)}}$$

given that the total expenditure of country J on sub-category M, which is in turn made up of a set of goods and services, can be represented as  $V_{iJ}^{(M)}$ .

It is therefore evident that the PPP for all goods and services can be calculated on the basis of the original expenditure and the PPPs for the various categories by using the ICP formulae in the following steps: (a) adopting country A as numeraire country and calculating  $A^{PPP(M)}$ , the PPP for each country and each category; and (b) aggregating all PPPs for each category in accordance with the present G-K method, which assumes that the distribution of overall expenditure on the various categories is known.

It should be noted that the "theoretical prices"<sup>0</sup><sub>i</sub> in the present G-K formula do not have the same unequivocal meaning as the theoretical prices in the basic formula. They appear as instrumental variables in order to facilitate computation operations.

Taking another example, let us assume that there are only two countries, country A and country B, that the items are distributed over the three categories , and , that the breakdown of expenditure on each category by each country in its own currency is known, and that the PPPs for the various categories are likewise known, as follows:

Expenditure

Category	Country	
	A (C-A)	B (C-B)
	6	8
	10	12
	8	12
Total	24	32

Purchasing-power parities

Category	Country	
	A PPP relative to country A (i) ( $A^{PPP_A}$ )	B PPP relative to country A (i) ( $A^{PPP_B}$ )
	1	4.0
	1	0.6
	1	1.0

Using the equations of the present G-K formulae, we obtain the following:

$$\sigma_{\alpha} = \frac{\frac{6}{.PPP_A} + \frac{8}{.PPP_B}}{\frac{6}{1} + \frac{8}{4.0}}$$

$$\sigma_{\beta} = \frac{\frac{10}{.PPP_A} + \frac{12}{.PPP_B}}{\frac{10}{1} + \frac{12}{0.6}}$$

$$\sigma_{\gamma} = \frac{\frac{8}{.PPP_A} + \frac{12}{.PPP_B}}{\frac{8}{1} + \frac{12}{1}}$$

$$\frac{1}{.PPP_A} = \frac{\frac{6}{1} \sigma_{\alpha} + \frac{10}{1} \sigma_{\beta} + \frac{8}{1} \sigma_{\gamma}}{6 + 10 + 8}$$

$$\frac{1}{.PPP_B} = \frac{\frac{8}{4.0} \sigma_{\alpha} + \frac{12}{0.6} \sigma_{\beta} + \frac{12}{1.0} \sigma_{\gamma}}{8 + 12 + 12}$$

If we assume that  $Z_A = 1/.PPP_A$  and  $Z_B = 1/.PPP_B$ , we obtain a series of first-order equations:

$$\begin{aligned} \sigma_{\alpha} &= 1/8(6Z_A + 8Z_B) \\ \sigma_{\beta} &= 1/30(10Z_A + 12Z_B) \\ \sigma_{\gamma} &= 1/20(8Z_A + 12Z_B) \\ Z_A &= 1/24(6 \sigma_{\alpha} + 10 \sigma_{\beta} + 8 \sigma_{\gamma}) \\ Z_B &= 1/32(2 \sigma_{\alpha} + 20 \sigma_{\beta} + 12 \sigma_{\gamma}) \end{aligned}$$

There are four independent equations. If  $Z_A = 1/.PPP_A$  is taken as a parameter, solutions can be obtained in terms of that parameter, as follows:

$$Z_B = 1/.PPP_B = (389/444).(1/.PPP_A)$$

$$.PPP_B = \frac{389}{444} .PPP_A$$

$$\sigma_{\alpha} = (722/389).(1/.PPP_A)$$

$$\sigma_{\beta} = (1518/5).(389).(1/.PPP_A)$$

$$\sigma_{\gamma} = (411/389).(1/.PPP_A)$$

### 3. Supercountry weights

The basic G-K method establishes theoretical prices in the following manner:

$$\overline{P}_i = \frac{1}{\sum_{J=1}^n Q_{iJ}} \cdot \sum_{J=1}^n \frac{V_{iJ}}{.PPP_J}$$

as derived from:

$$\begin{aligned} \overline{P}_i &= \frac{1}{\sum_{J=1}^n Q_{iJ}} \cdot \sum_{J=1}^n \frac{P_{iJ} Q_{iJ}}{.PPP_J} \\ &= \sum_{J=1}^n \frac{1}{Q_{iJ}} \cdot \sum_{J=1}^n \frac{Q_{iJ} P_{iJ}}{.PPP_J} \end{aligned}$$

(where we assume that there are prices for all items in the group of countries selected).

The theoretical price of item  $i$  is the average of the prices of that item in all countries after conversion into theoretical units of currency. The average used is that obtained by dividing total expenditure on the purchase of the item in the selected group of countries by the quantities purchased. Since the ultimate goal of ICP is to compare all countries of the world, the countries that have been selected by ICP can be viewed as a sample of countries and, in that case,  $\overline{P}_i$  may be considered an estimate of the world theoretical price. In order to obtain the best estimate however,  $\overline{P}_i$ , which is restricted to the weights of those countries selected by ICP, should not be used and such weights should rather be adjusted in order to take account not only of the quantities of item  $i$  purchased by the selected group of countries but also of those purchased by other countries. The formula for estimating  $\tilde{P}_i$ , the world theoretical price is:

$$\tilde{P}_i = \frac{1}{\sum_{j=1}^n \tilde{Q}_{iJ}} \cdot \sum_{j=1}^n \tilde{Q}_{iJ} \frac{P_{iJ}}{.PPP_J}$$

The assumption is here made that country  $J$ , selected by ICP, is representative of a number of similar countries with respect to certain properties.  $\tilde{Q}_{iJ}$  represents the total quantities of item  $i$  purchased by such similar countries. The present G-K formula for the theoretical price is written as follows:

$$\tilde{P}_i = \frac{\sum_{j=1}^n \tilde{V}_{iJ} / .PPP_J}{\sum_{j=1}^n \tilde{V}_{iJ} / .APPP_J} \quad i$$



where  $V_{iJ}$  is the total of the values for the similar countries. If these similar countries, as represented by country J, are  $h_J = 1, 2, \dots, H_J$ , then:

$$\tilde{V}_{\alpha J} = \sum_{h_J=1}^{H_J} V_{\alpha h_J}$$

and further:

$$\tilde{Q}_{iJ} = \sum_{h_J=1}^{H_J} Q_{ih_J} = \sum_{h_J=1}^{H_J} \frac{V_{\alpha h_J}}{P_i h_J}$$

No detailed data on quantities, values and prices for the various items and categories are, of course, available for those countries not participating in ICP. For that reason, ICP uses a rough procedure in order to take account of the weights of non-participating countries which consists of the following steps:

- (a) The GDP figures for all countries of the world are converted into United States dollars at the official rates of exchange;
- (b) Following conversion, the figures are aggregated for groups of countries;
- (c) The total GDP for each group is distributed among the ICP countries in accordance with principles consistent with the manner in which the sample of countries was selected;
- (d) The GDP figure thus allocated to a particular ICP country is reconverted from dollars into the national currency of that country at official exchange rates;
- (e) The GDP expressed in local currency is then distributed among the various expenditure categories in accordance with the original distribution of expenditure.

A distribution has been made of the 34 countries participating in ICP Phase III in accordance with two major indicators: per capita GDP in dollars; and the region in which the country is located - Africa, Asia, Europe, North America or Latin America. Table 1 shows the Phase III countries, with their original and weighted population and GDP for 1975. On the basis of the new figures for the ICP countries, weights referred to as "supercountry weights", can be obtained for the G-K formula.

Table 1. Distribution of Phase III countries by weighted population and GDP

(Per capita GDP in US dollars: GDP in billions of dollars:  
population in millions)

Per capita GDP	Country	Original figures		Weighted figures	
		GDP	Population	GDP	Population
<u>Africa</u>					
Under 250	Malawi	0.7	5.00	41.6	103.5
	Kenya	3.1	13.4	41.5	103.5
250-499	Zambia	2.4	5.0	83.1	207.2
Other African countries		390.8	160.0		
Total		414.2	166.2	414.2	166.2
<u>Asia</u>					
Under 250	India	608.2	68.0	608.2	86.0
	Pakistan	69.2	11.3	181.2	30.3
	Sri Lanka	13.5	3.4	181.2	30.3
250-499	Thailand	41.9	14.3	330.2	118.4
	Phillipines	42.5	15.6	330.2	118.4
	Korea	35.3	19.1	330.2	118.4
500-1249	Syria	7.4	5.5	43.6	34.0
	Malaysia	11.9	9.3	43.6	34.0
1250-2000	Iran	33.0	54.0	40.6	69.8
3000-5000	Japan	111.6	490.6	143.4	675.3
Other Asian countries		1257.9	6056.8		
Total		2232.4	1314.9	2232.4	1314.9
<u>Europe</u>					
500-1249	Romania	21.2	26.4	63.5	64.0
1250-1999	Yugoslavia	21.4	33.1	31.8	47.8
2000-2999	Hungary	10.5	22.7	88.8	227.2
	Ireland	3.1	7.8	88.8	227.2
	Poland	34.0	88.3	88.8	227.2
	Spain	35.6	101.0	88.8	227.2
3000-4999	Italy	55.8	172.1	55.8	172.1
	United Kingdom	56.0	228.8	56.0	228.8
	Austria	7.5	35.8	39.3	157.5
5000-6999	Netherlands	13.6	81.2	13.6	81.2
	Luxembourg	0.4	2.2	5.3	30.2
	Belgium	9.8	62.2	9.8	62.2

Table 1. (continued)

Per capita GDP	Country	Original figures		Weighted figures	
		GDP	Population	GDP	Population
More than 7000	France	52.8	335.7	52.8	335.7
	Germany, F. R.	61.8	424.8	61.8	424.8
	Denmark	5.1	35.5	78.7	187.3
Other European countries		434.8	1042.8		
Total		823.4	2700.4	823.4	2700.4
<u>North America</u>					
More than 7000	United States	213.5	1513.8	239.8	1683.8
<u>Latin America</u>					
500-1249	Colombia	23.6	13.6	52.3	31.7
	Brazil	106.2	109.2	106.2	109.2
	Uruguay	2.8	3.6	52.3	31.7
1250-2000	Mexico	60.1	79.0	60.1	83.6
	Jamaica	2.0	2.9	44.1	83.6
Other Latin American countries		120.3	131.5		
Total		315.0	339.8	315.0	339.8
<u>All countries of the world</u>					
ICP countries		1794.0	4265.0	4024.8	6205.1
Other countries		2230.8	1940.1		
Grand total		4024	6205.1	4024.8	6205.1

C. Estimates of PPPs at the category level of the classification of items

1. The PPP formula

In the case where no data are available on expenditure at the level of individual items within the category or on the quantities of such items purchased and where only their median prices are known, ICP applies the following procedure:

- (a) A numeraire country is established, say country A;
- (b) The price ratios for each item in the category in each country J are calculated relative to the corresponding prices in the numeraire country, country A;

(c) The geometric mean of the ratios for the category (that is to say for the complex item) is calculated for each country J in terms of the numeraire country A, in accordance with the following formula:

$$A^{PPP_J^{(M)}} = \sqrt[M]{\prod_{i=1}^M \frac{P_{iJ}}{P_{iA}}}$$

We have, for example, three countries, A, B and D, and the category of dairy produce, made up of the four items a, b, d and e. The PPP for the dairy produce category for countries B and D in terms of country A, the numeraire country, are to be calculated in terms of the following average prices:

Item	Country		
	Prices in national unit of currency		
	Dirhams A	Dinars B	Riyals D
a	16.322	8.000	16.000
b	10.000	6.322	10.000
d	10.000	8.000	9.802
e	4.000	1.788	2.000

With country A as numeraire country,  $A^{PPP_A^{(M)}} = 1$ , and the PPP for the dairy produce category for country B relative to country A is as follows:

$$\begin{aligned}
 A^{PPP_B^{(M)}} &= \sqrt[4]{\frac{P_{aB}}{P_{aA}} \cdot \frac{P_{bB}}{P_{bA}} \cdot \frac{P_{dB}}{P_{dA}} \cdot \frac{P_{eB}}{P_{eA}}} \\
 &= \sqrt[4]{\frac{8.000}{16.322} \times \frac{6.322}{10.000} \times \frac{8.000}{10.000} \times \frac{1.788}{10.000}} \\
 &= 0.57700
 \end{aligned}$$

The PPP for the dairy produce category for country D relative to country A is:

$$\begin{aligned}
 A^{PPP_D^{(M)}} &= \sqrt[4]{\frac{P_{aD}}{P_{aA}} \cdot \frac{P_{bD}}{P_{bA}} \cdot \frac{P_{dD}}{P_{dA}} \cdot \frac{P_{eD}}{P_{eA}}} \\
 &= \sqrt[4]{\frac{16.000}{16.322} \times \frac{10.000}{10.000} \times \frac{9.802}{10.000} \times \frac{2.000}{10.000}} \\
 &= 0.83255
 \end{aligned}$$

Now, if we assume that the values for expenditure on the dairy produce category in those countries are:

Country	Currency	Value of expenditure (in millions)
A	Dirhams	315
B	Dinars	275
D	Riyals	520

then the indices for the global quantities of the dairy produce category will be:

$$A^{QA(M)} = \frac{V_A^{(M)}}{V_A^{(M)}} / A^{PPPA} = \frac{315}{315} / 1.00 = 100.0\%$$

$$A^{QB(M)} = \frac{V_B^{(M)}}{V_A^{(M)}} / A^{PPPB} = \frac{275}{315} / 0.57700 = 151.3\%$$

$$A^{QD(M)} = \frac{V_D^{(M)}}{V_A^{(M)}} / A^{PPPD} = \frac{520}{315} / 0.83255 = 198.3\%$$

It will be noted that the global quantity for country D is almost twice that for country A, while the global quantity for country B is 1.51 times that for country A.

The PPPs for countries B and D can be found by calculating the ratio of the geometric mean of the prices of the four items in countries B and D to the geometric mean of the prices of the same items in country A:

$$P_A^{(M)} = 4 \sqrt{P_{aA} \times P_{bA} \times P_{dA} \times P_{eA}}$$

$$P_B^{(M)} = 4 \sqrt{P_{aB} \times P_{bB} \times P_{dB} \times P_{eB}}$$

$$P_D^{(M)} = 4 \sqrt{P_{aD} \times P_{bD} \times P_{dD} \times P_{eD}}$$

$$A^{PPP_A(M)} = P_A^{(M)} / P_A^{(M)} = 4 \sqrt{16.322 \times 10 \times 10 \times 4} / 16.322 \times 10 \times 10 \times 4 = 1.00$$

$$A^{PPP_B(M)} = P_B^{(M)} / P_A^{(M)} = 4 \sqrt{8 \times 6.322 \times 8 \times 1.788} / 16.322 \times 10 \times 10 \times 4 = 0.577$$

$$A^{PPP_D(M)} = P_D^{(M)} / P_A^{(M)} = 4 \sqrt{16 \times 10 \times 9802 \times 2} / 16.322 \times 10 \times 10 \times 4 = 0.577$$

and the indices for the global quantities of the dairy produce category will be:

$$A^{QB(M)} = \frac{V_B^{(M)}}{V_A^{(M)}} / \frac{P_B^{(M)}}{P_A^{(M)}} = \frac{275}{315} / \frac{5.18625}{8.98894} = 151.3\%$$

$$A^{QD(M)} = \frac{V_D^{(M)}}{V_A^{(M)}} \cdot \frac{P_D^{(M)}}{P_A^{(M)}} = \frac{520}{315} \cdot \frac{7.48370}{8.98894} = 198.3\%$$

If it is assumed that the geometric mean of the prices of the items included in the dairy produce category for country J is the price of the complex item (i.e. of the dairy produce category), then the result of dividing the total expenditure of country J on the purchase of dairy produce by the price  $P_J^{(M)}$  is the quantity of the complex item:

$$V_J^{(M)} / P_J^{(M)}$$

D. Estimation of missing prices: the country-product--dummy method

1. The formula for the CPD method

We have thus far assumed that, for all countries included in the comparison, all the price data on all items in the category are available. It may however sometimes happen that, in certain countries, prices for certain items in the category are not available. In France, for example, okra is sold in minute quantities to a small number of foreign consumers, so that no data on it are collected, whereas it is considered a major item in Iraq. In order to estimate such missing prices, ICP has devised the country-product--dummy (CPD) method. The objective is to estimate missing prices within a single category of items. Let us, at the outset, assume that the price ratios of one of the countries included in the comparison, say country J, relative to the numeraire country, country A, show a small dispersion so that it is possible to consider that the magnitude  $P_{iJ}/P_{iA} = K_{JA}$ , and that therefore  $P_{iJ} = K_{JA} \times P_{iA}$  is constant for all items i in the category under consideration.<sup>4/</sup> (In this case, when country J is the numeraire country, then obviously  $K_{AA} = 1$ .)

The relation  $P_{iJ} = K_{JA} \times P_{iA}$  shows that the price of item i in country J is linked to two parameters:  $K_{JA}$ , linked only with country J; and  $P_{iA}$ , linked only with item i. The basic assumption of the CPD method is that this relation, after correction, also obtains in the case where there is appreciable dispersion among price ratios for an item within the category. The correction is made by introducing a third parameter so that the relation is  $P_{iJ} = K_{JA} \times P_{iA} \times W_{iJ}$ , where  $W_{iJ}$  is a random variable, the distribution of the logarithm is subject to the normal law, the arithmetic mean is zero and the standard deviation ( $\sigma$ ) is constant and independent of country J.

<sup>4/</sup> If we were to take another country, say country A', as numeraire country, we would also obtain the following:

$$P_{iJ} = K_{JA'} \times P_{iA'}$$

$$P_{iA'} = K_{A'A} \times P_{iA}$$

and accordingly:

$$P_{iJ} = K_{JA'} \times P_{iA'} = K_{JA'} \times K_{A'A} \times P_{iA}$$

$$P_{iJ} = K_{JA'} \times K_{A'A} \times P_{iA}$$

$$K_{JA} = K_{JA'} \times K_{AA'}$$

Thus, the relation between  $K_{JA'}$  and  $K_{JA}$  is independent of item i and is not affected by a change of numeraire country.

In order to estimate the parameters  $K_{JA}$  and  $K_{iA}$  the CPD method is applied and the logarithm of the latter relation calculated, so that:

$$\log P_{ij} = \log K_{JA} + \log P_{iA} + \log W_{iJ}$$

$$Z_{iJ} = \beta_J + \gamma_i + U_{iJ}$$

That is to say that we assume that:

$$\gamma_i = \log P_{iA} ; Z_{iJ} = \log P_{iJ}$$

$$\beta_A = \log K_{AA} = \log 1 = 0 ; \beta_j = \log K_{iJ}$$

$$U_{iJ} = \log W_{iJ}$$

Here,  $E(u) = 0$ ,  $\sigma(u) = \sigma$ , and the latter relation can be written as:

$$Z_{iJ} = \sum_{h=1}^n \beta_h X_{ih} + \sum_{j=1}^m \gamma_j Y_{jJ} + U_{iJ}$$

by introducing two dummy variables, X and Y. Each variable corresponds to the following figures:

$$X_{ih} = 1 \text{ when } h = J$$

$$X_{ih} = 0 \text{ when } h \neq J$$

$$Y_{jJ} = 1 \text{ when } j = i$$

$$Y_{jJ} = 0 \text{ when } j \neq i$$

In the light of the price data available, the coefficients of regression of the relation can be estimated. They are:

$$\hat{\beta}_1, \hat{\beta}_2, \dots, \hat{\beta}_J, \dots, \hat{\beta}_n$$

$$\hat{\gamma}_1, \hat{\gamma}_2, \dots, \hat{\gamma}_i, \dots, \hat{\gamma}_m$$

Where the price of item i in country J is not available, if we have obtained the estimates  $\hat{\beta}_J$  and  $\hat{\gamma}_i$ , it can be calculated as follows:

$$\hat{Z}_{iJ} = \log P_{iJ} = \hat{\beta}_J + \hat{\gamma}_i$$

$$P_{iJ} = e^{\hat{\beta}_J + \hat{\gamma}_i}$$

In applying the CPD method, there is another way of estimating  $\hat{\beta}_J$  and  $\hat{\gamma}_i$  if price data for all the items in the category in all countries are available. If  $Z_{iJ}$  is the logarithm of the price of item i in country J, then:

$$Z_{iJ} = \beta_J + \gamma_i + U_{iJ}$$

Let us now apply the method of least squares to the coefficient of regression in order to estimate  $\beta_j$  and  $\gamma_i$  by the method of maximum reduction, given that  $\beta_A = 0$ :

$$U = \sum_{\substack{J=1 \\ J \neq A}}^n \sum_{i=1}^M (Z_{iJ} - \beta_J - \gamma_i)^2 + \sum_i^M (Z_{iA} - \gamma_i)^2$$

The partial derivatives of  $\beta_J$  and  $\gamma_i$  can be calculated as follows:

$$\frac{\partial U}{\partial \beta_J} = 0 ; -2 \sum_{i=1}^M (Z_{iJ} - \beta_J - \gamma_i) = 0$$

for  $J \neq A$  and  $J = 1, 2, \dots, n$ , and

$$\frac{\partial U}{\partial \gamma_i} = 0 ; -2 \sum_{\substack{J=1 \\ J \neq A}}^n (Z_{iJ} - \beta_J - \gamma_i) - 2 (Z_{iA} - \gamma_i) = 0$$

for  $i = 1, 2, \dots, M$ . The final set of equations can be written as follows:

$$M \hat{\beta}_J + \sum_{i=1}^M \hat{\gamma}_i = \sum_{i=1}^M Z_{iJ}$$

where  $J = A$  and  $J = 1, 2, \dots, n$ , and

$$\sum_{\substack{J=1 \\ J \neq A}}^n \beta_J + (n-1) \hat{\gamma}_i + \hat{\gamma}_i = \sum_{\substack{J=1 \\ J \neq A}}^n Z_{iJ} + Z_{iA} = \sum_{J=1}^n Z_{iJ}$$

where  $i = 1, 2, \dots, M$ .

If we assume that:

$$B = \sum_{\substack{J=1 \\ J \neq A}}^n \hat{\beta}_J ; T = \sum_{i=1}^M \hat{\gamma}_i$$

the set of equations will be:

$$1. M \hat{\beta}_J + T = \sum_{i=1}^M Z_{iJ}$$

$$J \neq A ; J = 1, 2, \dots, n$$

$$2. B + nT = \sum_{i=1}^M Z_{iJ}$$



Aggregating equation 1 for all countries (with the exception of the numeraire country, country A) and equation 2 for all items i, we obtain the following :

$$3. \quad MB + (J-1)T = \sum_{\substack{J=1 \\ J \neq A}}^n \sum_{i=1}^M Z_{iJ} = \sum_{J=1}^n \sum_{i=1}^M Z_{iJ} - \sum_{i=1}^M Z_{iA}$$

$$4. \quad MB + JT = \sum_{J=1}^n \sum_{i=1}^M Z_{iJ}$$

If we subtract equation 3 from equation 4, we obtain the following:

$$T = \hat{\gamma}_1 + \hat{\gamma}_2 \dots + \hat{\gamma}_M = \sum_{i=1}^M Z_{iA}$$

By substituting this value for equation 1:

$$M \hat{R}_J + \sum_{i=1}^M Z_{iA} = \sum_{i=1}^M Z_{iJ}$$

$$\hat{R}_J = 1/M \sum_{i=1}^M (Z_{iJ} - Z_{iA})$$

then:

$$\begin{aligned} Z_{iJ} &= \log P_{iJ} \\ Z_{iA} &= \log P_{iA} \\ Z_{iJ} - Z_{iA} &= \log P_{iJ} - \log P_{iA} = \log P_{iJ}/P_{iA} \\ \hat{R}_J &= 1/M \sum \log P_{iJ}/P_{iA} \end{aligned}$$

This makes it possible to write the coefficient as follows:<sup>5/</sup>

$$e^{\hat{R}_J} = \sqrt[M]{\prod_{i=1}^M \frac{P_{iJ}}{P_{iA}}}$$

The value  $e^{\hat{R}_J}$  will thus be equal to the geometric mean of the price ratios when data on all prices are available for all countries. This result stands if estimates previously obtained by the CPD method are substituted for the missing prices.

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<sup>5/</sup> We have already seen that:

$$A^{PPP(M)}_J = \sqrt[M]{\prod_{i=1}^M P_{iJ} / P_{iA}}$$

and accordingly:

$$A^{PPP(M)}_J = e^{\hat{R}_J}$$

Let us suppose that the group is made up of three countries, that the dairy produce category contains four items and that some of the prices are missing, as follows:

Item	Prices in national unit of currency		
	Dirhams	Dinars	Riyals
	A	B	D
a	*	4	8
b	5	*	5
d	5	4	*
e	2	*	1

There are two missing prices for country B and one each for countries A and D. It appears at first sight that the two missing prices for country B can be estimated on the basis of the price ratio of item d in countries B and A, that is to say  $4/5 = 0.8$ , and applying this ratio in order to determine the missing prices for items d and e in country B:

$$\begin{aligned} \hat{P}_{bB} &= 0.8 \times P_{dA} = 0.8 \times 5 = 4 \\ \hat{P}_{eB} &= 0.8 \times P_{eA} = 0.8 \times 2 = 1.6. \end{aligned}$$

However, another estimate for each price can be obtained if we take the price ratio of country B and country D relative to item a,  $4/8 = 0.5$ , in which case the new prices for country B will be:

$$\begin{aligned} \hat{P}_{aB} &= 5 \times 0.5 = 2.5 \\ \hat{P}_{eB} &= 0.5 \times 1 = 0.5 \end{aligned}$$

It will be noted that the results differ and likewise, if we wish to estimate the price of item a in country A, it would be, in comparison with country B:

$$\hat{P}_{aA} = 5/4 \times 4 = 5.0$$

and in comparison with country D:

$$\hat{P}_{aA} = 2/1 \times 8 = 16$$

The price estimate for item d in country D, in comparison with country A would be:

$$\hat{P}_{dD} = 5/5 \times 5 = 5.0$$

and in comparison with country B:

$$\hat{P}_{dD} = 8/4 \times 4 = 8.0$$

These are, in turn, widely different results, for the price estimate for an item in one country depends on the choice of comparator country. In order to estimate missing prices, ICP therefore adopts the CPD method since it makes use of all the relations between all prices available in all countries. Such a method is called a "generalized bridge - country method".

Let us begin by writing the linear coefficient of regression, with country A as numeraire country, that is to say that  $A = 0$ :

$$Z_{iJ} = \beta_B X_{iB} + \beta_D X_{iD} + \gamma_a \gamma_{aJ} + \gamma_b \gamma_{bJ} + \gamma_d \gamma_{dJ} + \gamma_e \gamma_{eJ} + U_{iJ}$$

$Z_{ij} = \log P_{ij}$ , and the logarithm is called a "natural" logarithm, that is to say that  $P_{ij} = e^{Z_{ij}}$ , where  $e = 2.71828$ . The following table gives the values assumed by the variables  $X_{iJ}$  and  $Y_{iJ}$  when price data are available.

Item	Country	$Z_{iJ}^*$	$X_{iJ}$		$Y_{iJ}$			
			$X_{iB}$	$X_{iD}$	$Y_{aJ}$	$Y_{bJ}$	$Y_{dJ}$	$Y_{eJ}$
a	B	$\log 4 = 1.38631$	1	0	1	0	0	0
a	D	$\log 8 = 2.07946$	0	1	1	0	0	0
b	A	$\log 5 = 1.60945$	0	0	0	1	0	0
b	D	$\log 5 = 1.60945$	0	1	0	1	0	0
d	A	$\log 5 = 1.60945$	0	0	0	0	1	0
d	B	$\log 4 = 1.38631$	1	0	0	0	1	0
e	A	$\log 2 = 0.69315$	0	0	0	0	0	1
e	D	$\log 1 = 0.00000$	0	1	0	0	0	1

\* This is a natural logarithm. In using the logarithm tables, which have a decimal basis, to obtain the natural logarithm, the decimal-based logarithm figure is divided by 0.43429 (i.e. the decimal logarithm of  $e = 2.71828$ ).

From the figures in the table, we obtain an estimate of the coefficients of regression:

$$\begin{array}{l} \hat{\beta}_B = -0.54974 \\ \hat{\beta}_D = -0.18326 \end{array} \qquad \begin{array}{l} \hat{\gamma}_a = 2.09938 \\ \hat{\gamma}_b = 1.70107 \\ \hat{\gamma}_d = 1.77275 \\ \hat{\gamma}_e = 0.43820 \end{array}$$

and it is thus possible to estimate the missing prices, which are:

$$\begin{array}{l} P_{aA} = e^{\hat{\beta}_A + \hat{\gamma}_a} = e^{2.09938} = 8.1611 \\ P_{bB} = e^{\hat{\beta}_B + \hat{\gamma}_b} = e^{1.15133} = 3.1623 \\ P_{dD} = e^{\hat{\beta}_D + \hat{\gamma}_d} = e^{1.5133} = 4.9012 \\ P_{eB} = e^{\hat{\beta}_B + \hat{\gamma}_e} = e^{-0.11154} = 0.8944 \end{array}$$

It is also possible to calculate the other prices by applying the results obtained from the coefficient of regression and comparing them with the original prices, as follows:

Item	Country	$\hat{\beta}_J$	$\hat{\gamma}_i$	$\hat{\beta}_J + \hat{\gamma}_i$	Price resulting from application of regression equation	Original Price
a	B	-0.54974	2.09938	1.54964	4.710	4
a	D	-0.18326	2.09938	1.91612	6.794	8
b	A	0.00000	1.70167	1.70167	5.483	5
b	D	-0.18326	1.70167	1.51841	4.565	5
d	A	0	1.77275	1.77275	5.887	5
d	B	-0.54974	1.77275	1.22301	3.397	4
e	A	0	0.43820	0.43820	1.550	2
e	D	-0.18328	0.43820	0.25492	1.290	1

The PPP for the dairy produce category for countries B and D relative to country A can then be estimated:

$$\begin{aligned} \frac{A^{PP}_B(M)}{A^{PP}_D} &= \frac{e^{\hat{\beta}_B}}{e^{\hat{\beta}_D}} &= e^{-0.54974} &= 0.5771 \\ & &= e^{-0.1326} &= 0.8326 \end{aligned}$$

### 3. The weighted country-dummy--product method

Let us assume that the complex item (or category) includes 1000 items and that there are three countries, A, B and D. Let us further assume that for both country A and country B 990 prices are available and that only 20 prices are available for country D. In applying the CDP method, we would expect the 980 missing prices for country D to be strongly influenced by the prices for countries A and B and the impact of the prices for country D to be almost nil. To equalize the influence of the different countries, each price must therefore be repeated a number of times in order to weight the regression equation. The prices available for country D can be repeated 99 times and those for countries B and D twice. The number of available prices is thus:

$$\begin{aligned} \text{Country A} & 990 \times 2 = 1980; \\ \text{Country B} & 990 \times 2 = 1980; \\ \text{Country D} & 20 \times 99 = 1980. \end{aligned}$$

The equalization process is thus completed. Generally speaking, if the number of prices available for items in a given category in country J is  $M_J$  and the total number of prices for items in the category is M, then equalization is achieved by assigning to each of the prices for country J a weight of the magnitude  $M/M_J$  in calculating the regression relation.

In the example given (p. 41 above), three prices are available for country A and for country D while two are available for country B. It is therefore possible to achieve equalization by weighting the figures for countries A and D by 4/3 and those for country B by 4/2, or by repeating the figures for countries A and D four times and repeating those for country B six times and then calculating the regression equation. The relevant variables for the latter case appear in the accompanying table.

Item	Country	$Z_{iJ}$	$X_{iJ}$		$Y_{iJ}$			
			$X_{iB}$	$X_{iD}$	$Y_{aJ}$	$Y_{bJ}$	$Y_{dJ}$	$Y_{eJ}$
a	B	$\log 4 = 1.38631$	1	0	1	0	0	0
a	B	$\log 4 = 1.38631$	1	0	1	0	0	0
a	B	$\log 4 = 1.38631$	1	0	1	0	0	0
a	B	$\log 4 = 1.38631$	1	0	1	0	0	0
a	B	$\log 4 = 1.38631$	1	0	1	0	0	0
a	B	$\log 4 = 1.38631$	1	0	1	0	0	0
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a	D	$\log 8 = 2.07946$	0	1	1	0	0	0
a	D	$\log 8 = 2.07946$	0	1	1	0	0	0
a	D	$\log 8 = 2.07946$	0	1	1	0	0	0
a	D	$\log 8 = 2.07946$	0	1	1	0	0	0
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b	A	$\log 5 = 1.60945$	0	0	0	1	0	0
b	A	$\log 5 = 1.60945$	0	0	0	1	0	0
b	A	$\log 5 = 1.60945$	0	0	0	1	0	0
b	A	$\log 5 = 1.60945$	0	0	0	1	0	0
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b	D	$\log 5 = 1.60945$	0	1	0	1	0	0
b	D	$\log 5 = 1.60945$	0	1	0	1	0	0
b	D	$\log 5 = 1.60945$	0	1	0	1	0	0
b	D	$\log 5 = 1.60945$	0	1	0	1	0	0
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d	A	$\log 5 = 1.60945$	0	1	0	0	1	0
d	A	$\log 5 = 1.60945$	0	1	0	0	1	0
d	A	$\log 5 = 1.60945$	0	1	0	0	1	0
d	A	$\log 5 = 1.60945$	0	1	0	0	1	0
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d	B	$\log 4 = 1.38631$	1	0	0	0	1	0
d	B	$\log 4 = 1.38631$	1	0	0	0	1	0
d	B	$\log 4 = 1.38631$	1	0	0	0	1	0
d	B	$\log 4 = 1.38631$	1	0	0	0	1	0
d	B	$\log 4 = 1.38631$	1	0	0	0	1	0
d	B	$\log 4 = 1.38631$	1	0	0	0	1	0
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e	A	$\log 2 = 0.69315$	0	0	0	0	0	1
e	A	$\log 2 = 0.69315$	0	0	0	0	0	1
e	A	$\log 2 = 0.69315$	0	0	0	0	0	1
e	A	$\log 2 = 0.69315$	0	0	0	0	0	1
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e	D	$\log 1 = 0.00000$	0	1	0	0	0	1
e	D	$\log 1 = 0.00000$	0	1	0	0	0	1
e	D	$\log 1 = 0.00000$	0	1	0	0	0	1
e	D	$\log 1 = 0.00000$	0	1	0	0	0	1

The regression relation can be calculated on the basis of those figures:

$$Z_{iJ} = \beta_B X_{iB} + \beta_D X_{iD} + \gamma_a Y_{aJ} + \gamma_b Y_{bJ} + \gamma_d Y_{dJ} + \gamma_e Y_{eJ} + u_{ij}$$

where  $\beta_A = 0$ , given that A is numeraire country,  $\beta_B = -0.53721$ ,  $\beta_D = -0.15813$ ,  $\gamma_a = 2.04913$ ,  $\gamma_b = 1.68850$ ,  $\gamma_d = 1.79788$  and  $\gamma_e = 0.42564$ . The PPP for the diary produce category in countries B and D relative to the numeraire country, country A, is therefore:

$$\begin{aligned} \widehat{A PPP_B(M)} &= e^{\beta_B} = e^{-0.53721} = 0.5844 \\ \widehat{A PPP_D(M)} &= e^{\beta_D} = e^{-0.15813} = 0.8537 \end{aligned}$$

The missing prices are estimated as follows:

$$\begin{aligned} \widehat{P_{aA}} &= e^{\beta_A + \gamma_a} = e^{\gamma_a} = e^{2.04913} = 7.7610 \\ \widehat{P_{bB}} &= e^{\beta_B + \gamma_b} = e^{1.15129} = 3.1623 \\ \widehat{P_{dD}} &= e^{\beta_D + \gamma_d} = e^{1.63975} = 5.1538 \\ \widehat{P_{eB}} &= e^{\beta_B + \gamma_e} = e^{-0.11157} = 0.8944 \end{aligned}$$

The regression equation can also yield estimates for the other prices. The following table presents a comparison between the original figures and the figures resulting from the application of the CDP method both with and without weighting.

Category	Item	Country	Original price	Price resulting from application of regression equation	
				Unweighted	Weighted
$P_{aA}$	a	A	missing	8.161	7.761
$P_{aB}$	a	B	4	4.710	4.535
$P_{aD}$	a	D	8	6.794	6.626
$P_{bA}$	b	A	5	5.483	5.411
$P_{bB}$	b	B	missing	3.162	3.162
$P_{bD}$	b	D	5	4.565	4.620
$P_{dA}$	d	A	5	5.887	6.037
$P_{dB}$	d	B	4	3.397	3.528
$P_{dD}$	d	D	missing	4.901	5.154
$P_{eA}$	e	A	2	1.550	1.531
$P_{eB}$	e	B	missing	0.894	0.894
$P_{eD}$	e	D	1	1.29	1.307

The figures resulting from the application of the regression formula, whether weighted or not, approximate more and more closely to the original figures the more items there are in the category.

Part Two

**IMPLEMENTATION OF THE VARIOUS PHASES OF ICP**

In its first publication on the topic, concerning the implementation of ICP Phases I and II, ESCWA provided information on the results obtained. We shall here discuss the implementation of Phases III and IV, preparations for Phase V and the methodologies used in comparisons of real GDP using the so-called shortcut or reduced-information method and in regional comparisons and core-country comparisons.

### III. ICP PHASE III AND STUDIES ON THE EXTRAPOLATION OF COMPARISONS TO ALL YEARS AT CURRENT AND CONSTANT PRICES

#### A. Results for Phase III (benchmark year 1975)

In 1982, a third volume was published, reporting on the preparation, implementation and results of Phase III.<sup>6/</sup> Phase III, organized under the supervision of UNSO and the World Bank, covered 34 countries and adopted 1975 as benchmark year. The accompanying tables give the most important results contained in that volume

It will be noted from table 2 that GDP figures show a wide dispersion. There are five countries for which, at official rates of exchange, per capita GDP is less than 5 per cent of that of the United States. However, in terms of real GDP there is only one such country. While the overall GDP of the United States accounts for more than 37 per cent of the grand total of GDP for the 34 countries at official rates of exchange, in international dollars it is less than 32 per cent. At official exchange rates, Spain's per capita GDP is 15 per cent less than that of Italy; in international dollars, however, it is 4 per cent greater.

Prices in Belgium, Denmark, France, the Federal Republic of Germany and the Netherlands are high in comparison with those in the United States in 1975, making the PPP for those countries higher than the official dollar exchange rate. Prices in the African and Asian countries (with the exception of Japan) and in Latin America are low, being sometimes one half and in the case of three Asian countries less than one third of the United States level. Prices are not, however, always equally low but vary from one country to another within each geographical region. It is this fact that requires independent comparisons to be made among the countries of each region so as to determine the factors responsible for high prices in each particular country. Any agreement reached to carry out international comparisons among the countries of the ESCWA region would have a useful effect by requiring central planning organizations to draw up sound intercountry and interregional programmes.

The third volume divides the Phase III countries into six income groups, as shown in table 3.

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<sup>6/</sup> Irving B. Kravis, Alan Heston and Robert Summers, World Product and Income: International Comparisons of Real Gross Product (Baltimore, The Johns Hopkins University Press, 1982).



Table 2. Per capita GDP in US dollars at official exchange rates and in international dollars for Phase III countries, 1975

Country	In US dollars converted at exchange rate	In international dollars*	Quantity index
<u>Africa</u>			
Kenya	241	470	6.6
Malawi	138	352	4.9
Zambia	495	738	10.3
<u>Asia</u>			
India	146	470	6.6
Iran	1587	2705	37.7
Japan	4474	4907	68.4
Korea	583	1484	20.7
Malaysia	780	1541	21.5
Pakistan	189	590	8.2
Philippines	376	946	13.2
Sri Lanka	183	668	9.3
Syria	718	1794	25.0
Thailand	359	936	13.0
<u>Europe</u>			
Austria	5010	4995	69.6
Belgium	6298	5574	77.7
Denmark	7498	5911	82.4
France	6428	5877	81.9
Germany, F.R.	6797	5953	83.0
Hungary	2125	3559	49.6
Ireland	2673	3049	42.5
Italy	3440	3861	53.8
Luxembourg	6472	5883	82.0
Netherlands	6061	5397	75.2
Poland	2586	3598	50.1
Romania	1742	2387	33.3
Spain	2946	4010	55.9
United Kingdom	4134	4588	76.0
Yugoslavia	1664	2591	36.1
<u>Latin America</u>			
Brazil	1149	1811	25.2
Colombia	568	1609	22.4
Jamaica	1406	1723	24.0
Mexico	1465	2487	34.7
Uruguay	1308	2844	39.6
<u>North America</u>			
U.S.A.	7176	7176	100.0

\* The international dollar has the same purchasing power as the US dollar relative to overall GDP. However, the purchasing power of the international dollar for each individual category of GDP differs from that of the US dollar.

Table 3. ICP Phase III countries grouped by income level

Group No.	Range of real per capita GDP (US = 100)	Number of countries
I	0-14.9	8
II	15-29.9	6
III	30-44.9	6
IV	45-59.9	4
V	60-89.9	9
VI	90-100.0	1
Total		34

Table 4 shows that a country's PPP for the capital formation category is higher than its PPP for GDP, a feature which is characteristic of all groups of countries except group VI. The PPP for the government category is low for groups I, II, III and IV and high for group V.

In order to make a comparison between the actual category prices of each country and those of the United States, the PPP for each category in each country is divided by the official dollar rate of exchange. If A represents the United States, J any comparator country,  $P_J^{(M)}$  the price of one of the components (consumption, capital formation, government, i.e. the complex item) in country J in the units of currency of that country, and  $P_A^{(M)}$  the United States price of the same component in United States dollars, then the following relation obtains:

$$P_J^{(M)} / P_A^{(M)} = A^{PPP_J^{(M)}}$$

The actual price ratio is obtained by dividing the country J price by the official dollar exchange rate (ER):

$$\frac{P_J^{(M)}}{ER} \cdot \frac{1}{P_A^{(M)}} = \frac{A^{PPP_J^{(M)}}}{ER}$$

From table 4 the actual price indices can be calculated as in table 5, where the price indices for capital formation show that capital goods prices in the United States are lower than in the European countries. Internal capital goods prices in the developing countries are low relative to those in the United States and Europe. Relative government expenditure in the developing countries remains very meagre because the inflated number of officials in government service have very low productivity. Price indices increase in a regular manner in step with the increase in a country's GDP, and the same is true of quantity indices. The price indices for the consumption component range from 30 for India and Sri Lanka to 122 for Denmark, a four-fold increase; price indices for the capital formation component range from 23 for Sri Lanka to 138 for Austria and Luxembourg, a six-fold increase; price indices for the government category range from 12 for Sri Lanka to 160 for Denmark, a more than 13-fold increase; and price indices for GDP, the median of such components, range from 27 for Sri Lanka to 127 for Denmark, a

Table 4. PPPs for gross domestic product, consumption, capital formation and government, 1975

Country	Purchasing-power parities (currency unit per US dollar)				Exchange rates
	Consumption	Capital formation	Government	GDP	
<u>Group I</u>					
Malawi	0.335	0.537	0.196	0.341	0.866
Kenya	3.61	6.20	2.77	3.80	7.41
India	2.50	4.13	1.45	2.59	8.38
Pakistan	3.32	4.11	1.67	3.18	9.93
Sri Lanka	3.20	2.41	1.30	2.93	10.6
Zambia	0.441	0.579	0.306	0.431	0.644
Thailand	7.2	11.0	6.0	7.6	20.4
Philippines	2.63	5.85	1.43	2.89	7.27
<u>Group II</u>					
Korea	191.0	215.0	147.0	190.0	484.0
Malaysia	1.22	1.31	1.17	1.22	6.40
Colombia	10.4	13.5	8.5	10.8	30.9
Jamaica	0.688	1.027	0.730	0.7742	0.909
Syria	1.32	1.98	1.71	1.48	3.70
Brazil	5.31	5.98	3.46	5.20	8.20
<u>Group III</u>					
Romania	7.6	12.9	6.7	8.8	12.0
Mexico	7.2	8.5	6.8	7.4	12.5
Yugoslavia	9.8	17.1	10.2	11.2	17.4
<u>Group III</u>					
Iran	34.9	53.3	38.3	39.7	67.6
Uruguay	1.04	3.02	0.63	1.06	2.30
Ireland	0.366	0.487	0.396	0.388	0.450
<u>Group IV</u>					
Hungary	11.1	17.6	10.7	12.3	20.7
Poland	13.2	19.6	11.3	14.3	19.9
Italy	567.0	639.0	595.0	582.0	652.8
Spain	39.8	52.3	57.1	42.3	57.4
<u>Group V</u>					
United Kingdom	0.386	0.522	0.372	0.406	0.450
Japan	271.0	299.0	323.0	271.0	296.8
Austria	15.6	23.9	20.5	17.5	17.4
Netherlands	2.76	2.92	4.00	2.84	2.53
Belgium	39.5	45.6	55.8	41.6	36.8
France	4.63	5.01	5.17	4.69	4.29
Luxembourg	36.7	50.3	52.9	40.2	36.8
Denmark	6.98	7.40	9.18	7.29	5.75
Germany, F.R.	2.79	2.86	3.55	2.81	2.46
<u>Group VI</u>					
United States	1.00	1.00	1.00	1.00	1.00

Table 5. Price indices for GDP, consumption, capital formation and government, 1975

Country	Price indices (US = 100)			
	Consumption	Capital formation	Government	GDP
<u>Group I</u>	40	60	25	40
Malawi	39	62	23	39
Kenya	49	84	37	51
India	30	49	17	31
Pakistan	33	41	17	32
Sri Lanka	30	23	12	27
Zambia	68	90	48	67
Thailand	35	54	29	37
Philippines	36	80	20	40
<u>Group II</u>	50	64	46	52
Korea	40	45	30	39
Malaysia	51	54	48	51
Colombia	34	44	28	35
Jamaica	76	113	80	82
Syria	36	54	46	40
Brazil	65	73	42	63
<u>Group III</u>	60	92	57	65
Romania	64	107	56	73
Mexico	58	68	54	59
Yugoslavia	56	99	59	64
Iran	52	79	57	59
Uruguay	54	88	28	46
Ireland	83	110	89	88
<u>Group IV</u>	69	93	74	74
Hungary	54	85	52	60
Poland	66	98	56	72
Italy	87	98	91	89
Spain	69	91	99	73
<u>Group V</u>	103	122	133	107
United Kingdom	86	116	83	90
Japan	91	101	109	91
Austria	90	138	118	100
Netherlands	109	116	158	112
Belgium	107	124	152	113
France	108	117	120	109
Luxembourg	100	138	145	110
Denmark	122	129	160	127
Germany	113	116	144	114
<u>Group VI</u>	100	100	100	100
United States	100	100	100	100

four-fold or five-fold increase.

Per capita quantity indices for GDP based on the international dollar, given in table 6, range from 4.9 for Malawi to 83 for the Federal Republic of Germany, approximately a 17-fold increase. For quantity indices, chapter 6 of the volume reporting on Phase III provides full data on 151 categories. We shall here restrict ourselves to a summary table, table 6, distinguishing only two types of expenditure, that on commodities and that on services. These components are made up as follows:

Commodities

All foodstuffs  
Clothing and footwear, excluding repair services  
Gas and fuel  
Cleaning and maintenance materials, and matches, nails and other household non-durables  
Medication  
Automobiles, bicycles and other means of transport, and spare parts  
Books and office equipment  
Cosmetics and personal care

Services

Repair of clothing and footwear  
Rent  
Building maintenance  
Electricity  
Household services  
Travel by road, rail, air and sea  
Post, telephone and telegraph  
Entertainment, cinemas and theatres  
Health services; services of physicians, hospitals and midwives  
Educational services  
Restaurants and hotels  
Hairdressers and public baths  
Expenditures of non-residents

It can be inferred from table 6 that quantity indices for both commodities and services increase relative to those of the United States as GDP rises, those for commodities a little more rapidly than those for services. The average quantity index for commodities for countries within each group ranges from 8.8 for group I to 77.4 for group V, approximately a nine-fold increase, while that for services ranges from 9.4 for group I to 73 for group V, an eight-fold increase.

B. Extrapolation of benchmark estimates of real GDP to other years

Chapter 8 of the volume reporting on Phase III comprises an attempt to estimate real GDP for non-benchmark years on the basis of the results obtained in Phases I, II and III for 1970, 1973 and 1975. It should be noted that, in view of the tentative nature of the methodology used for the estimates, the

Table 6. Per capita quantity indices for commodity and service components of GDP with real indices based on international dollars, 1975

Group and country	Quantity indices based on international dollars (US = 100)		
	Commodities	Services	GDP
<u>Group I*</u>	8.8	9.4	9.0
Malawi	5.1	4.5	4.9
Kenya	5.8	8.1	6.6
India	6.3	7.1	6.6
Pakistan	8.3	8.1	8.2
Sri Lanka	8.7	10.6	9.3
Zambia	9.7	11.4	10.3
Thailand	14.5	10.0	13.0
Philippines	12.3	15.1	13.2
<u>Group II</u>	23.4	22.7	23.1
Korea	22.5	16.8	20.7
Malaysia	21.4	21.6	21.5
Colombia	21.0	25.5	22.4
Jamaica	20.8	30.6	24.0
Syria	28.6	17.3	25.0
Brazil	25.7	24.2	25.2
<u>Group III</u>	37.5	37.0	37.3
Romania	34.4	30.9	33.3
Mexico	36.2	31.4	34.7
Yugoslavia	36.8	34.7	36.1
Iran	43.4	25.7	37.7
Uruguay	34.0	51.4	39.6
Ireland	39.9	47.9	42.5
<u>Group IV</u>	53.8	49.2	52.4
Hungary	51.3	46.0	49.6
Poland	52.8	44.5	50.1
Italy	53.8	53.8	53.8
Spain	57.4	52.6	55.9
<u>Group V</u>	77.4	73.0	76.0
United Kingdom	55.2	82.1	63.9
Japan	71.6	61.5	68.4
Austria	72.1	64.3	69.6
Netherlands	82.0	61.0	75.2
Belgium	82.6	67.3	77.7
France	85.0	75.4	81.9
Luxembourg	85.4	74.8	82.0
Denmark	76.9	93.9	82.4
Germany	85.9	76.7	83.0
<u>Group VI</u>	100.0	100.0	100.0
United States	100.0	100.0	100.00

\* Group entries are averages for the countries within the group.

work is done on the responsibility of the authors and not that of UNSO or the World Bank. Chapter 8 assumes that a country's per capita GDP is made up of domestic absorption (DA) and the net foreign balance (NFB). DA is the aggregate of all categories except NFB. NFB is aggregate exports of goods and services less imports of goods and services.

Country J's DA for year t in international dollars can be estimated by calculating country J's PPP for DA in year t. The formula is as follows:

$$A_{PPPJ,t}^{DA} = A_{PPPJ,o}^{DA} \cdot \frac{P_{J,t}^{DA} / P_{J,o}^{DA}}{P_{A,t}^{DA} / P_{A,o}^{DA}}$$

where  $A_{PPPJ,o}^{DA}$  is country J's PPP for DA in the extrapolation year o;  $P_{J,t}^{DA}$  is an implicit price index for country J in year t, obtained by dividing country J's expenditure on DA in current prices by its expenditure on DA in constant prices for year t;  $P_{J,o}^{DA}$  is an implicit index for country J in year o, obtained by dividing country J's expenditure on DA in current prices by its expenditure on DA at constant prices for benchmark year o;  $P_{A,t}^{DA}$  is an implicit index for country A (the United States) for year t;  $P_{A,o}^{DA}$  is an implicit index for country A (the United States) for the benchmark year o. Country J's DA in international dollars can be obtained by dividing its DA in domestic currency by the PPP for DA in accordance with the following formula:

$$\overline{DA} = DA \div A_{PPPJ,t}^{DA}$$

The NFB of a country is estimated by subtracting imports of goods and services from exports of goods and services and dividing the difference first by population (N) and then by the official exchange rate. The NFB expressed in United States dollars is then multiplied by the international price of the NFB for the extrapolation year ( $\overline{\overline{NFB}}$ ). The following relation is obtained:

$$\overline{\overline{NFB}} = \sum_{J=1}^{J=h} W_J \cdot \frac{\overline{(DA)}_J}{\overline{\overline{(DA)}}_J}$$

where  $\overline{(DA)}_J$  is country J's per capita DA in dollars at the official rate of exchange;  $(DA)_J$  is country J's per capita DA in international dollars; and  $W_J$  is a weight. The NFB is thus established in international dollars. The real per capita GDP of country J in international dollars can, accordingly, be established:

$$(GDP)_J = (DA)_J + (NFB)_J$$

Chapter 8, having introduced the theoretical formula for the estimation of real GDP for various years, goes on to estimate real per capita GDP for 1975 on the basis of the figures established in Phase I for 1970 and to compare the estimates with the figures actually obtained in Phase III, as in table 7.

It can be seen from table 7 that, in the case of most European countries and some Asian countries, the approximation of the estimates obtained in accordance with the above formula to the actual figures is close, while it is almost non-existent for Kenya and Korea. This is perhaps due to the fact that uniform methods were not used in Phase I and Phase III and to a deficiency in the data.

Table 7. Indices of real GDP per capita for 15 countries, 1970, 1973 and 1975

(U.S. = 100 in each year)

Country	Benchmark indices			1975 extrapolated from 1970	1975 extrapolated estimate + benchmark estimate
	1970	1973	1975		
	(1)	(2)	(3)	(4)	(5) = (4) / (3)
Kenya	5.88	5.94	6.56	5.2	0.79
India	6.45	6.05	6.56	6.3	0.96
Philippines	11.7	12.0	13.2	12.9	0.98
Korea	11.8	14.6	20.7	15.1	0.73
Malaysia	15.6	19.7	21.5	17.6	0.82
Colombia	17.2	17.8	22.4	19.2	0.86
Iran	19.4	28.1	37.7	42.8	1.14
Italy	48.0	47.4	53.8	46.7	0.87
United Kingdom	62.7	60.7	63.9	61.7	0.97
Japan	58.5	63.7	68.4	63.7	0.93
Netherlands	68.3	69.3	75.2	72.0	0.96
Belgium	72.3	76.5	77.7	79.4	1.02
Germany	76.5	76.0	83.0	79.5	0.96
France	71.9	75.4	81.9	78.8	0.96
United States	100.0	100.0	100.0	100.0	1.00

Chapter 8 of the Phase III report then presents a table giving indices of real per capita GDY for 30 Phase III countries for the period 1950 to 1980. Figures for only some of the countries and years are given in table 8, where estimates for all years are made on the basis of the figures for the benchmark years of Phases I, II and III. It can be seen that the per capita domestic income figures for Japan increased more rapidly than the corresponding figures for the United States. Over the 30-year period there was an increase of 433 per cent for Japan and of 215 per cent for the Federal Republic of Germany. Over 25 years, Iran achieved great progress, recording an increase of 340 per cent by 1976, statistical data becoming unavailable after 1978. The Syrian Arab Republic maintained a stable rate relative to growth in the United States until 1970 but, with effect from 1971, the relative magnitude began to increase appreciably, rising from 17.1 to 25.0.



C. Estimation of real per capita GDP at constant 1975 prices

Chapter 8 of the volume reporting on Phase III uses the following simplified formula to estimate real per capita GDP at constant 1975 prices for the period 1950 to 1977:

$$RGDP_{J,t} = RGDP_{J,75} \cdot \frac{GDP_{J,t}}{GDP_{J,75}}$$

where  $RGDP_{J,t}$  is the per capita GDP of country J for year t at constant 1975 prices in international dollars;  $RGDP_{J,75}$  is the per capita GDP of country J for benchmark year 1975 in international dollars;  $GDP_{J,t}$  is the per capita GDP of country J for year t at constant prices; and  $GDP_{J,75}$  is the per capita GDP of country J for benchmark year 1975 at constant prices. Table 9 covers only some of the phase III countries for some years.

Table 8. Comparisons of indices of real per capita gross domestic income, 1950-1980

(U.S. 100)

Country	1950	1955	1960	1965	1970	1975	1979	1980
Kenya	7.8	7.4	6.8	5.2	5.9	6.6	6.2	6.3
India	7.1	7.0	7.5	6.4	6.5	6.6	5.7	---
Zambia	11.0	15.0	15.3	15.0	15.5	10.3	7.6	---
Colombia	18.5	18.7	17.5	16.0	17.3	22.4	22.5	23.1
Syria	17.1	---	16.5	17.0	17.1	25.0	23.7	25.4
Iran	11.9	13.5	16.5	14.9	19.4	37.7	---	---
United Kingdom	59.1	59.6	64.2	64.0	62.7	63.7	64.0	65.7
Japan	17.1	21.2	29.8	38.8	58.5	68.4	70.0	74.1
Germany, F.R.	40.8	53.5	68.0	69.4	76.5	83.0	85.9	87.7
France	48.2	50.1	59.2	62.6	71.9	81.9	85.9	87.7
United States	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 9. Comparisons of real per capita GDP at constant 1975 prices in international dollars, 1950-1977

Country	1950	1955	1960	1965	1970	1975	1977
Kenya	385	395	396	362	445	471	516
India	345	384	416	413	463	471	505
Zambia	415	514	670	794	738	738	711
Colombia	931	1058	1084	1151	1330	1609	1727
Syria	735	967	942	1218	1312	1744	1830
Iran	659	730	1062	1259	1898	2705	2854
United Kingdom	2739	3143	3406	3841	4243	4588	4907
Japan	828	1163	1649	2493	4120	4907	5317
Germany, F.R.	1989	2943	3809	4541	5461	5952	6511
France	2263	2646	3209	3967	5040	5877	6308
United States	4472	5114	5210	6067	6646	7167	7802

For the countries in this small sample, annual growth rates in real per capita GDP at constant 1975 prices over the period 1950 to 1977 were therefore as follows:

Country	Growth rate (percentage)
Japan	11.6
Iran	9.0
Germany, F.R.	7.2
France	6.2
Syria	5.5
Colombia	3.7
United Kingdom	3.5
United States	3.3
Zambia	3.2
India	2.3
Kenya	1.7

Iran is ranked in second place in this sample, following Japan. However, given the fall in oil prices it is by no means certain that it will maintain its high ranking. The statistics indicate that the Syrian Arab Republic maintains an annual growth rate in real per capita GDP at constant prices in the order of 5.5 per cent. The United States retains first place inasmuch it has the highest figure for real per capita GDP, at 11,448 for 1980, while its annual growth rate is only in the order of 3.3 per cent. The European countries and Japan are still far from surpassing the United States figure. The 1980 figures for per capita GDP in United States dollars at official rates of exchange for a number of Arab countries are as follows:<sup>7/</sup>

Kuwait	20,143
Qatar	31,610
Saudi Arabia	16,953
United Arab Emirates	30,233

These countries must participate in Phase V or Phase VI in order to ascertain whether their real per capita GDP is higher or lower than the corresponding figure for the United States.

#### D. Shortcut methods and reduced-information methods

One of the goals of ICP is to conduct international comparison studies on a large number of countries once every five years, to devise shortcut methods of obtaining results on an annual basis and to extrapolate those results to non-ICP countries in order to obtain figures for the world as a whole. Two methods can be distinguished; shortcut methods and reduced-information methods. Shortcut methods endeavour to identify structural relationships between real GDP and certain monetary or physical indicators for

<sup>7/</sup> United Nations, Yearbook of National Accounts Statistics 19---, table 1.

those ICP countries for which all such indicators are available. On the basis of these indicators, the relationships established can yield estimates of real GDP. Reduced-information methods have the goal of expanding the coverage of international comparisons to include those countries unable to participate in ICP, on the basis of limited data on prices and major expenditure items.

In presenting the two methods, the sources used are two World Bank studies by Sultan Ahmad; Approaches to Purchasing-power Parity and Real Product Comparisons Using Shortcuts and Reduced Information (World Bank Staff Working Paper No.418, Washington D.C., September 1980) and "International real income comparisons with reduced information" (Paper No. 16, United Nations Interorganizational Meeting on Integration of Country Groups into World Comparisons of Purchasing Power of Currencies, Bellagio, Italy, September 1984).

1. The shortcut method with monetary indicators

Let us assume that the per capita gross domestic product of country J in its own currency is  $GDP_J$ , that its nominal per capita GDP in dollars is  $Z_J$  (GDP in the national currency divided by the exchange rate:  $Z_J = GDP_J/ER_J$ ), and that its real per capita GDP in international dollars is  $Y_J$  (GDP in the national currency divided by the purchasing-power parity relative to country A, the United States:  $Y_J = GDP_J/A_{PPP_J}$ ). Now, when  $Z_J$  and  $Y_J$  are divided by the per capita GDP of the United States:

$$\frac{Z_J}{GDP_A} = z_J ; \frac{Y_J}{GDP_A} = y_J$$

we note that, for the developing countries,  $z$ , the index of nominal GDP, is lower than  $y$ , the index of real GDP. In the case of India, for example,  $y/z = 3.05$  for 1970, and in that of the Syrian Arab Republic  $y/z = 2.50$  for 1975.

In order to explain this phenomenon, a number of research workers have put forward shortcut formulae for the estimation of real per capita GDP. In the light of studies conducted in 1954, 1958 and 1967, the following shortcut formula was proposed:<sup>8/</sup>

$$\left(\frac{1}{y} - 1\right) = B\left(\frac{1}{z} - 1\right) + u$$

This formula was called "the rule of four-ninths". However, after the ICP results were published, the relative magnitude of the real GDP came to be assessed in accordance with another formula:

$$y_J = 1 + 1.409(z_J - 1) - 0.450 (z_J - 1)^2$$

<sup>8/</sup> Paul A. David, "Just How Misleading are Official Exchange Rate Conversions?", The Economic Journal, vol.82, September 1972, pp.979-990.

The coefficient of correlation,  $R^2$ , is 0.98 and there are 32 degrees of freedom (df). There is, however, doubt as to the validity of the formula in a regime of managed floating currencies. The formula uses a single unrealistic independent variable and two countries with the same nominal income index would appear to have the same real income index, while the latter depends on a variety of factors, such as the ratio of imports plus exports to GDP, the extent of deficits in the balance of trade, current receipts from tourism, etc. In chapter 8 of the report on Phase III, Kravis, Heston and Summers endeavour to introduce new formulae but, as noted by the authors themselves in evaluating those formulae, they are still far from definitive.

## 2. The shortcut method with non-monetary or physical indicators

This method seeks to establish real GDP on the basis of non-monetary indicators, such as consumption of electricity, number of motor vehicles, stocks of telephones, etc. To be successful the method must satisfy certain conditions, among them that the non-monetary indicators used must be easily available in all countries, that the relationship with real income must be amenable to economic interpretation and that the algebraic function relating such indicators to real income must be stable over time and space.

In his 1980 study, Ahmad proposed eight indicators which were available for a large number of countries; consumption of cement, steel, energy and newsprint; stocks of road vehicles, telephones, and radio receivers; and circulation of letters. All such indicators are assigned per capita indices, the United States being 100. The relation between the logarithm of real per capita GDP ( $y$ ) and that of each of the non-monetary indicators ( $x_1 \dots x_n$ ) is linear:

$$\log y = a + B_1 \log x_1 + B_2 \log x_2 + \dots + B_n \log x_n + u$$

where  $u$  is a random variable subject to the natural law, and:

$$\sigma = \sigma_0 \quad ; \quad E(u) = 0$$

Three variables, letters (L), steel (S) and energy (E), were found to perform consistently well and the correlation coefficient,  $R^2$ , was close to 1.0. The equation estimated from the 1970-1973 sample was as follows:

$$\log y = 1.6253 + 0.2850 \log L + 0.2340 \log S + 0.1383 \log E$$
$$R^2 = 0.9657$$

Monetary and non-monetary indicators can be combined, and the following non-linear equation obtained:

$$\log y = 1.0073 + 0.8808 \log z - 0.0755(\log z)^2 + 0.2368 \log L$$
$$R^2 = 0.9909$$

## 3. Reduced-information methods

This category of methods involves defining a basket of items which is smaller than the total ICP sample. Three such methods can be distinguished: a method using published data; a method using ad hoc approaches; and a method employing regression approaches.

(a) The reduced-information method based on published data

The United Nations keeps detailed data on prices for the purpose of computing post-adjustment allowances at its various duty stations. The 1973 data include prices for nine of the ICP Phase II countries,<sup>9/</sup> as well as data for non-participating countries, referring to the capitals of the countries concerned. The procedure begins with a reclassification of the list of items pertaining to the United Nations in accordance with the ICP categories. The prices for each country are then divided by the corresponding United States prices. The geometric mean of the price relatives included in each category (of which there are 66) are calculated and the latter figure compared with the corresponding ICP figure. This is done by calculating, for each category and each country, the geometric mean of the United Nations prices and that of the ICP prices, that is to say the PPP according to the United Nations data and that according to the ICP data. The arithmetic mean of these ratios is then calculated for the ICP group of countries. Table 10 presents a summary of the most important categories.

It can be seen from the figures for total consumption that the values obtained for PPPs when computed from United Nations data were, on average, 20 per cent higher than those obtained using ICP data, suggesting that an estimate of the ICP - type PPP can be obtained by computing it from United Nations data and reducing it by 20 per cent. However, the results obtained for the non-food categories were vitiated by considerable random errors that might prove misleading, thereby detracting from the use of United Nations data gathered for purposes of post-adjustment computations for different duty stations.

(b) The reduced-information method using ad hoc approaches

This method investigates whether the ICP Phase I results can be replicated using data on fewer prices than those actually obtained for Phase I. In the design of Phase I, price data were to have been gathered on a large number of items, the number of price specifications being 1,300. However, the average number of items on which data were gathered by the Phase I countries was about 400, covering most of the 153 expenditure categories. Experiments were conducted in order to determine how much information could be dispensed with without unduly affecting the final results. The reduction was made, first, by limiting the number of categories and then by limiting the number of items. The PPPs obtained on the basis of the reduced data were compared with those obtained with the full set of Phase I data.<sup>10/</sup> The experiments were restricted to consumption component categories and items.

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<sup>9/</sup> Colombia, India, Iran, Japan, Korea, Kenya, Malaysia, the Philippines and the United States.

<sup>10/</sup> The ten ICP Phase I countries were Colombia, France, the Federal Republic of Germany, Hungary, India, Italy, Japan, Kenya, the United Kingdom and the United States of America.

(i) Deletion of categories

Three aggregates were chosen: food, beverages and tobacco; non-food consumption; and total consumption. The categories in each aggregate were ranked in order of importance, as measured by their average expenditure weights in the three less developed countries among those participating in Phase I, Colombia, India and Kenya. This selection was made on the grounds that reduced-information methods would be most needed for the developing countries. First, one quarter of the least important categories were eliminated from each list; then, successively, the least important half and two-thirds were eliminated. Thus, from the food, beverages and tobacco aggregate, originally made up of 39 categories, three reduced samples of 30, 20 and 13 categories were retained. The items in the deleted categories were disregarded, and the PPP of each country for each of the samples selected was estimated by the binary comparison method. The PPP for each sample was then divided by the PPP obtained on the basis of the full data on the 39 categories. Table 11 contains the results of these computations. The figures show that a relative reduction in the size of the sample by deleting categories introduces a bias into comparisons that ought to be avoided.

(ii) Deletion of items

In this case, all categories were retained. Binary comparisons were calculated with the number of items in each category limited, successively, to no more than five, four, three, two and finally one item. The PPPs for each sample were calculated and expressed as a ratio of the PPP calculated on the basis of the full data. Table 12 shows the results obtained. Clearly, when it is necessary to operate on a reduced-information basis, deletion of items and retention of categories reduces errors of bias, and the results obtained from samples having few items per category are more reliable than those obtained from samples having fewer categories.

(iii) The reduced-information method based on the regression approach

This method was explained by Ahmad in his studies of 1980 and 1984 (see p. 57 above). As he has stated, the method is not intended to replace implementation of ICP but to make it possible to carry out comparisons similar to those of ICP before the results of the various Phases become available. In his 1980 study, prepared before the results of Phase III were ready, Ahmad used the method to forecast the results for 15 countries that had not participated in Phases I and II (excluding the Syrian Arab Republic, Mexico and Romania). Likewise, in his 1984 study he used the regression equation method to forecast the results of Phase IV, which were not yet ready when the study was carried out.

a. The 1980 study

In the 1980 study the Phase II results were used. They covered some 1,300 item specifications distributed over the 153 categories which together comprise GDP. The categories fall into six aggregates or sectors, the first three being sub-aggregates of consumption: (1) food, beverages and tobacco; (2) clothing and furnishings; (3) rent, medical care, transportation, and

Table 10. Comparison between PPPs computed from United Nations data and ICP data, 1973

Major aggregates	Ratio of United Nations to ICP PPP		
	Mean	Standard deviation	Coefficient of variation (percentage)
Bread and cereals	1.085	0.253	23
Meat	1.106	0.488	44
Fish	0.795	0.191	17
Milk, cheese and eggs	1.402	1.325	94
Oils and fats	1.283	0.515	40
Fruit and vegetables	1.354	0.351	26
Coffee, tea and cocoa	1.222	0.386	32
Spices, sweets and sugar	1.157	0.282	24
Beverages	1.001	0.369	37
Tobacco	1.228	0.652	53
Average for food, beverages and tobacco	1.095	0.140	13
Clothing	0.914	0.236	26
Footwear	1.829	1.059	58
Clothing and footwear	1.074	0.335	31
Household furnishings and operations	1.445	0.198	14
Medical care	1.733	0.410	24
Transport operating costs	0.787	0.237	30
Purchased transport	1.728	1.444	84
Communications	3.635	3.227	90
Transport and communications	1.203	0.564	47
Recreation and education	1.656	0.638	39
Other expenditure	1.724	0.946	55
Total consumption	10202	0.152	13

Table 11. Mean absolute deviation in PPPs computed from samples reduced by deleting categories

Percentage of sample	Mean absolute deviation		
	Food, beverages and tobacco (percentage)	Non-food consumption (percentage)	Total consumption
75	4	8	16
50	6	28	17
33	10	28	25

recreation and education; (4) producer durables; (5) construction; and (6) government. The PPP of each of the 15 countries<sup>11/</sup> for each sector (S) was determined relative to that of the numeraire country, the United States, in accordance with the following regression equation:

$$\log \frac{A^{PPP}_{J,S}}{ER_J} = a + \sum_{i=1}^{k_S} B_i \log \frac{P_{iJ}/P_{i,us}}{ER_J} + u$$

where country J = 1,2,...,15; item i = 1,2,...,k<sub>S</sub>; A<sup>PPP</sup><sub>J,S</sub> is the purchasing-power parity of country J for sector S, ER<sub>J</sub> is the exchange rate for country J; P<sub>iJ</sub> is the price of item i in country J in the domestic currency of country J; and P<sub>i,us</sub> is the price of item i in dollars in the United States. The initial step was that of selecting a set of prices such that R<sup>2</sup>, the coefficient of correlation, was close to 1.0. Ahmad managed to select 46 prices for the six sectors where all values for R<sup>2</sup> were greater than 0.99.

By way of example, the regression equation for the food, beverages and tobacco (FBT) sector is as follows: log FBT = 0.11237 + 0.084365 log X1 + 0.227148 log X2 + 0.099550 log X3 - 0.181635 log X4 - 0.042595 log X5 - 0.183228 log X6 + 0.445992 log X7 - 0.154656 log X8 + 0.239275 log X9 + 0.433586 log X10; R<sup>2</sup> = 0.9988. The price relatives, X1 ... X10 are as follows:

Chicken:

$$X1 = \frac{P_{1,J}/P_{1,us}}{ER_J}$$

Mackerel:

$$X2 = \frac{P_{2,J}/P_{2,us}}{ER_J}$$

Sardines:

$$X3 = \frac{P_{3,J}/P_{3,us}}{ER_J}$$

Milk:

$$X4 = \frac{P_{4,J}/P_{4,us}}{ER_J}$$

<sup>11/</sup> Austria, Brazil, Denmark, Ireland, Jamaica, Luxembourg, Malawi, Pakistan, Poland, Spain, Sri Lanka, Thailand, Uruguay, Yugoslavia and Zambia.



Table 12. Mean absolute deviation in PPPs computed from samples reduced by deleting items

Category	Number of items per category				
	5	4	3	2	1
<u>Food, beverages and tobacco</u>					
Percentage of sample	94	90	82	68	43
Mean absolute deviation (percentage)	0.7	1.3	2.4	4.9	4.8
<u>Consumption excluding food, beverages and tobacco</u>					
Percentage of sample	81	74	65	52	30
Mean absolute deviation (percentage)	0.6	1.7	3.2	4.7	5.0
<u>Total consumption</u>					
Percentage of sample	85	79	70	57	30
Mean absolute deviation (percentage)	0.7	1.6	3.2	3.4	3.4

Apples:

$$X5 = \frac{P_{5,J}/P_{5,us}}{ER_J}$$

Onions:

$$X6 = \frac{P_{6,J}/P_{6,us}}{ER_J}$$

Lettuce:

$$X7 = \frac{P_{7,J}/P_{7,us}}{ER_J}$$

Beans:

$$X8 = \frac{P_{8,J}/P_{8,us}}{ER_J}$$

Potatoes:

$$X9 = \frac{P_{9,J}/P_{9,us}}{ER_J}$$

Beer:

$$X10 = \frac{P_{10,J}/P_{10,us}}{ER_J}$$

The PPP of each sector having been estimated by means of the regression equation, an estimate of PPP at the GDP level can be obtained by applying the G-K method of multilateral comparisons and solving a set of simultaneous and homogeneous equations. Finally, Ahmad predicted the Phase III results for real per capita GDP for 1975, as in table 13. The actual Phase III figures, as published, have been entered alongside his estimates. The reduced-information method based on the regression equation thus yielded good estimates for Ireland, Malawi, Pakistan, Sri Lanka, Thailand and Zambia, while there were notably strong deviations for Spain, an overestimate by 48 per cent, and Austria, an overestimate by 31 per cent.

Table 13. Comparison of nominal per capita GDP, real per capita GDP as predicted by the regression equation method, and actual real per capita GDP as established in Phase III, 1975

Country	Per capita GDP		
	Nominal	Real	As published for Phase III
		Predicted by reduced information (regression equation) method	
Austria	70.6	91.1	69.6
Brazil	16.0	28.5	25.2
Denmark	99.2	71.9	82.41
Ireland	36.6	43.7	42.5
Jamaica	20.2	38.2	24.0
Luxembourg	86.5	89.9	82.0
Malawi	1.95	5.84	4.90
Pakistan	2.10	9.92	8.23
Poland	36.5	-	50.1
Spain	40.8	82.6	55.96
Sri Lanka	3.52	9.36	9.30
Thailand	4.85	13.4	13.0
Uruguay	17.9	41.5	39.6
Yugoslavia	23.1	-	36.1
Zambia	7.02	9.00	10.3
United States	100.0	100.0	100.0

b. The 1984 study

For the 1984 study, Ahmad used the Phase III results covering 1,600 item specifications distributed over 150 categories. In applying his shortcut method based on the regression approach, he managed to select items so that the sample, called the "regression sample", was increased to 126 items distributed over 31 categories. The regression equation was the same as that used in the 1980 study, namely:

$$\log \frac{PPP_J}{ER_J} = a + \sum_{i=1}^k B_i \log \frac{P_{iJ}/P_{i,us}}{ER_J} + U$$

where country  $J = 1, 2, \dots$  and item  $i = 1, \dots, k$ . After establishing the principal prices and obtaining the expenditure weights for the various categories, he set about solving the G-K set of simultaneous and homogeneous equations in order to obtain PPPs for consumption, capital formation, government and per capita GDP.

In addition to the regression sample, Ahmad refers to a "judgement sample", made up of 129 items distributed over 31 categories, selected by a

number of experts as being more suitable than others for inclusion in a reduced information sample. The idea was to estimate PPPs for each category not by using regression equations, but by adopting the same procedures as used in the various Phases, namely deriving the simple geometric mean of the various price ratios of the items included in the abbreviated list. The PPPs for the various categories thus obtained represent the raw material for the G-K set of equations for obtaining estimated PPPs for nominal per capita GDP and then estimating real per capita GDP. Ahmad's 1984 study took account of the results of both the regression sample and the judgement sample in forecasting the Phase IV figures, which were not, of course, available at the time the study was carried out. The figures, for 1980, are for the following countries; Costa Rica, Dominican Republic, Guatemala, India, Indonesia, Kenya, Morocco, Nigeria, Panama, Senegal, Tanzania, Tunisia, the United States of America and Zimbabwe. The actual Phase IV results have also been entered in table 14. The results show that the regression sample figures come closer than those of the judgement sample but are still far from accurate in the case of Costa Rica, the Dominican Republic, Guatemala, Panama and Tunisia, where the disparity is greater than 16 per cent.

Table 14. Comparison between nominal and real per capita GDP predicted on the basis of the regression sample, real GDP predicted on the basis of the judgement sample, and real GDP according to the Phase IV figures, 1980

(US = 100)

Country	Per capita GDP				(3)-(4) (4) (percentage)
	Nominal	Real			
		Judgement sample	Regression sample	Phase IV results	
(1)	(2)	(3)	(4)	(5)	
Tanzania	2.29	2.46	3.31	3.44	-3.8
Kenya	3.72	4.47	5.56	6.03	-8.0
India	2.11	2.46	5.49	5.33	3.0
Senegal	4.45	5.02	5.95	5.78	3.0
Nigeria	8.79	9.96	9.12	8.38	8.8
Zimbabwe	6.97	7.73	9.15	8.37	9.3
Indonesia	4.33	5.21	9.01	9.64	6.5
Morocco	7.71	9.32	12.47	11.39	9.5
Guatemala	9.49	10.76	13.55	20.28	-33.2
Dominican Republic	10.71	11.00	14.64	17.53	-16.5
Costa Rica	18.55	16.95	22.40	27.40	-18.2
Tunisia	11.98	13.24	23.22	18.85	23.2
Panama	16.74	19.42	23.98	27.89	-16.7
United States	100.0	100.0	100.0	100.0	100.0

#### IV. ICP PHASE IV, THE NEW OECD INITIATIVE, AND ICP IN AFRICA

##### A. ICP Phase IV

##### 1. Preparation of the volume reporting on Phase IV

Sixty-one countries took part in Phase IV (benchmark year 1980), and the results for 60 countries are ready for publication. The European Economic Community (EEC), the Organization for Economic Co-operation and Development (OECD) and a number of United Nations bodies (including the Economic Commission for Europe (ECE) and the Economic Commission for Latin America and the Caribbean (ECLAC) with regard to matters relating to their respective regions) all had a share in the preparatory work. The Statistical Office of the European Communities (EUROSTAT) co-ordinated comparisons for 15 African countries. Austria co-ordinated comparisons for Finland, Hungary, Poland and Yugoslavia. UNSO was directly responsible for comparisons among the ESCAP countries and was provided with a special budget for allocation to Phase IV. Austria, Belgium, Canada, Denmark, Japan, the Netherlands, Norway, Spain, the United Kingdom and the World Bank also shared in financing the project.

##### 2. Methodology of Phase IV

The methodology adopted was the same as that for Phases I, II and III. In particular, the endeavour was made to obtain prices for items of major importance for expenditure in as many Phase IV countries as possible. The CPD method was applied to the prices available for each category in order to estimate missing prices for certain items in some countries. The category parity (CP) was then estimated and, on the basis of the CP and of expenditure ratios, quantity ratios for each category were obtained indirectly. The method of aggregating the quantities of the detailed categories in the multilateral comparisons led to the use of a set of international prices for each category. These international prices were used, in turn, to evaluate category quantities in international currency units (ICUs). The G-K method was applied in order to obtain international prices, as in previous Phases. In Phase IV, however, a distinction was drawn between the base country for quantity comparisons and the numeraire country for purposes of establishing units of currency and PPPs. The United States had been both base country and numeraire country throughout Phases I to III. In Phase IV, however, while it continued to be numeraire country, the world average (that is to say the average of the 60 countries participating in the project and the other, non-participating, countries) expressed in international dollars provided the basis for per capita quantity comparisons for all countries. Given that the comparisons were made at the regional level, the EEC opted for the arithmetic mean of its member countries while OECD chose the arithmetic mean for the world, that is to say for 60 countries, in making comparisons. ICP applied the rule of "fixity" to the regional results obtained.

##### 3. The Phase IV results

Table 15 presents 1980 data on nominal per capita GDP converted into dollars at official rates of exchange and on real per capita GDP in ICUs, in the present case international dollars, in accordance with the results of ICP Phase IV. It also gives data on a country's real per capita GDP relative to the overall average per capita GDP for the world as a whole. The overall average was calculated on the assumption that the countries participating in

Phase IV were representative of the countries of the same region which did not participate, and they were assigned supercountry weights. Estimates of PPPs are given as are official exchange rates and price levels (United States = 100).

The arithmetic mean of real per capita GDP in the Phase IV group of countries is 3969 international dollars and, in the world as a whole, including non-participating countries, 2933 international dollars. The latter figure was obtained by assigning supercountry weights to each of the participating countries within the regions. The real per capita GDP of each country relative to this world average was then calculated.

Table 16 gives the breakdown in international dollars of the real per capita GDP of each Phase IV country into its major components of private consumption, public consumption and capital formation. The figure for capital formation comprises domestic private and public capital formation but does not include the net trade balance (exports less imports). The countries of each region are grouped separately and the PPPs of the countries of each region are calculated on the basis of their own data alone, in accordance with the rule of fixity. The EEC countries, for example, are presented in table 16 as shown in table 16.1. Figures for countries of the same region are directly comparable while those for the countries of one region are not directly comparable with those for countries of another.

Table 16, in giving a breakdown of GDP in each region into major components, distinguishes between international prices and regional prices as shown in table 16.2.

In the case of capital formation in Africa, it is to be noted that its relative share in real GDP at African prices is 23 per cent while at international prices it is no more than 14.5 per cent. The explanation for this difference is that prices for capital goods are relatively high in Africa and somewhat lower in Europe and the United States. No direct quantitative comparisons can therefore be made between a country belonging to one region and one belonging to another. In order to facilitate comparisons between countries belonging to different regions, international prices for the world as a whole were estimated and then quantity indices for the three components computed for each country participating in Phase IV, as in table 16.

#### B. The new OECD initiative

A new initiative was taken by OECD as a result of a decision in September 1982 to compute real GDP and PPPs after a 25-year interruption. The activity was to extend to all 18 member countries. The EEC, which had begun to compile figures for 12 European countries at the beginning of 1980, provided data for Belgium, Denmark, France, the Federal Republic of Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain and the United Kingdom. OECD collected price data for 1980 from its six remaining members, namely Austria, Canada, Finland, Japan, Norway and the United States. The benchmark year was 1980. At the end of 1984, a "Preliminary report on real gross product in OECD countries and associated purchasing-power parities" was issued. It was prepared by Peter Hill, Chief of the OECD Statistics Section, and summarized the activities of the Section in the international comparisons field. A final report, entitled "Purchasing-power

Table 15. Nominal per capita GDP, real per capita GDP and PPPs for Phase IV countries, 1980

Country	National currency	Exchange rate per \$US	GDP		Real per capita GDP relative to world average	Purchasing-power parity (international dollars)	Price Level (US=100)
			Nominal (dollars)	Real (international dollars)			
<b>A. Africa</b>							
Botswana	Pula	0.7769	1087	1741	59	0.511	66
Cameroon	CFA francs	211.3	830	981	33	178.8	85
Ethiopia	Birr	2.07	141	308	10	0.927	45
Cote d'Ivoire	Francs	211.3	1282	1485	51	182.4	86
Kenya	Shillings	7.4202	423	690	24	4.549	61
Madagascar	Francs	211.3	367	626	21	126.6	60
Malawi	Kwacha	0.8121	209	453	15	0.369	45
Mali	Francs	422.6	204	367	12	232.6	55
Morocco	Dirhams	3.9367	878	1304	44	2.651	67
Nigeria	Naira	0.5465	997	959	33	0.568	104
Senegal	CFA francs	211.3	521	758	26	145.2	69
Tanzania	Shillings	8.195	257	394	13	5.345	65
Tunisia	Dinars	0.405	12356	2156	74	0.257	63
Zambia	Kwacha	0.7885	647	792	27	0.647	82
Zimbabwe	Dollars	0.6425	728	958	33	0.486	76
<b>B. Asia</b>							
India	Rupees	7.863	246	610	21	3.15	40
Indonesia	Rupiahs	626.99	480	1104	38	278	44
Israel	Shekels	5.124	5507	6799	232	4.14	81
Japan	Yen	226.74	8910	8414	287	240	106
Korea	Won	607.43	1528	2407	82	412	63
Pakistan	Rupees	9.9	347	1069	36	3.21	32
Philippines	Pesos	7.5114	737	1741	59	3.18	42
Sri Lanka	Rupees	16.534	280	1180	40	3.92	24
<b>C. Europe</b>							
Austria	Schillings	12.938	10261	8625	294	15.39	119
Belgium	Francs	29.243	11813	9436	322	36.61	125
Denmark	Kroner	5.6359	12964	9831	335	7.43	132
Finland	Markkaa	3.7301	10480	8641	295	4.52	121
France	Francs	4.2260	12137	9780	333	5.24	124
Germany, F.R.	Deutsche mark	1.8177	13260	10200	348	2.37	130
Greece	Drachmas	42.617	4192	5097	174	35.42	83
Hungary	Forint	32.733	1900	4632	157	13.55	41
Ireland	Pounds	0.4859	5244	5480	187	0.461	95
Italy	Lire	856.5	7011	7788	266	759	89
Luxembourg	Francs	29.243	12539	10626	362	34.59	118

Table 15. (continued)

Country	National currency	Exchange rate per \$US	GDP		Real per capita GDP relative to world average	Purchasing-power parity (international dollars)	Price Level (US=100)
			Nominal (dollars)	Real (international dollars)			
<b>C. Europe (continued)</b>							
Netherlands	Guilders	1.9881	11855	9316	318	2.53	127
Norway	Kroner	4.9392	14111	11325	386	6.16	125
Poland	Zlotys	31.051	2247	4322	147	16.14	52
Portugal	Escudos	50.062	2450	3832	131	31.66	63
Spain	Pesetas	71.77	5658	6353	217	63.65	89
United Kingdom	Pounds	0.4303	9345	8253	281	0.487	113
Yugoslavia	Dinars	24.911	3150	4042	138	19.42	78
<b>D. Central and South America</b>							
Argentina	Pesos	1837.2	5430	3830	131	2604	142
Bolivia	Pesos	24.51	937	1591	54	14.51	59
Brazil	Cruzeiros	52.7139	2059	3322	113	32.52	62
Chili	Pesos	39.0	2484	3622	124	26.67	68
Colombia	Pesos	47.28	1301	2784	95	21.99	46
Costa Rica	Colones	8.57	2147	3136	107	5.79	68
Dominican Republic	Pesos	1.00	1192	2007	68	0.594	59
Ecuador	Sucres	25.0	1463	2583	88	14.16	57
El Salvador	Colones	2.5	751	1426	49	1.31	52
Guatemala	Quetzales	1.0	1085	2322	79	0.467	47
Honduras	Lempiras	2.0	674	1208	41	1.12	56
Mexico	Pesos	22.951	2480	4590	156	12.40	54
Panama	Balboas	1	1816	3158	108	0.564	56
Paraguay	Guaranies	126	1403	2108	72	83.87	67
Peru	Soles	288.65	1121	2497	85	1296.6	45
Uruguay	New Pesos	9.16	34596	4178	142	7.58	83
Venezuela	Bolivoares	4.2925	3952	5414	185	3.14	73
<b>E. North America</b>							
Canada	Dollars	1.169	10781	11615	396	1.085	92
United States	Dollars	1.0	11447	11447	390	1.00	1.00

Table 16. Relative magnitude of components of real per capita GDP, 1980

(U.S. = 100.0)

Country	Consumption		Capital formation	
	Private	Public	Domestic	Including net balance of trade
<b>A. <u>Africa</u></b>				
Botswana	11.0	29.6	24.6	16.74
Cameroon	1.7	10.4	4.9	4.90
Ethiopia	3.5	6.1	0.7	0.4
Cote d'Ivoire	9.4	27.0	9.2	6.1
Kenya	6.0	9.8	5.8	3.9
Madagascar	6.6	7.8	2.8	0.1
Malawi	3.9	7.2	2.0	0.96
Mali	3.4	7.7	1.0	-0.1
Morocco	11.4	22.4	5.1	1.8
Nigeria	6.8	10.5	7.3	8.1
Senegal	7.8	19.5	2.4	-1.7
Tanzania	3.3	5.6	2.8	1.3
Tunisia	18.3	20.8	11.9	9.8
Zambia	4.2	22.7	54.6	4.2
Zimbabwe	7.4	14.1	6.4	5.7
<b>B. <u>Asia</u></b>				
India	5.2	8.1	4.2	4.0
Indonesia	9.2	10.2	8.6	10.7
Israel	45.4	148.9	60.5	24.5
Korea	20.3	14.0	29.9	26.5
Pakistan	12.1	4.4	3.6	2.3
Philippines	17.0	9.0	11.1	9.6
Sri Lanka	12.0	3.6	10.1	7.8
<b>C. <u>EEC, OECD and Europe Group 2</u></b>				
Belgium	82.6	71.2	96.1	87.0
Denmark	82.3	112.8	86.4	82.4
France	80.8	80.3	111.2	104.9
Germany, F.R.	84.8	52.9	121.0	131.1
Greece	41.2	41.8	53.8	33.9
Ireland	45.4	53.7	64.3	37.2
Italy	69.6	49.8	80.9	70.3
Luxembourg	84.4	76.1	128.96	117.3
Netherlands	77.6	76.9	88.2	97.1
Portugal	39.6	41.5	28.4	10.2
Spain	55.9	35.96	60.4	56.0
United Kingdom	71.6	101.4	52.4	63.2
Austria	75.4	50.2	96.4	72.8
Canada	102.6	65.6	114.1	29.6
Finland	61.2	90.7	118.8	119.0



Table 16. (continued)

Country	Consumption		Capital formation	
	Private	Public	Domestic	Including net balance of trade
Japan	58.3	21.0	138.1	140.0
Norway	69.8	129.8	133.5	176.9
United States	100.0	100.0	100.0	100.0
Hungary	37.9	27.6	52.0	52.1
Poland	35.1	37.9	45.3	43.3
Yugoslavia	33.3	45.5	57.9	50.1
<b>D. <u>Central and South America</u></b>				
Argentina	36.0	19.1	63.2	60.5
Bolivia	11.7	26.8	7.7	8.2
Brazil	34.1	9.8	32.0	31.3
Chile	32.2	30.3	62.6	60.5
Colombia	25.8	14.9	16.7	17.9
Costa Rica	30.0	28.0	25.8	17.1
Dominican Republic	20.1	3.9	16.7	12.3
Ecuador	20.4	19.5	29.8	30.8
El Salvador	15.6	11.3	4.2	4.7
Guatemala	22.3	8.0	7.4	6.4
Honduras	11.2	7.8	8.0	6.0
Mexico	45.1	14.8	37.0	37.3
Panama	22.4	25.9	29.7	28.3
Paraguay	19.7	10.8	15.4	10.1
Uruguay	41.4	32.1	52.2	44.8
Venezuela	41.0	22.0	35.5	51.2

Table 16.1 Breakdown of real per capita expenditure in the EEC countries by major components, 1980

(In international dollars)

Country	Consumption		Capital formation	Real GDP*/
	Private	Public		
Belgium	6399	1103	2158	9436
Denmark	6240	1803	1909	9831
France	6369	1182	2417	9780
Germany, F.R.	6551	782	2676	10200
Greece	3647	604	1225	5097
Ireland	3820	759	1412	5480
Italy	5723	869	1750	7788
Luxembourg	6721	1267	2934	10626
Netherlands	6000	1285	1937	9316
Portugal	3406	630	647	3832
Spain	4659	448	1420	6353
United Kingdom	5538	1465	1465	8253

\*/ The total of the components does not equal GDP since net balance of trade is not included.

Table 16.2 International prices and regional prices

Price	Type of expenditure	Regions					
		Africa	Asia	Central and South America	EEC	*/ OECD	*/ Europe Group 2**/
Regional	Private consumption	67.7	72.3	70.1	68.3	67.7	66.7
	Public consumption	11.3	7.1	6.8	11.5	10.8	10.4
	Capital formation	23.0	20.6	23.1	20.2	21.5	22.9
	Real GDP	100.0	100.0	100.0	100.0	100.0	100.0
International	Private consumption	67.0	71.6	74.2	67.9	66.8	64.3
	Public consumption	19.5	12.2	5.1	9.6	9.1	11.1
	Capital formation	14.5	16.2	20.7	22.5	24.1	24.6

\*/ OECD also includes Austria, Canada, Finland, Japan, Norway and the United States.

\*\*/ Europe Group 2 includes Hungary, Poland and Yugoslavia.

parities and real expenditures in the OECD" and prepared by Michael Ward, OECD Adviser on ICP, was issued towards the end of 1985.

## 1. The preliminary OECD report

### (a) International price and quantity measurements

The preliminary report (Hill, 1984) presents a new set of measurements of real per capita GDP and its components in the OECD countries for 1980 and estimates for 1981, 1982, and 1983. The procedures followed are set out below.

Real per capita GDP for the OECD countries was obtained by evaluating goods and services in accordance with a single set of prices for all of these countries. These prices were the actual average prices for the OECD countries over the course of the year. This method (that is to say the adoption of a fixed set of prices) was the same as that used in measuring volume change from year to year in a particular country when benchmark prices are applied in order to calculate product or expenditure at constant prices. Thus, the international measurements of real per capita GDP in those countries can be interpreted in the same way as the volume indices used in calculating real growth rates within a single country. In order to make volume comparisons, it is both better and easier first to make price comparisons by calculating the PPP for one of the components of GDP for country J and then to use the PPP as a deflator. This is done by dividing the value of the component expressed in the units of currency of country J by that of the PPP for the component. Finally, volumes are obtained and volume comparisons can then be made.

PPPs are considered to be in the category of price indices since they are calculated on the basis of price comparisons for items having the same specifications in all countries. PPPs also have the same properties as official rates of exchange, since they provide rates at which the currency of one country can be converted into that of another. They have, however, a basic distinction in that they can be used to compare price levels in various countries simultaneously, an advantage not enjoyed by official rates of exchange since they fluctuate, rising and falling as a result of a variety of factors, such as an upsurge in confidence in the future of one particular currency as was the case in the period 1982-1984.

The preliminary report notes that there are considerable differences between nominal per capita GDP valued at official rates of exchange and real per capita GDP calculated in accordance with PPPs, particularly as between countries at disparate levels of economic development. Thus, the nominal per capita GDP of the Federal Republic of Germany is 5.3 times greater than that of Portugal, while the real per capita GDP is only 2.7 times greater. In comparing the United States with the European countries, the report demonstrates this disparity in the results presented in table 17, which are rounded to the nearest ten dollars. The nominal per capita GDP of each of these European countries is greater than that of the United States, while their real per capita GDP is less.

For international measurements of volume, the Hill report points to the same procedure used to obtain measurement of volume for a single country over a number of years, namely the method of evaluating goods and services in various countries by selecting a single common set of international prices. These prices were selected by adopting the averages applicable to all OECD

Table 17. Real and nominal per capita GDP for the United States and some European countries

Country	Per capita GDP (dollars)		Relative GDP (US = 100)	
	Nominal	Real	Nominal	Real
United States	11450	11450	100	100
Belgium	11880	9440	104	82
Denmark	12940	9830	113	86
France	12180	9780	106	85
Germany, F.R.	13240	10200	116	89
Luxembourg	12670	10630	111	93
Netherlands	11970	9320	105	81
Norway	14120	11330	123	99

countries in 1980 and were expressed in dollars. The same G-K method was followed in calculating the international price ( $\pi_i$ ) and the purchasing-power parity ( $PPP_J$ ):

$$\pi_i = \frac{\sum_{J=1}^n \frac{P_{iJ}}{PPP_J}}{\left[ \frac{q_{iJ}}{\sum_{J=1}^n q_{iJ}} \right]}$$

$$PPP_J = \frac{\sum_{i=1}^m P_{iJ} q_{iJ}}{\sum_{i=1}^m \pi_i q_{iJ}}$$

where  $p_{iJ}$  is the price of item  $i$  in country  $J$  in the currency unit of country  $J$ ;  $q_{iJ}$  in the quantity of item  $i$  purchased by country  $J$ ; and  $p_{iJ} q_{iJ}$  is the value of item  $i$  purchased by country  $J$  in the unit of currency of country  $J$ .

Measurements of volume are affected by the set of international prices selected. In selecting averages of the prices for the OECD countries, the report considers that the resulting comparisons are more in keeping with the economic situation of those countries. The report also draws a distinction between nominal value and real value, real value being obtained by evaluating quantities in international dollars ( $\pi_i$ ) and nominal value calculated by merely applying the official rate of exchange to the value in the national currency. When both real and nominal values are available for a particular category (say, for example, GDP) and a particular country, then it is possible to gauge the implicit price for that country. At the inter-country level, the implicit price can be gauged by dividing the ratio of the nominal values for two countries A and B, after conversion into the same currency at the official

rate of exchange, by the volume index for those countries. That is to say that the implicit price index is:

$$\frac{ER_A}{ER_B} \times \frac{\sum P_{iB} Q_{iB}}{\sum P_{iA} Q_{iA}} \quad / \quad \frac{\sum \pi_i Q_{iB}}{\sum \pi_i Q_{iA}}$$

Taking France and the Federal Republic of Germany as an example, the implicit price for France is 12180/9010 or 1.35183 and that for Germany is 13240/9400 or 1.4085. The implicit price index for France in terms of German prices would be 1.35182/1.4085 = 0.9598 # 96%.

Another kind of implicit price index that can be calculated at the inter-country level is indicated in the 1984 report. It can be obtained by dividing the ratio of the nominal GDPs of the two countries, each evaluated separately in the national currency of the country in question, by the quantity index. However, the index thus computed is not a price index in the customary sense but what is called a purchasing-power parity. A PPP does not have the same properties as a price index since it refers to a number of currency units of one of the countries that must be converted into a single currency unit of the other. In other words, a PPP has more properly the properties of a rate of exchange than those of a price index. The formula may be written as follows:

$$\begin{aligned} A^{PPP_B} &= \frac{\sum P_{iB} Q_{iB}}{\sum P_{iA} Q_{iA}} \quad / \quad \frac{\sum \pi_i Q_{iB}}{\sum \pi_i Q_{iA}} \\ &= \frac{\sum P_{iB} Q_{iB}}{\sum \pi_i Q_{iB}} \quad / \quad \frac{\sum P_{iA} Q_{iA}}{\sum \pi_i Q_{iA}} \end{aligned}$$

The PPP ratio is peculiar in that it is a special monetary exchange rate ensuring equivalence of price levels in countries A and B. In other words, if prices in country B are converted into the unit of currency of country A on the basis of the PPP ratio (instead of the rate of exchange), no significant differences will be observed between the price level in country B and that in country A. This explains the use of the term "purchasing-power parity". If, for example, the value of a specific aggregate of items in country B is converted into the units of currency of country A on the basis of the PPP ratio, then the monetary amount after conversion would purchase an equivalent aggregate of items in country A. Since relative prices in the two countries are disparate, the equivalence of the two aggregates in countries A and B will not necessarily be perfect, but the results will be very close.

The preliminary report stresses the need to establish the PPP ratio on the basis of a specific aggregate of goods and services and for each specific aggregate to have its own PPP ratio. It states that the general PPP ratio frequently used in international comparisons is that for all items that go to make up all components of total final expenditure. When the aggregate of items is less inclusive, such as private consumption, its PPP ratio will differ slightly from the overall PPP ratio. The report considers that, from a theoretical point of view, the PPP ratio is established as a result of comparisons of nominal and real values within a group of countries but, in practice, it calculates PPPs ratios directly from prices collected from the various OECD countries. In fact, it is recognized that the price ratios between two countries vary less than the corresponding quantity ratios, so that the direct calculation of prices is feasible, costs are reduced and the

practical difficulties of obtaining quantitative data are avoided, even though the ultimate goal is still to obtain quantity measurements.

(b) The OECD programme to calculate real per capita GDP for 1980

The programme commenced at the beginning of 1983. At that time, EUROSTAT published results for 12 of the OECD countries. OECD therefore decided to supplement such data for the EEC countries by including, at the least, the major non-EEC countries, namely the United States, Canada, Japan and Norway.

The report speaks of the technical difficulties encountered by OECD with regard to the prices of goods and services in the United States. The new methodology for consumer price indices introduced in 1978 created a difficulty in the computation of average prices at the national level. It is these prices that are needed in order to calculate PPPs. OECD was thus prompted to resort to special procedures, comparing prices in three large United States cities (New York, Chicago and Seattle) with those in similar Canadian cities (Montreal, Toronto and Vancouver). It was possible to establish a relationship between the prices of consumer goods and services in the United States and Canada, then a relationship between consumer prices in Canada and in the other OECD countries. The difficulties did not extend to capital goods and government expenditure since, in those areas, the methodology of the United States did not differ from that of the other OECD countries. The report states that, in the light of the above difficulties, the data for the four non-EEC countries are not precise in terms of the results obtained although they are sound at the level of general aggregates.

Finally, OECD added data for Austria and Finland. Austria was a core country for the EEC group and Europe Group 2, the latter largely made up of Eastern European countries and including Finland. Austria and Finland were thus included with the other countries to make up an expanded group of 18 countries for which figures were compiled by OECD.

(c) The results for benchmark year 1980

Table 18, taken from the OECD report, summarizes the results of the study. Column 1 shows the traditional nominal per capita GDP figures after conversion into dollars at the official 1980 rate of exchange. Column 2 shows the per capita GDP figures obtained by evaluating all goods and services in all OECD countries on the basis of a constant set of prices. The prices are, in fact, averages of the prices for the OECD countries. In order to preserve comparability with the nominal figures, the real figures are also expressed in United States dollars by scaling the average prices used in such a way that the value of total United States GDP is the same whether expressed in the actual United States prices of 1980 or in average OECD prices. In principle, of course, any country can be used as benchmark country for purposes of comparing columns 1 and 2. For the sake of convenience, the report chooses the United States as numeraire country without assigning weights to United States prices or quantities. The report calls attention to the considerable differences between columns 1 and 2. The dollar rate had reached an all-time low and the United States was ranked eighth among OECD countries in nominal per capita GDP, a result that surprised data users. However, in real or volume GDP the United States remains, with Canada, in the first rank.

Table 18. Principal results for 1980

Country	(1)		(2)		(3)	(4)	(5)
	Nominal GDP at official exchange rates	Rank	Real or volume GDP at international rates	Rank			
	Per capita, in international dollars	Rank	Per capita, in international dollars	Rank		National currency units per US dollars	
United States	11450	8	11450	2	100	1.00	1.00
Canada	10760	9	11620	1	93	1.17	1.08
Japan	8910	13	8410	12	106	227	240
Austria	10270	11	8630	11	119	12.9	15.4
Belgium	11880	7	9440	8	126	29.2	36.6
Denmark	12940	3	9830	6	132	5.64	7.43
Finland	10480	10	8640	10	121	4032	4.52
France	12180	5	9780	7	125	4.23	5.24
Germany, F.R.	13240	2	10200	5	130	1.82	2.37
Greece	4170	17	5100	17	82	42.6	35.1
Ireland	5250	16	5480	16	96	0.487	0.461
Italy	7000	14	7790	14	90	856	759
Luxembourg	12670	4	10630	4	119	29.2	34.6
Netherlands	11970	6	9320	9	128	1.99	2.53
Norway	14120	1	11330	3	125	4.94	6.16
Portugal	2480	18	3830	18	65	50.1	31.7
Spain	5660	15	6350	15	89	71.1	63.7
United Kingdom	9390	12	8250	13	114	0.430	0.487
Median income	10620		8980				

The column 3 figures show differences in national price levels, previously termed "implicit prices". Internal prices in the Federal Republic of Germany are 30 per cent higher than those in the United States. Internal prices in Japan are slightly higher than those in the United States, but remain low relative to those in Austria, Belgium, Denmark, Finland, Germany, Luxembourg, the Netherlands and the United Kingdom.

Columns 4 and 5 are intended to facilitate comparison between the official exchange rate of each OECD country and its PPP.

(d) The behaviour of purchasing-power parity since 1980

The preliminary report presents the following simplified formula for the calculation of the PPP of GDP for various years before and after 1980:

$$(A^{PPP}B)_t = \frac{P_t(B)}{P_t(A)} \cdot (A^{PPP}B)_0$$

where  $(A^{PPP}B)_0$  is the purchasing-power parity of country B relative to country A for 1980;  $(A^{PPP}B)_t$  is the PPP of country B relative to country A for year t;  $P_t(A)$  is the PPP of country A for year t relative to 1980; and  $P_t(B)$  is the inflation index of country B for year t relative to 1980. For example, the PPP of GDP in the Federal Republic of Germany relative to the United States for 1980 was  $(A^{PPP}B)_0 = 2.37$ . In 1982, the inflation index at 1982 prices relative to 1980 was 1.091. The index for the United States for the same period was 1.164. Thus, the PPP for 1982 is:

$$(A^{PPP}B)_t = 2.37(1.091/1.164) = 2.22$$

In this way, PPPs for the period 1970 to 1984 were estimated for all OECD countries. Table 19 below brings together exchange rates and PPPs. It shows that the official exchange rates (ER) of some European countries, such as Austria, Belgium, France, the Netherlands, and the United Kingdom, reached their lowest in 1980, becoming lower than the corresponding PPPs. Between 1980 and 1984 the dollar rate improved relative to that of the European currencies and the official rates of exchange in all European countries became higher than their PPPs.

## 2. The final OECD report

The final report (Ward, 1985) explains the procedure followed by OECD in estimating PPPs and international prices previously referred to in the preliminary report. It speaks in some detail of the method used to estimate government expenditure and expenditure on building and construction and on the purchase of machinery and equipment. It then goes on to discuss the method used for estimating rents and transportation and to present detailed results for the various categories of private consumption. These particular methods are appropriate for the statistical situation in the European countries in question and in the United States, Canada and Japan. Only the most important results contained in the 1985 report are given here.



Table 19. Estimated PPPs and official exchange rates, 1970-1984  
(Units of national currency per US dollar)

Country	1970		1975		1980		1981		1982		1983		1984	
	PPP	ER	PPP	ER	PPP	ER	PPP	ER	PPP	ER	PPP	ER	PPP	ER
United States	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Canada	0.91	1.05	1.00	1.02	1.08	1.17	1.10	1.20	1.13	1.23	1.14	1.23	1.14	1.30
Japan	237	360	277	297	240	227	226	221	215	249	207	238	202	238
Austria	16.47	26.00	17.18	17.40	15.39	12.90	15.030	15.90	14.99	17.10	14.88	18.00	15.08	20.01
Belgium	36.34	50.00	39.96	36.80	36.31	29.20	35.40	37.10	35.44	45.70	35.94	51.10	36.46	57.78
Denmark	5.81	7.50	6.96	5.75	7.43	5.64	7.51	7.12	7.82	8.33	8.09	9.15	8.31	10.36
Finland	3.03	4.20	4.09	3.86	4.52	4.32	4.62	4.82	4.76	5.57	4.92	5.960	5.19	6.01
France	4.18	5.55	4.62	4.29	5.24	4.23	5.39	5.44	5.67	6.57	5.93	7.62	6.18	8.74
Germany, F.R.	2.81	3.66	2.79	2.46	2.37	1.82	2.27	2.26	2.22	2.43	2.19	2.55	2.17	2.85
Japan	19.4	30.0	24.6	32.3	35.4	42.6	39.0	55.4	45.5	66.8	52.2	88.1	60.8	112.7
Ireland	0.250	0.417	0.340	0.452	0.461	0.487	0.496	0.621	0.534	0.705	0.566	0.805	0.561	0.909
Italy	378	625	485	653	759	856	825	1137	909	1353	1001	1519	1076	1757
Luxembourg	37.0	50.0	35.9	36.8	34.6	29.2	34.3	37.1	34.6	45.7	36.2	51.1	37.3	57.8
Netherlands	2.38	3.62	2.70	2.53	2.53	1.99	2.45	2.50	2.43	2.67	2.37	2.85	2.39	3.21
Norway	5.41	7.14	5.82	5.23	6.16	4.94	6.45	5.74	6.63	6.45	6.79	7.30	7.06	8.16
Portugal	14.4	28.8	17.8	25.6	31.7	50.1	34.4	61.3	39.3	79.5	46.4	110.8	58.4	146.1
Spain	30.7	70.0	39.8	57.4	63.7	71.7	66.4	92.3	70.6	109.9	75.5	143.4	81.7	160.8
United Kingdom	0.260	0.417	0.349	0.452	0.487	0.430	0.500	0.498	0.500	0.572	0.503	0.659	0.511	0.752

(a) Behaviour of per capita GDP over the period 1970-1984, and comparison with the United States

It will be noted from table 20 that, while in 1980 national price levels were sometimes lower and sometimes higher than those of the United States, in 1984 all national price levels were lower, the nominal per capita GDP figures for all countries being lower than those for the corresponding real per capita GDP. Portugal's nominal per capita GDP, for example, was only 41 per cent of its real per capita GDP. Examination of the figures for the five-year period 1980-1984 gives rise to two observations: first, that the difference between nominal and real per capita GDP was over 30 per cent in eight of the countries in 1984 and in only one country in 1980; and secondly, that exchange rates changed rapidly over the five-year period while PPPs changed only slowly, calling attention to the need for caution in calculating volume for the various countries on the basis of official exchange rates.

Table 20. Indices for per capita nominal and real GDP and implicit price indices

Country	Nominal GDP per capita		Real GDP per capita		Ratio of national price level to US price level (1) : (2) = (3)	
	(1)		(2)		(3)	
	1980	1984	1980	1984	1980	1984
Canada	94	85	102	98	92	86
Japan	78	67	74	78	106	85
Austria	90	57	75	74	119	77
Belgium	106	52	85	81	125	64
Denmark	113	71	86	87	132	81
Finland	94	70	78	79	121	88
France	106	59	86	82	124	72
Germany, F.R.	116	67	89	86	130	78
Greece	36	23	44	41	83	55
Ireland	48	32	51	52	95	62
Italy	61	41	69	65	89	63
Luxembourg	111	56	94	84	118	66
Netherlands	105	57	82	75	127	76
Norway	123	88	99	100	125	88
Portugal	22	13	34	32	63	41
Spain	49	28	56	57	89	52
United Kingdom	83	50	73	72	113	69
Median	77	70	84	83		

(b) Real per capita expenditure on particular categories of items

The final report also compares the components of real per capita GDP among the OECD countries. Table 21 presents data on real expenditure on the most important categories of real per capita GDP in international dollars.

Table 21. True values for principal categories of per capita GDP, 1980

(In international dollars)

Principal categories of real GDP	United States	Japan	Canada	Norway	Finland	Austria	United Kingdom	Spain	Portugal
<u>Private consumption</u>									
Food, beverages and tobacco	1331	829	1439	1199	1062	1169	1098	1533	1155
Clothing and footwear	547	318	494	334	298	476	391	417	228
Gross rents, fuel and power	1454	806	1353	872	902	943	1000	515	558
Household equipment and operation	520	295	543	337	294	319	319	359	165
Medical care	662	741	664	966	754	761	539	427	294
Transport and communications	1363	442	1069	500	573	716	499	440	184
Recreation and education	596	622	626	351	270	293	563	344	136
Miscellaneous goods and services	945	738	1069	479	485	938	903	514	201
<u>Collective consumption of government</u>									
	1885	1051	1312	2426	1685	1154	1869	571	830
<u>Fixed capital formation</u>									
Building and construction	1215	1559	1720	1729	1552	1373	520	882	326
Machinery and equipment	1055	1034	1133	867	615	786	582	373	181
<u>Real per capita GDP</u>									
	11447	8414	11615	11325	8641	8625	8253	6353	3832

Table 21. (continued)

Principal categories of real GDP	Netherlands	Luxembourg	Italy	Ireland	Greece	Germany, F.R.	France	Denmark	Belgium
<u>Private consumption</u>									
Food, beverages and tobacco	1468	1333	1545	918	1277	1373	1474	1351	1447
Clothing and footwear	463	326	404	217	296	546	345	272	395
Gross rents, fuel and power	862	1227	869	451	328	997	985	1266	930
Household equipment and operation	513	516	321	218	225	662	500	482	688
Medical care	743	525	405	418	263	687	859	664	652
Transport and communications	562	1121	483	303	442	881	711	695	655
Recreation and education	577	252	343	546	287	568	426	549	366
Miscellaneous goods and services	695	1176	787	680	408	701	856	516	834
<u>Collective consumption of Government</u>	1521	1521	1208	955	740	1007	1515	2432	1609
<u>Fixed capital formation</u>									
Building and construction	1151	1793	1013	846	864	1583	1399	1239	1530
Machinery and equipment	637	823	421	511	233	834	758	590	546
<b>Real per capita GDP</b>	<b>9316</b>	<b>10626</b>	<b>7788</b>	<b>5480</b>	<b>5097</b>	<b>10200</b>	<b>9780</b>	<b>9831</b>	<b>9436</b>

It contains 11 categories, eight for private consumption and government consumption and two for fixed capital formation. A direct estimate of the true value (or volume) of each category was made by expressing items in the category at average international prices. It was thus possible to estimate a special value for the category PPP. The final report notes that total expenditure on health was classified with private consumption even if such expenditure was in fact undertaken by government. Japan had the lowest expenditure on the food category, reflecting the distinctive structure of consumption in a country where meagre quantities of meat and dairy products, which are relatively expensive among other foodstuffs in Europe and North America, are consumed and where large quantities of fish are consumed instead. Italy takes first place in real consumption of food, and the United States in real expenditure on clothing, rents, fuel and transport and communications. France heads the list of OECD countries for health care, and Canada, followed by Japan, for recreation and education. Spain has the lowest figure for government expenditure, less than 25 per cent that of Denmark and Norway. Luxembourg and Canada lead the OECD countries in capital formation and Portugal lags behind with no more than 18 per cent of the expenditure of Canada, the leading country.

The final report goes on to give a breakdown of expenditure on food, beverages and tobacco for all the OECD countries except Finland, as in table 22. The table shows that meat takes first place in real expenditure on food items with an average figure of 281 international dollars. This is followed by fruit and vegetables with an average figure of 170 and a wide dispersion between the lowest (Ireland, 50 per cent of the average) and the highest (Italy, 200 per cent of the average).

Real expenditure on milk and dairy produce comes third with an average figure of 134 international dollars and a wide dispersion between the highest, Norway, and the lowest, Japan. The average figures for 1980 per capita expenditure on non-alcoholic and alcoholic beverages are, respectively, 37 and 115 international dollars. Average per capita expenditure on tobacco in 1980 was 97 international dollars, ranging from 6 for Portugal to 165 for the Netherlands. These figures undoubtedly require clarification since there is an appreciable difference between the lowest and the next highest figure, 61. Can it be that there are few smokers in Portugal, or that smokers in the Netherlands are so numerous that expenditure on tobacco exceeds that on the purchase of bread or cereal products?

(c) Purchasing-power parities for major expenditure categories, 1980

Table 23 gives PPPs for the various categories of GDP, that is to say the average ratios of national prices to the corresponding international prices for each item. The average international prices are themselves expressed in United States dollars by equating the total value of the United States GDP measured at average international prices with its value in United States dollars. This does not, however, mean that the average international price of an item, even though expressed in dollars, is equivalent to the actual price of that item in the United States. Thus we note that, in the United States itself, a particular PPP value differing from 1.000, the PPP for United States GDP, corresponds to each category of goods and services, as can be seen from column 1 of the table. The PPP for GDP, 1.000, accords with the assumption made that the international price level is, on average, equivalent to the actual 1980 United States price level within the country. By examining

Table 22. Real per capita expenditure on principal components of the food, beverages and tobacco category, 1980

(In international dollars)

Principal components of the food, beverages and tobacco category	(In international dollars)									
	United States	Japan	Canada	Norway	Austria	United Kingdom	Spain	Portugal		
Bread and cereals	112	123	109	94	113	127	155	133		
Meat	292	60	408	203	230	250	414	258		
Fish	48	176	27	68	16	27	120	142		
Milk, cheese and eggs	134	51	203	147	117	185	120	168		
Oils and fats	44	7	68	40	58	40	104	133		
Fruit and vegetables	216	89	220	149	190	118	219	149		
Other food	197	171	145	155	139	150	104	40		
Non-alcoholic beverages	52	25	55	42	34	31	25	14		
Alcoholic beverages	129	50	116	159	142	81	89	102		
Tobacco	97	74	69	73	74	121	61	6		
Food, beverages and tobacco	1331	829	1439	1199	1169	1098	1533	1155		

  

Principal components of the food, beverages and tobacco category	(In international dollars)									
	Netherlands	Luxembourg	Italy	Ireland	Greece	Germany, F.R.	France	Denmark	Belgium	
Bread and cereals	143	152	182	104	100	201	152	124	151	
Meat	239	297	391	269	313	301	386	237	415	
Fish	42	24	40	35	37	23	59	36	48	
Milk, cheese and eggs		137	161	91	129	133	164	128	128	
Oils and fats	42	79	67	38	66	55	69	81	66	
Fruit and vegetables	182	153	359	85	338	174	175	94	168	
Other food	205	132	78	94	81	167	147	228	147	
Non-alcoholic beverages	56	43	19	14	35	47	45	39	39	
Alcoholic beverages	198	148	105	32	55	181	181	233	114	
Tobacco	165	135	128	117	102	98	68	136	126	
Food, beverages and tobacco	1468	1333	1545	918	1277	1373	1474	1351	1447	

Table 22. (continued)

Table 23. PPPs for major expenditure categories, 1981

(National currencies per \$US)

Major GDP Categories	United States	Japan	Canada	Norway	Finland	Austria	United Kingdom	Spain	Portugal
Food, beverages and tobacco	0.909	325	0.98	6.95	5.46	15.93	0.501	61.03	37.09
Clothing and footwear	0.882	237	0.94	8.23	4.73	17.80	0.484	70.95	38.17
Gross rents, fuel and power	1.041	243	1.03	5.61	4.22	13.10	0.458	64.00	26.20
Household equipment and operation	0.871	221	1.09	8.07	5.03	17.94	0.574	70.47	42.46
Health care	1.343	155	1.39	4.44	2.96	11.21	0.349	59.06	20.12
Transport and communications	0.891	230	1.01	9.31	6.17	18.93	0.675	74.49	45.07
Recreation and education	1.007	280	1.12	7.65	6.41	16.29	0.401	57.60	29.25
Miscellaneous goods and services	1.054	244	1.06	5.78	4.37	13.72	0.481	40.77	29.88
Private consumption	0.992	246	1.06	6.57	4.77	15.12	0.488	63.62	33.57
Government consumption	1.114	192	1.36	5.39	3.99	15.30	0.383	67.61	18.58
Building and construction	0.956	276	1.01	6.17	3.86	14.41	0.644	58.40	47.23
Machinery and equipment	0.904	208	1.06	7.68	5.96	18.17	0.580	74.10	55.33
Fixed capital formation	0.931	249	0.93	6.67	4.46	15.78	0.621	63.90	50.04
GDP	1.000	240	1.08	6.16	4.52	15.39	0.487	63.65	31.66

Table 23. (continued)

Major GDP categories	Netherlands	Luxembourg	Italy	Ireland	Greece	Germany, F.R.	France	Denmark	Belgium
Food, beverages and tobacco	2.12	33.39	771	0.497	36.42	2.37	4.97	8.13	33.86
Clothing and footwear	2.62	49.51	885	0.547	46.69	2.57	6.54	9.77	44.21
Gross rents, fuel and power	2.46	36.41	549	0.345	44.72	2.57	5.34	7.50	38.98
Household equipment and operation	2.50	39.92	987	0.597	45.25	2.44	6.22	7.24	37.82
Health care	2.26	30.68	645	0.462	25.79	2.35	4.66	7.45	32.34
Transport and communications	3.01	32.73	919	0.719	34.81	2.64	6.13	9.06	41.05
Recreation and education	2.16	29.59	816	0.257	21.66	2.11	5.05	6.84	33.69
Miscellaneous goods and services	2.37	26.41	701	0.498	33.31	2.27	4.90	7.13	33.57
Private consumption	2.39	33.10	753	0.475	35.77	2.40	5.32	7.84	36.19
Government consumption	2.80	40.17	690	0.407	35.31	2.38	5.17	6.30	38.90
Building and construction	2.72	34.11	700	0.445	32.47	2.24	4.58	6.78	34.07
Machinery and equipment	2.83	38.67	1122	0.691	61.36	2.57	6.13	8.36	39.78
Fixed capital formation	2.76	35.86	835	0.534	39.95	2.36	5.12	7.34	36.35
GDP	2.53	34.59	759	0.461	35.42	2.37	5.24	7.43	36.61



Table 24. Relative price indices for major expenditure categories, 1980

(GDP = 100)

Major GDP Categories	United States	Japan	Canada	Norway	Finland	Austria	United Kingdom	Spain	Portugal	Luxembourg	Italy	Ireland	Greece	Germany, F.R.	France	Denmark	Belgium	
Food, beverages and tobacco	91	135	91	113	121	104	103	96	117	97	102	108	103	100	95	109	92	
Clothing and footwear	88	99	87	134	105	116	99	111	121	143	117	119	132	108	125	132	121	
Gross rents, fuel and power	104	101	95	91	93	85	94	101	83	105	72	75	126	108	102	101	106	
Household equipment and operation	87	92	101	131	111	117	118	111	134	115	130	129	128	103	119	97	103	
Health care	134	65	129	72	66	73	72	93	64	89	85	100	73	99	89	100	88	
Transport and communication	89	96	93	151	136	123	139	117	142	95	121	156	98	111	117	122	112	
Recreation and education	101	117	103	124	142	106	82	90	92	86	107	54	61	89	96	92	92	
Miscellaneous goods and services	105	102	98	94	97	89	99	95	94	76	92	108	94	96	93	96	92	
Private consumption	99	102	98	107	105	98	100	100	106	96	99	103	101	101	102	106	99	
Government consumption	111	80	126	88	88	99	79	106	59	116	91	88	100	100	99	85	106	
Building and construction	96	115	98	100	85	94	132	92	149	99	92	96	92	95	87	91	93	
Machinery and equipment	90	87	86	125	132	118	119	116	175112	148	150	173	109	117	113	109	109	
Fixed capital formation	93	104	93	108	99	103	128	100	158	104	110	116	113	100	98	99	99	
GDP	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

the prices in the United States column it is possible to compare United States prices for the various categories of goods and services with the average international prices applied to the OECD group of countries. It can be seen, for example, that prices for transport and communications services in the United States are, relatively speaking, lower than the general average of the average international prices pertaining to the OECD group, that health services are, on the other hand, relatively more costly than the general average and that prices for machinery are lower than those for government services.

In order to complete the analysis of PPPs for the other OECD countries, the PPPs for each category in each country are calculated, in accordance with the data contained in table 23, on the basis of the PPP for each country's GDP, as in table 24. The table shows that there are great differences in price structure as between the United States and Japan in particular in respect of expenditure on health care, food, beverages and tobacco, and government consumption, but that there is no negative correlation between the relative prices of the two countries. There is, on the other hand, a strong negative correlation between the relative prices of the United States and Portugal, except in the case of building and construction. This is not surprising in a comparison between two countries one of which, the United States, has the highest real per capita GDP and the other, Portugal, the lowest. The table also shows significant differences between relative prices across categories within one and the same country. Obviously, the differences would increase if a greater number of sub-categories were to be introduced, that is to say that the PPPs for sub-categories in a particular country would be even farther from the official exchange rate than is the overall PPP for that country's GDP.

Table 25 below contains a breakdown of the food, beverages and tobacco category for selected OECD countries showing a great dispersion of relative prices for sub-categories around GDP. From the practical point of view, the calculation of PPPs and of real expenditure on the various categories is a basic source of useful data for the study of a country's economic structure.

Table 25. Relative price indices for the food, beverages and tobacco sub-categories for selected OECD countries, 1980

(GDP = 100)

Sub-category	Japan	Norway	Portugal	Ireland	Denmark
Bread and cereals	120	95	101	104	109
Meat	191	149	139	109	120
Fish	104	97	134	96	120
Milk, cheese and eggs	128	73	93	94	102
Oils and fats	173	61	103	76	56
Fruit and vegetables	179	134	143	156	140
Other food	138	120	131	107	106
Non-alcoholic beverages	141	119	84	127	94
Alcoholic beverages	189	114	105	166	98
Tobacco	101	142	582	117	150
Food, beverages and tobacco	135	113	117	108	109
GDP	100	100	100	100	100

### C. The International Comparison Project in Africa

ICP was extended to Africa by EUROSTAT. Fifteen African countries participated in ICP Phase IV and their results included. The Phase IV African countries were; Botswana, Cameroon, Cote d'Ivoire, Ethiopia, Kenya, Madagascar, Malawi, Mali, Morocco, Nigeria, Senegal, Tanzania, Tunisia, Zambia and Zimbabwe. A EUROSTAT study was discussed at Addis Ababa in February 1984, and detailed results will be included in the forthcoming report on Phase IV. It is anticipated that the EUROSTAT figures will be adjusted for purposes of comparison at the world level. The overall results for the African countries already published by UNSO have been given above. We shall here give some detailed results, with the caveat that they will differ slightly from those to be disseminated internationally. The figures nevertheless retain their coherence at the regional level. The EUROSTAT study adopts the scheme of the United Nations System of National Accounts (SNA) and international comparisons of purchasing power are based on GDP and its uses as defined by SNA and the European System of Integrated Economic Accounts (ESA).

#### 1. The method of computation of purchasing-power parities and real values

The computation of PPPs and real values requires two kinds of data: average national prices (i.e. prices at the country level) for a selected aggregate of goods and services; and a set of values for GDP and its components and categories expressed in the national currency. The categories must be at a sufficiently detailed level. Estimates of PPPs and real values are obtained in two steps, the first limited to the estimation of PPPs at the sub-category level, and the second endeavouring to estimate PPPs and real values for the categories and components of GDP and for GDP itself.

##### (a) Step one: the estimation of PPP for sub-categories

The method adopted is that of requesting each country, in preparing its list of goods and services, to identify the items most representative of each sub-category and to provide a full and accurate specification of each in such a way that meaningful comparisons can be made between countries. Of course, the full list of items in a sub-category may not be available in a particular country. As a result of the application of this method of selecting items and collecting prices, each sub-category will contain more than one item. However, the price-table for the sub-category, the matrix of items, may not be full or complete since some countries are unable to ascertain prices for certain goods and services. Therefore, as previously stated, ICP and UNSO make use of the country-product--dummy (CPD) method.

The countries of Eastern Europe and the EEC use the Elteto-Koves-Szule (EKS) method to compute the PPP for each sub-category. The EKS PPP formula is based on the notion that the Fisher index is the most appropriate index for inter-country comparisons. The Fisher index is nothing more than the unweighted geometric mean of two other indices, the Laspeyres index and the Paasche index. For a group of countries  $n$ , the Fisher indices are  $n(n-1)/2$ . From the theoretical point of view, such indices lack the property of

transitivity. The EKS formula, which does seek to attain transitivity, is therefore adopted. The formula is set up so that the magnitude is a lower limit:

$$\Delta = \sum_{Jk} [\log(\text{EKS})_{Jk} - \log k^{\text{PPP}_J}]^2$$

Thence the sub-category PPP formula is established:

$$(\text{EKS})_{Jk} = \left[ (k^{\text{PPP}_J})^2 \cdot \prod_{\substack{l=1 \\ l \neq J, k}}^n \frac{l^{\text{PPP}_J}}{l^{\text{PPP}_k}} \right]^{1/n}$$

where  $k^{\text{PPP}_J}$  is the PPP value for country J relative to country k according to the Fisher formula; and  $l^{\text{PPP}_J}$  and  $l^{\text{PPP}_k}$  are PPP values for countries J and k relative to country l, adopted as bridge country between countries J and k.

In applying ICP in the African countries, the EKS formula was used in order to estimate PPPs at the sub-category level, i.e. in step one, by making binary comparisons among those countries. In order to compare country J with country k, we compute the price ratios of those items considered of major importance in the sub-category for country J in accordance with the Laspeyres formula. The geometric mean of the Laspeyres and Paasche subindices will be the index representing one component of the PPP of the country J sub-category relative to country k.

(b) Step two: estimation of PPPs and of real values for GDP and for major components and categories of GDP

For the African countries, the G-K method was used in step two. As previously mentioned, this method is based on a single set of common average prices known as international prices. Each international price is the average of the sum of national prices converted into a single currency by dividing it by the PPP after weighting by quantities, as follows:

$$\bar{P}_i = \frac{1}{\sum_J Q_{iJ}} \sum_{J=1}^n \frac{P_{iJ}}{k^{\text{PPP}_J}} Q_{iJ}$$

The PPP of country J relative to country k is, in turn, established as follows:

$$k^{\text{PPP}_J} = \frac{\sum_{J=1}^n P_{iJ} Q_{iJ}}{\sum_{J=1}^n \bar{P}_i Q_{iJ}}$$

We have also indicated that the two formulae, established for single items, can, after transformation, be generalized and applied to sub-categories for computation of PPPs, real values and real GDP. The formulae can be written as follows:

$$\hat{\sigma}_t = \frac{\sum_{J=1}^n V_{.J}(t)}{.PPP_J}$$

$$= \frac{\sum_{J=1}^n V_{.J}(t)}{A^{PPP_J}(t)}$$

$$\frac{1}{.PPP_J} = \frac{\sum_{t=1}^M \hat{\sigma}_t A^{PPP_J}}{\sum_{t=1}^M V_{.J}(t)}$$

where  $t$  is the sub-category;  $M$  is the number of sub-categories;  $A^{PPP_J}(t)$  is the purchasing-power parity for subcategory  $t$  in country  $J$  relative to country  $A$ ; and  $V_{.J}(t)$  is the total original value of sub-category  $t$  in country  $J$  expressed in the units of currency of country  $J$ . The symbol  $\hat{\sigma}_t$  represents a theoretical price whose value can be derived from the formula and which is used only for the computation operations, that is to say for the computation of  $.PPP_J$ , the purchasing-power parity of country  $J$ 's GDP. It is called the instrumental variable.

The unit of currency chosen to measure real value is the African dollar, and it is termed the standard unit of purchasing power. It is not the unit of currency of any African country but a common unit for the 15 African countries participating in ICP inasmuch as the total GDP of those countries was computed in dollars at official rates of exchange; that total is considered as equivalent to the total real GDP of those countries.

## 2. Results of the comparisons

The study restricts itself to the principal results of the comparisons for 1980. The results cover comparisons of GDP, private consumption, government consumption and fixed capital formation.

### (a) Per capita GDP and PPP for 1980

The price-level index was obtained by dividing PPP by the country's official rate of exchange. It will be seen from table 26 that the African group of countries can be divided into two subgroups. The first is made up of 11 countries whose price levels are lower than the overall level for the two groups as a whole, the overall index varying between 93 and 56. They are Botswana, Ethiopia, Kenya, Madagascar, Malawi, Mali, Morocco, Senegal, Tanzania, Tunisia and Zimbabwe. The second subgroup comprises those whose price levels are higher than the overall level of 100, and it includes Cameroon, Cote d' Ivoire, Nigeria and Zambia. These four countries, because of their extremely high prices and large populations, have had a notable effect on average prices for the group as a whole. Price-level indices for the other countries are correspondingly lower.

Table 26. Per capita GDP and PPP, 1981

Country	Per capita GDP in dollars		Per capita volume index in dollars (Average = 100)		Official exchange rate in units of national currency per US dollar	PPP of African dollar in national currency	Price-level index (Average = 100)
	US	African	US	African			
	Cameroon	910	876	139	134	211.3	219.53
Cote d'Ivoire	1291	1212	198	186	211.3	224.99	106
Madagascar	373	495	57	76	211.3	159.43	75
Mali	212	309	33	47	422.6	290.10	69
Morocco	879	1049	135	161	3.937	3.297	84
Senegal	513	591	79	91	211.3	183.3	87
Tunisia	1386	1761	212	270	0.405	0.319	79
Botswana	1058	1301	166	199	0.776	0.647	83
Ethiopia	1385	246	21	38	2.070	1.158	56
Kenya	441	580	68	89	7.420	5.640	76
Malawi	205	361	31	55	0.812	0.462	57
Nigeria	862	682	132	105	0.547	0.690	126
Tanzania	262	324	40	50	8.195	6.628	81
Zambia	649	637	99	98	0.789	0.804	102
Zimbabwe	755	811	116	124	0.636	0.592	93
Average	653	653	100	100	100	100	100

The Francophone countries, such as Cameroon, Cote d'Ivoire, Madagascar and Senegal, all have the same official exchange rate, but their price indices vary between 75 per cent and 106 per cent. In the study, Tunisia retains the highest per capita GDP whether at the official rate (\$US 1,386) or in terms of real value (1,761 African dollars). Cote d'Ivoire is ranked second at the official rate (\$US 1,291) and third in terms of real value (1,212 African dollars). The study classifies the 15 countries as rich or poor. The rich countries are those for which the per capita GDP figure is greater than that for the group of 15 countries. They are Botswana, Cameroon, Cote d'Ivoire, Morocco, Nigeria, Tunisia and Zimbabwe. The poor countries are Ethiopia, Kenya, Madagascar, Malawi, Mali, Senegal, Tanzania and Zambia. These countries retain that classification whether their GDP is expressed at official exchange rates or in terms of real value.

(b) PPPs for major uses of GDP, 1980

Table 27 shows that the price level for government consumption in Ethiopia, Mali and Tanzania is low relative to the price level for GDP, which, in turn, is also low. The price level for fixed capital formation in such poor countries as Ethiopia, Malawi and Mali, appears to be very high relative to the price level for GDP, and investment costs in those countries are extremely burdensome.

(c) PPPs for the various categories of private consumption

The study classifies private consumption items according to the following major categories: food, beverages and tobacco; clothing and footwear; gross rents, fuel and power; furniture, household equipment and maintenance; medical services and health costs; transport and communications; recreation and education services; and miscellaneous goods and services. Examination of the figures in table 28 shows that prices for Morocco are consistent and clustered together in all categories while those for Malawi show a wide dispersion, the price level for the gross rents, fuel and power category being twice as high as that for the food, beverages and tobacco category. There is also wide dispersion in price levels for Ethiopia, Nigeria, Senegal and Tanzania.

Table 27. PPPs for major uses of GDP, 1980

Country	Official exchange rate	Purchasing-power parities			GDP
		Consumption		Fixed capital formation	
		Private	Government		
Cameroon	211.3	223.06	200.64	217.17	219.53
Cote d'Ivoire	211.3	231.78	224.42	210.81	224.99
Madagascar	211.3	156.62	181.64	188.28	159.43
Mali	422.6	297.29	220.94	500.30	290.10
Morocco	3.937	3.126	3.584	3.945	3.297
Senegal	211.3	187.37	172.77	200.46	183.3
Tunisia	0.405	0.291	0.389	0.370	0.319
Botswana	0.776	0.662	0.757	0.600	0.647
Ethiopia	2.070	1.185	0.950	1.971	1.158
Kenya	7.402	5.416	5.517	7.049	5.640
Malawi	0.812	0.431	0.505	0.735	0.462
Nigeria	0.547	0.740	0.699	0.610	0.609
Tanzania	8.195	7.461	4.778	6.48	6.628
Zambia	0.7896	0.815	0.865	0.715	0.804
Zimbabwe	0.636	0.566	0.715	0.591	0.592

(d) Volume indices for various categories of private consumption, 1980

Per capita volume indices for various categories of private consumption were computed (see table 29, where per capita intermediate consumption in the 15 African countries = 100). Comparison of the volume indices for the food, beverages and tobacco category shows great dissimilarities between Tunisia and Ethiopia, and the question arises as to whether real consumption in the former country is greater than that in the latter. Comparison of the volume indices for the clothing and footwear category yields a very wide dispersion as between Cameroon and Malawi, real expenditure on the category in Cameroon being ten times that in Malawi. Detailed studies will have to be made in

Table 28. PPPs for categories of private consumption, 1980

Country	Official exchange rate	Food, beverages and tobacco	Clothing and footwear	Gross rents and fuel and power	Furniture, household equipment & maintenance	Medical services and health costs	Transport and communications	Recreation and education services	Miscellaneous goods and services	Private consumption
Cameroun	211.3	240.19	192.17	173.15	251.65	249.98	244.68	226.97	220.35	223.06
Cote d'Ivoire	211.3	228.31	249.55	139.8	304.46	315.24	279.32	371.12	226.70	231.78
Madagascar	211.3	155.29	204.68	146.63	164.21	207.14	169.951	145.45	141.22	156.62
Mali	422.6	294.73	305.64	310.63	324.06	341.30	285.58	406.63	419.88	297.29
Morocco	3.937	3.084	3.312	3.147	3.230	3.369	3.232	3.292	2.7741	3.126
Senegal	211.3	170.43	192.0	209.85	236.76	257.02	259.48	290.01	186.92	187.37
Tunisia	0.405	0.278	0.389	0.280	0.314	0.206	0.345	0.334	0.209	0.293
Botswana	0.776	0.589	0.695	0.818	0.776	0.554	0.696	0.849	0.674	0.662
Ethiopia	2.070	1.079	1.343	1.903	0.801	1.033	1.443	0.983	1.227	1.187
Kenya	7.420	5.108	5.486	6.528	5.413	4.032	5.783	6.811	5.502	5.416
Malawi	0.812	0.360	0.532	0.737	0.612	0.511	0.636	0.398	0.648	0.431
Nigeria	0.457	0.765	0.654	0.847	0.705	0.841	0.510	0.645	0.749	0.740
Nigeria	8.195	8.692	7.043	3.770	7.323	3.377	11.249	4.787	10.010	7.461
Zambia	0.789	0.767	0.979	0.880	1.022	0.837	0.996	1.156	1.199	0.815
Zimbabwe	0.636	0.476	0.728	0.528	0.693	0.560	0.558	0.744	0.775	0.566

Table 29. Volume indexes for various categories of private consumption, 1980  
(Arithmetic mean for the 15 countries = 100)

Country	Real GDP	Food, beverages and tobacco	Clothing and footwear	Gross rents and fuel and power	Furniture, household equipment & maintenance	Medical services and health costs	Transport and communications	Recreation and education services	Miscellaneous goods and services	Private consumption
Cameroun	134	81	280	166	184	310	289	184	152	144
Cote d'Ivoire	186	147	216	213	90	48	340	128	176	169
Madagascar	76	107	49	98	57	17	46	83	126	90
Mali	47	69	31	27	33	22	171	12	9	60
Morocco	161	178	194	217	149	151	135	83	242	177
Senegal	91	124	139	113	58	51	66	38	45	107
Tunisia	270	256	221	497	246	443	190	189	270	280
Botswana	199	144	133	154	192	287	163	189	199	156
Ethiopia	38	35	36	40	99	55	63	87	81	46
Kenya	89	87	77	77	37	93	98	77	150	91
Malawi	55	85	29	40	44	44	64	36	45	64
Nigeria	105	102	88	67	79	87	69	127	71	92
Tanzania	50	59	79	72	30	55	11	24	22	54
Zambia	98	108	53	68	42	137	18	15	29	82
Zimbabwe	124	107	92	115	322	143	317	179	104	139



order to provide a plausible interpretation of such differences, since Cameroon is here ranked first over such countries as Tunisia and Morocco which are renowned for their textile, leather and footwear industries. Tunisia's expenditure on gross rents, fuel and power, at 497, is 18 times that of Mali, at 27, and twice that of Morocco, a country ranked second among the 15. Likewise, Tunisia also takes first place in expenditure on health services (443), spending 25 times as much as Malawi (17) in real terms; Cameroon is ranked second (310). It is surprising to find that Cote d'Ivoire and Senegal seem to lag behind in real expenditure on health services, being ranked after Ethiopia, Malawi and Tanzania. In expenditure on transport and communications, Cote d'Ivoire is ranked first (340), its real expenditure on transport services being 31 times that of Tanzania (11). Zimbabwe is ranked second, Cameroon third, Tunisia fourth and Mali fifth. For this type of real expenditure, in fact, Mali is about 71 per cent above the average.

Based on comparisons of real expenditure on recreation and health services, four classes of countries can be distinguished: (a) advanced; Botswana, Cameroon, Tunisia and Zimbabwe: (b) above average; Cote d'Ivoire and Nigeria: (c) below average; Ethiopia, Kenya, Madagascar and Morocco: and (d) less than half the average; Malawi, Mali, Senegal, Tanzania and Zambia.

(e) Volume indices for major subcategories of the food, beverages and tobacco consumption category, 1980

Table 30 covers the following sub-categories: (a) food: bread and cereals; meat; fish; milk, dairy produce and eggs; oils and fats; fruit and vegetables; sugar; coffee, tea and cocoa; (b) beverages: alcoholic beverages; non-alcoholic beverages; (c) tobacco.

Analysis of the table shows that per capita consumption of bread and cereals in Cameroon, Ethiopia, Nigeria, Zambia and Zimbabwe is less than the overall average, while it is very high relative to the average in Botswana, Madagascar, Malawi, Morocco and Tunisia. Consumption of fish in Ethiopia, Kenya and Tanzania is almost nil, despite the proximity of the Indian Ocean. In inland countries such as Botswana, Malawi, Mali and Zimbabwe, but not in Zambia, real consumption of fish is also low. Senegal ranks first in volume of fish consumed at more than five times the average consumption and more than 170 times the consumption of Ethiopia. Tunisia is ranked first in consumption of milk, dairy produce and eggs. These items are, of course, combined in a single sub-category, and the study makes no estimate of the consumption of eggs as a separate item. As is well known, Tunisia consumes record numbers of eggs, particularly in celebrating the religious feast days and during the holy month of Ramadan. This would seem to justify Tunisia's first-place ranking in consumption of milk, dairy produce and eggs.

In the fats and oils sub-category, real consumption in Malawi, Mali and Tanzania is virtually nil while Morocco, Senegal and Tunisia consume more than twice the world average, a fact no doubt attributable to local production of olive oil and peanut oil. The high consumption of fruit and vegetables in Morocco and Tunisia likewise reflects their abundant agricultural production. Their consumption of large quantities of sugar accords with the corresponding consumption of wheat derivatives, substantial amounts of confectionary being prepared in the home for religious feast days, as it does with coffee and tea consumption. On the other hand, consumption of alcoholic beverages is very

Table 30. Per capita volume indices for major sub-categories of the food, beverages and tobacco consumption category, 1980

(Average for the 15 countries = 100)

Country	Major food items										Beverages		Total food, beverages and tobacco
	Total food items	Bread and cereals	Meat	Fish	Milk, dairy produce and eggs	Oils and fats	Fruit and vegetables	Sugar	Coffee, tea and cocoa	Alcoholic	Non-Alcoholic	Tobacco	
Cameroon	69	78	87	65	45	95	65	22	62	301	49	92	81
Cote d'Ivoire	130	114	156	211	244	94	123	120	38	439	192	77	147
Madagascar	116	167	177	91	31	44	104	167	39	22	23	136	107
Mali	74	100	174	34	31	14	32	65	18	27	11	64	69
Morocco	196	214	194	58	151	283	233	566	195	7	28	171	178
Senegal	134	137	108	523	79	196	125	73	17	23	65	91	124
Tunisia	277	304	180	82	354	475	600	296	297	14	70	357	256
Botswana	129	196	179	13	283	30	41	225	159	381	37	351	144
Ethiopia	34	47	39	3	31	23	59	20	26	64	26	33	35
Kenya	85	131	39	5	251	36	106	64	146	125	53	132	87
Malawi	90	182	74	29	66	10	61	45	9	85	15	37	85
Nigeria	101	62	99	154	85	105	53	22	134	60	188	73	102
Nigeria	65	87	46	42	37	15	116	72	28	38	2	26	59
Tanzania	82	11	110	177	43	89	116	83	27	497	115	206	108
Zambia	82	11	110	177	43	89	116	83	27	497	115	206	108
Zimbabwe	76	41	96	39	155	71	39	115	119	421	193	366	107

Table 31. Per capita volume indices for sub-categories of final government consumption and gross fixed capital formation, 1980

(Average of the 15 countries = 100)

Country	Final government consumption				Gross fixed capital formation					
	Real GDP	Compensation of employees	Purchases of goods and services	Final government consumption	Major subcategories			Installations	Gross fixed capital formation	
					Machinery and equipment	Means of transportation	Housing construction			
Cameroon	134	110	57	88	175	155	162	167	101	127
Cote d'Ivoire	186	133	332	217	194	257	207	302	263	248
Madagascar	76	69	79	73	71	94	36	43	94	76
Mali	47	73	37	58	40	24	37	16	11	20
Morocco	161	188	196	191	125	123	138	227	90	131
Senegal	91	194	93	151	48	33	43	2	113	53
Tunisia	270	236	190	216	445	303	376	369	239	300
Botswana	199	166	259	206	662	304	488	158	318	357
Ethiopia	38	53	38	47	14	15	14	18	5	10
Kenya	89	118	119	118	92	112	104	97	35	75
Malawi	55	49	77	61	42	37	37	25	52	45
Nigeria	105	83	79	81	88	113	96	97	153	124
Nigeria	50	74	44	61	96	49	76	34	34	48
Tanzania	50	74	44	61	96	49	76	34	34	48
Zambia	98	165	164	164	160	175	167	96	61	109
Zimbabwe	124	91	184	130	131	98	123	46	47	81

low in Morocco and Tunisia and high in Botswana, Cameroon, Cote d'Ivoire and Zambia. Finally, no plausible explanation can be given for the great disparities in tobacco consumption.

(f) Volume indices for sub-categories of final government consumption and gross fixed capital formation, 1980

In table 31, final government consumption does not include health services (hospitals and clinics), which are assigned to private household consumption. Analysis of the volume indices for per capita compensation of employees yields comparisons among countries with respect to level of salaries paid to employees of government departments. It can be inferred that the country with the highest volume index for such compensation will bear the heaviest cost burden. This can be seen in the case of Tunisia, where the per capita cost is 236 per cent of that in the group of 15 countries as a whole. In Mali it is less than one half. Current government expenditure on purchases of goods and services is high in the rich countries and low in the poor countries with the exception of Zambia.

Botswana leads the group in gross fixed capital formation with a per capita volume index more than 3.5 times the overall average, followed by Tunisia with three times and Cote d'Ivoire with 2.5 times the average. It can be seen that all of the volume indices for gross fixed capital formation are high, those for four other countries also being above the general average, namely Cameroon (127), Morocco (131), Nigeria (124) and Zambia (109). Of the indices that fall below the average, those for Ethiopia and Mali, at 10 and 20 per cent of the average respectively, are poor indeed.

These are the principal tables given in the EUROSTAT study on the African countries. As previously stated, the figures have been included in the ICP Phase IV results and adjusted to enhance their comparability with those for other regions of the world.

## V. PREPARATIONS FOR PHASE V

Preparations for ICP Phase V are being made in the light of an evaluation of the methodology of Phase IV and of the recommendations of the Interorganizational Meeting on the International Comparison Project held at Bellagio, Italy, from 24 to 28 September 1984.

### A. Evaluation of Phase IV implementation

#### 1. Continued use of the Geary-Khamis method

ICP objectives did not change in the design and implementation of Phase IV and the endeavour continued to be to make comparisons of PPPs and to estimate real GDP and real values for its components (private consumption, government consumption and capital formation) for all countries. The method of estimation was no different in Phase IV from that used since Phase I, namely the G-K method.

In a study issued in August 1985, UNSO reported that several factors encouraged continued use of the method. There had been increased demand from universities and research centres for the kind of data provided by ICP, and statisticians in the various countries had been satisfied with the use of the method from a technical point of view. There had been increasing interest on the part of national statistical organizations in participating in the project and there were increasing numbers of experts in international comparisons in both international organizations and national statistical organizations, even in the developing countries. There had as a result been an improvement in the quality of the statistical data and in the accuracy with which PPPs and real values for GDP and its components could be estimated. Statistical training centres had at their disposal numerous publications explaining detailed methods for dealing with newly arising cases and problems.

ICP experts nevertheless continue to encounter numerous obstacles that they have so far been unable to overcome. There are, in addition to the financial constraints limiting the conduct of thorough statistical research, difficulties in devising agreed methods for reconciling the various regional results and bringing them together in a consistent manner within a world-wide framework. In Phase IV, the attempt was made first to establish regional comparisons and then to use them to establish world comparisons.

#### 2. Regionalization of the ICP project and its consequences

One major difference introduced in Phase IV was that, while in Phases I, II and III all the participating countries had been regarded as a single group and direct comparisons made at the world level, countries were now broken down by region, regional comparisons made and world comparisons obtained on that basis. A number of major considerations were involved in the regionalization of ICP. The number of participating countries had increased; regionalization of the few Phase I countries would have been difficult, while there were 60 Phase IV countries. There were methodological considerations; regionalization presented a kind of homogeneous statistical stratification that helped improve the quality of international comparisons. Certain organizational factors were involved; statistical organizations in some regions have more time than those in others to devote to the elaboration of international comparisons and, with the regionalization of ICP, some of the regional comparisons could be

published before world comparisons were made. There had been a strengthening of regional interest; there was a general tendency among countries participating in economic schemes at the regional level to be more interested in comparisons among countries of the same region than in those involving countries of other regions. Finally, there were financial factors; a number of countries and international organizations wished to devote considerable sums to financing comparisons within their respective regions and allocated insignificant or purely nominal amounts to those outside.

In the light of such considerations, regionalization has certain advantages, and most participating countries and ICP experts prefer it to the centralized method. It must, however, be acknowledged that regionalization involves a number of major caveats. With regionalization, ICP becomes less uniform in the various regions since, in making regional comparisons, regional organizations prefer to use their own distinctive schemata, thereby undermining the reliability of the project as a whole. The allocation of considerable funds for regional comparisons and insignificant amounts for core-country comparisons adversely affects the quality of the world comparisons since, for lack of adequate funding, they are not based on thorough research. There is a certain incompatibility between regional comparisons based on regional averages and world comparisons based on world averages. Each of these caveats will be discussed below.

(a) Lack of a uniform methodology in the various regions

If, in fact, the general methodological approach is defective, then ICP is doomed to failure and figures for real GDP and its components will be inconsistent and incomparable across regions. The view that methodological differences in the implementation of Phase IV are entirely negative factors is, however, mistaken. Flexibility should not be confused with inconsistency, and an effort has been made to adapt the general methodological principles to special regional circumstances. Examples of methodological differences might be as follows: in comparing real expenditure on education, one region might choose the number of pupils as an indicator while another might choose the number of teachers; or one region might have more detailed data and might use a greater number of expenditure sub-categories while others might use only the minimum number. It is doubtless difficult to establish a precise dividing line between cases of flexibility and cases of inconsistency. There may also be real differences of opinion among experts in various regions as to choice of indicators, thereby leading to deviations. UNSO must, in that event, be familiar with all the methodological details of the various regional comparisons so as to be able to intervene to settle any disagreements likely to lead to inconsistency.

(b) Deficiency of core-country comparisons

The Phase IV core-country comparisons (that is to say comparisons between countries belonging to different regions) may be defective. While regional organizations allocated sufficient funds for regional comparisons, in designing Phase IV UNSO envisaged only meagre funding for the preparation and implementation of the core-country comparisons. Other than in special cases, UNSO could only communicate with the core-countries in the various regional bodies and receive data from them by correspondence, and such a procedure was unable to provide the precise and detailed information required for the matching of price representatives. Other core-country data are also far from

perfect. The core-country comparisons could have been more accurate if adequate funding had been allocated at the design stage of Phase IV.

(c) Lack of uniformity in the measurement of averages

This caveat is difficult to eliminate. It was not a factor in Phases I to III, before the regionalization of the project, since at that time only world price averages were used as units of measurement. Assuming, for example, that the average price of one kilogram of sugar is equivalent to that of three kilograms of salt at the world level, then for purposes of comparison in the three earlier phases the equivalence of one kilogram of sugar to three of salt would have held for each participating country regardless of the region to which it belonged. With regionalization, however, a number of different measurements were introduced since regional comparisons use regional average prices as weights. For example, one kilogram of sugar might be equal in value to four kilograms of salt in region A and two in region B, giving rise to two different measures. For world comparisons between countries, the easy solution is to adopt the world average prices, say, in the present case, one kilogram of sugar being equivalent in value to three kilograms of salt. Such an easy solution would, however, give rise to a situation where the world-level results for the countries of a particular region would differ from those at the regional level. For the purposes of the present example, let us assume that region B comprises two countries which consume only sugar and salt. Let us call the first country "Saltia", since it consumes two units of salt for every unit of sugar, and the second "Sugarland", since it consumes two units of sugar for every unit of salt. Let us assume that, in region B, the price of one kilogram of sugar is equivalent to the value of two kilograms of salt. Computing Sugarland's quantity index relative to Saltia within region B by using the averages for region B as weights for region B's quantity index we obtain the following:  $(2 \times 2) + (1 \times 1) / (1 \times 2) + (2 \times 1) = 5/4 = 1.25$ . Computing Sugarland's quantity index relative to Saltia within regions A and B as a whole, that is to say its quantity index at the world level, the world averages (where, in the present case, the price of one kilogram of sugar is equivalent to the value of three kilograms of salt) are used as weights, and we obtain the following:  $(2 \times 2) + (1 \times 1) / (1 \times 3) + (2 \times 1) = 7/5 = 1.40$ .

Just as two different values are obtained for Sugarland's quantity index relative to Saltia in this simple hypothetical example, different comparative results have been encountered by ICP. When, for example, ICP compared Austria and Hungary, it obtained results that varied with the country-group framework in which the two countries appeared. For the group consisting of Austria and Hungary alone, a pure binary comparison, the average prices of the two were adopted as weights; for Europe Group 2, made up of Austria, Finland, Hungary, Poland and Yugoslavia, the average prices of all five countries; for the European group of countries participating in Phase IV, the average prices of all those countries; and for all countries of the world participating in Phase IV, the average world prices. Thus, for the sole purpose of estimating Hungary's quantity index relative to Austria, four different results were obtained. Such a situation undermines confidence in ICP results, since the result of any comparison between Hungary and Austria changes with the participation or non-participation of other countries and since the mere fact of another country joining the project is sufficient to change the results of comparisons between the two.

In order to avoid a multiplicity of different results in international comparisons, ICP introduced a harsh solution in Phase IV, under the name of the fixity rule, requiring that, in international comparisons, all intra-regional ratios should be the same as those already published in the regional comparisons. Among the results obtained by EUROSTAT in regional comparisons of 12 countries, for example, the real per capita GDP of France is 25.6 per cent higher than that of Italy. Accordingly, the 18 OECD countries and the 60 ICP countries have retained the 25.6 per cent ratio in computing the quantity index for France relative to Italy.

This solution, however, should be re-examined since, when a number of different measurements are used (in the present case regional price averages), application of the fixity rule may deprive international comparisons of the properties of transitivity and additivity. ICP Phase IV arrived at another solution requiring regional groupings to be regarded as a single unit or "block" (for example, in comparing the OECD block with the ECE block, the ECE block with the ECLAC block, etc.). World comparisons of GDP are made between blocks on the basis of average world prices and the real GDP of each block then distributed among its countries in the ratios obtained in the regional comparisons. Thus, retaining the fixity rule, the real GDP figures of countries belonging to different regions can be compared. The comparability is, however, at the level of total real GDP only and not at that of components or categories; private consumption, consumption of foodstuffs, consumption of bread, etc. cannot be compared. Comparisons of components and categories of GDP can be made among the countries of a single region but not among countries of different regions.

The Phase IV results for 60 countries, covering real GDP, private consumption, government consumption and capital formation, were given in chapter IV above. It should be pointed out in that connection that comparisons between countries in different regions are proper only in respect of GDP; comparisons of private consumption, government consumption and capital formation can be made only between countries of a single region and not between two countries belonging to different regions.

Table 32 gives per capita quantity indices for Tunisia (belonging to the ECA group) relative to France (belonging to the EEC group) computed in two different ways: using the block method while retaining the fixity rule; and using 1980 average world prices.

Table 32. Per capita quantity indices for Tunisia relative to France

(France = 100)

Components of GDP	Index computed by block method with fixity rule	Index computed at average world prices, without fixity
Real private consumption	24.0	21.6
Real government consumption	15.7	50.8
Real capital formation	20.8	15.2
Real GDP	22.0	22.0

Given such incompatibility, UNSO is considering the possibility of issuing two sets of results, one based on average regional prices and the other on average world prices.

B. Seminar of ICP experts, September 1984

At the invitation of UNSO, a seminar attended by experts from a number of countries and regional groupings was held at Bellagio, Italy, from 24 to 28 September 1984 with a view to devising a procedure for linking countries belonging to different regions in the design of ICP Phase V. The seminar also discussed the classification of goods and services. Two UNSO studies on core-countries were presented, explaining the procedure for making world comparisons on the basis of regional comparisons and using the ICP Phase IV core countries. Before introducing the linking procedure, we shall present a simple example.

The objective is to compute the PPP at the world level for each of the African countries. This is done by obtaining PPPs for each country in African dollars, that is to say at the regional level, and using core countries. For the purpose of the present example, there are only two core countries, Kenya and Senegal. Their PPPs relative to average African prices are: for Kenya, 12 Kenyan shillings; and for Senegal, 450 CFA francs. Their PPPs relative to average world prices are: for Kenya, one United States dollar is equivalent to six Kenyan shillings; and for Senegal, one United States dollar is equivalent to 200 CFA francs. The linking factor,  $L_{BK}$ , where B is the regional grouping (in the present example Africa) and K the category of goods and services (in the present example fruit), will be as follows:

$$L_{BK} = \sqrt{\frac{6 \times 200}{12 \times 450}} = 0.4714$$

Finally, in order to obtain the PPP relative to the United States dollar, that is to say the PPP at the world level, for each African country participating in ICP (including Kenya and Senegal), 12/ the PPPs relative to the African dollar (the regional comparisons) are multiplied by the linking factor of 0.4714.

The general formula for the linking factor is:

$$L_{BK} = \sqrt{\frac{\prod_{l=1}^n PM_{lBK}}{\prod_{l=1}^n PR_{lBK}}}$$

where L is core country number n; B is the regional grouping; K is the category; PM is the PPP for comparator country l at the world level for

12/ It should be noted that the PPP for Kenya relative to Senegal is 450/12 or 0.0267 Kenyan shillings in the African context and 200/6 or 0.0300 Kenyan shillings in the world context.



category K; and PR is the PPP for comparator country 1 at the regional level for category K. The meeting did not, however, manage to adopt a definitive formula for obtaining world comparisons on the basis of regional comparisons using a series of core countries and merely accepted the recommendations of UNSO that the Office should continue its efforts with a view to devising a fully evolved procedure in accordance with clear criteria.

### C. Beginning of preparatory work for ICP Phase V

#### 1. Characteristics of Phase V

Like Phase IV, Phase V will be designed on the basis of regionalization and the world comparisons will consequently be composed of two principal constituent elements; world comparisons, and core comparisons providing a connection between one region and the others. The regional comparisons will cover: OECD, made up of 22 countries, 12 of them members of EEC; the African region comprising 23 to 24 countries; the Far East region, comprising 8 to 10 countries; and Europe Group 2, comprising five countries, two of which also belong to OECD. Although a number of Latin American countries and the Syrian Arab Republic have expressed interest in participating in Phase V, neither the ECLAC region nor the ESCWA region have as yet taken part in regional comparisons despite the need for such comparisons in the regions concerned. The principal role of core comparisons is to provide bridges (PPPs and per capita volume indices) between regions connecting the results of the various regional comparisons so as to establish world comparisons. Since there are no regional comparisons for the ECLAC and ESCWA regions, the core comparisons have another role, namely to connect such individual core countries as Argentina, Brazil, Chile, Colombia, Jamaica and the Syrian Arab Republic with the world comparisons. Core countries are therefore of two kinds: one where the core country represents the region to which it belongs (for example, the United Kingdom representing the OECD countries, Kenya representing Africa, or India representing East Asia); and the other where the core country represents only itself (for example, Argentina or Colombia). Core countries of the first type can be further divided into two subgroups; core countries representing a single region, and core countries representing two regions at one and the same time. Examples of the second subgroup are Austria, which belongs both to OECD and Europe Group 2, and Japan, which belongs both to OECD and the ESCAP region. In such cases a connection can be established with both regions.

#### 2. The two basic lists of goods and services

Before field work begins, the ICP central staff will distribute two basic lists to be used by all Phase V countries; a list of basic headings, and a list of specifications. The list of basic headings will contain the categories for which, at a minimum, data are required from participants. Initial agreement on a list of 166 categories has been reached by the statistical offices of the United Nations, OECD and EEC. The list of specifications will assist the various regions and pairs of countries to select the specifications for which prices will be collected in order to estimate PPPs, but it is not of a binding nature and regions may add or delete whatever specifications they wish. The list cannot possibly be definitive, since the central staff is not capable of monitoring goods and services in all countries or of deciding the optimum number of specifications that must be selected from each category in order to make comparisons. It may therefore be suggested to each country that, in selecting specifications, it should, after

studying the list received from the ICP central staff, identify those items for which prices will be collected, determine those items to be added to the list, and rank the items within each category in order of importance. Each country should then inform its partners in the comparison, by correspondence, of the proposed modifications. After an exchange of views, agreement will be reached on the list of specifications to be applied in making comparisons.

### 3. The model for regional comparisons

Regional comparisons are the first constituent element of world comparisons, and the quality of the latter will therefore be affected by the manner in which the former are carried out. Accordingly, UNSO has prepared a model for regional comparisons in which PPPs for one major category (men's clothing) are estimated for ten countries (A,B,...J) in one region. Since weighting is not used at the category level, the PPP of each country relative to each category is calculated by taking the unweighted geometric mean of the various items in a single category, that is to say the geometric mean of the price ratios of the items.

With regard to the selection of the various items in a single category for the purpose of calculating PPPs, the question arises whether such items need to be available for all or only some of the ten countries. In answering that question, it must be borne in mind that a sound estimate of the PPP of one country relative to another requires that the specifications of the items within the category should be identical and of equal importance in the two countries. Obviously, the number of identical specifications of equal importance in a given category will be greater in a comparison of two countries than in a comparison of ten. To obtain a sound estimate of PPP, a multilateral comparison of binary elements is therefore necessary. The answer to the question is that, in basing a multilateral comparison on binary elements, it is sufficient for identical specifications to be available for any two countries, and they need not be available for all ten.

In the UNSO model, the regional multilateral comparison is thus based on binary elements, so that 45 binary PPPs must first be calculated. For each binary comparison, items must be selected in each category which are identical and of equal importance only for the two countries involved in that particular binary comparison. Where there are no such common, identical items for binary comparison of a particular category, UNSO proposes three possible solutions in order to fill the gap.

The first solution involves the use of the regression method or hedonic approach. This method is based on the correlation between a number of physical characteristics and economic values and is used in comparisons in the construction sector. The second proposed solution is applied in the absence of full identity or correspondence of items for the two countries in the binary comparison, when identity is established by artificial means by agreement among experts in the two countries on the adjustment of prices to eliminate quality differences. The method was applied by ICP in previous Phases and is used by the countries of Europe Group 2 (Austria, Hungary, Norway, Poland and Yugoslavia). The third solution is to obtain a comparison between the two countries by using an indirect rather than a direct method, inasmuch as the comparison is made within the framework of the multilateral comparison covering ten countries in a single region.

Having proposed these three solutions for filling gaps in binary comparisons of a particular category of items, UNSO sets forth a procedure for multilateralization of the binary results. Its presentation is based on a multilateral matrix of items in a particular category where the columns and rows represent the countries of the region and the PPPs calculated directly from the binary comparisons are entered in the cells, that is to say the points at which columns and rows intersect, as follows:

Matrix of PPPs for country X relative to country Y within the region

Country X relative to country Y	A	B	...X...	J
A	1	A <sup>PPP</sup> B	A <sup>PPP</sup> X	A <sup>PPP</sup> J
B	B <sup>PPP</sup> A	1	B <sup>PPP</sup> X	B <sup>PPP</sup> J
Y	Y <sup>PPP</sup> A	Y <sup>PPP</sup> B	Y <sup>PPP</sup> X	Y <sup>PPP</sup> J
J	J <sup>PPP</sup> A	J <sup>PPP</sup> B	J <sup>PPP</sup> X	1

The basic assumption is made that the matrix is complete, that is to say that PPPs for all the binary comparisons have been computed directly. UNSO notes, however, that, even in this case, the matrix contains only intermediate results since the PPPs composing the various elements of the matrix do not have the property of transitivity. In other words:

$$C^{PPPA} \neq (B^{PPPA}) \cdot (C^{PPPB})$$

In order to render the matrix transitive, the so-called EKS-ization process is applied. This method has previously been mentioned in connection with its use in estimating the PPPs for various categories in the African countries and, it will be recalled, it is written as follows:

$$K^{(EKS)}_J = \sqrt{\prod_{i=1}^J \frac{1^{PPP}_J}{1^{PPP}_K}}$$

This formula brings about transitivity:

$$K^{(EKS)}_D \times D^{(EKS)}_J = K^{(EKS)}_J$$

The EKS (Elteto, Koves and Szulc) method yields a matrix of transitive indices that deviate minimally from the original-country binary indices and, as UNSO recalls, is not new in ICP work, having been applied in previous Phases. What is new to Phase V, as UNSO itself stresses, is the widening of the field in which the method is applied. EKS can now also be used in the case where matrices are incomplete, that is where some of the cells are devoid of direct estimates of PPPs. The new method was presented by Pal Koves in Index Theory and Economic Reality (Akademiai Kiado, Budapest, 1983). Pages 167-170 of the book were reproduced by UNSO in order to explain the computation of PPPs by presenting an example involving one region made up of six countries and a situation where not all binary comparison PPPs are directly available. The example is here reproduced after reference to the

source and modification of the symbols used so that they accord with those of ICP.

In the case of the six countries, there are 15 binary comparisons (6 x 5/2), so that 15 PPPs have to be established. The complete matrix contains 36 cells (6 x 6) but, obviously, the PPP of a country relative to itself will be 1, and the PPP of country J relative to country K will be the inverse of the PPP of country K relative to country J. The matrix is therefore in two sections, upper and lower, separated by the axis formed by the cells of the column and line of a particular country, and all the figures in the lower section are the inverse of those in the upper. The incomplete matrix for the six countries is as follows:

Incomplete matrix of PPPs for six countries

	A	B	C	D	E	F
A	1	2	--	1.8	2.5	
B	0.5	1	0.5			
C	--	1.25	1	1.2	--	1.3
D	0.556	--	0.8333	1	1.5	
E	0.3636	--	--	0.6667	1	0.7
F	--	--	0.7692	1.4286		1

The matrix contains a set of PPPs obtained directly from binary comparisons. Thus, the PPP of country B relative to country A, directly on the basis of the binary comparison and the prices for those two countries alone, is 2, as can be seen at the intersection of column B with line A. Now, in order to obtain the PPP of country B relative to country A in the multilateral comparison framework (i.e. that of the six countries concerned) using the results of the binary comparisons, the EKS formula is applied:

$$A^{(EKS)}_B = \sqrt[6]{\frac{6}{1=1} \frac{1 \text{ PPP}_B}{1 \text{ PPP}_A}}$$

In order to simplify the formula, the abbreviated symbol  $1^{PPP}_B$  will be used instead of  $1 \text{ PPP}_B$ :

$$A^{(EKS)}_B = \sqrt[6]{\frac{(A^{PB}) (B^{PB}) (C^{PB}) (D^{PB}) (E^{PB}) (F^{PB})}{(A^{PA}) (B^{PA}) (C^{PA}) (D^{PA}) (E^{PA}) (F^{PA})}}$$

$$= \sqrt[6]{\frac{2 \times 1 \times 1.25 \times (D^{PB}) (E^{PB}) (F^{PB})}{1 \times 0.5 \times 0.5556 \times 0.3636 \times (C^{PA}) (E^{PA})}}$$

However,  $A^{(ESK)}_B$  cannot be computed for the following PPP numerator countries:  $F^{PB}$ ;  $E^{PB}$ ;  $D^{PB}$ ;  $F^{PA}$ ; and  $C^{PA}$ . The matrix, in turn, does not contain direct values for these PPPs. Koves (op.cit.) suggests that they can be estimated, and the  $A^{(ESK)}_B$  estimation formula is as follows:

$$A^{(ESK)}_B = \sqrt[6]{\frac{24.750495 (D^{PB}) (E^{PB}) (F^{PB})}{(\hat{C}^{PA}) (\hat{F}^{PA})}}$$

Koves also explains how these PPPs can be estimated on the basis of the binary PPPs available, while acknowledging that such PPPs lack transitivity and that the estimate will therefore be approximate. Beginning with the computation of  $C^{PA}$ , an estimate of the purchasing-power parity of country A relative to country C, it can be determined by either of the two equations:

$$(\hat{C}^{PA}) \# (C^{PB}) \times (B^{PA}) = 1.25 \times 0.5 = 0.625$$

$$(\hat{C}^{PA}) \# (C^{PD}) \times (D^{PA}) = 1.2 \times 0.5556 = 0.66672$$

The geometric mean of the two values is:

$$\hat{C}^{PA} = \sqrt{0.625 \times 0.66672} = 0.6455$$

Similarly, a value for  $D^{PB}$ , an estimate of the purchasing-power parity of country B relative to country D, can be calculated by either of the two equations:

$$\hat{D}^{PB} \# (B^{PA}) (A^{PB}) = 0.5556 \times 2.0 = 1.1112$$

$$\hat{D}^{PB} \# (D^{PC}) (C^{PB}) = 0.8333 \times 1.25 = 1.041625$$

and the geometric mean is:

$$\hat{D}^{PB} = \sqrt{1.1112 \times 1.041625} = 1.0758$$

$E^{PB}$ , an estimate of the purchasing-power parity of country B relative to country E, can be computed by a single equation:

$$\hat{E}^{PB} = (E^{PA}) (A^{PB}) = 0.3636 \times 2.0 = 0.7272$$

Likewise,  $F^{PB}$ , an estimate of the purchasing-power parity of country B relative to country F, can be computed by a single equation:

$$\hat{F}^{PB} = (F^{PC}) (C^{PB}) = 0.7692 \times 1.25 = 0.9615$$

Finally,  $F^PA$ , an estimate of the purchasing-power parity of country A relative to country F, can be computed by the following equation:

$$\begin{aligned} \hat{E}^PA &= (F^PE) (E^PD) (D^PC) (C^PB) (B^PA) \\ &= 1.4286 \times 0.6667 \times 0.8333 \times 1.25 \times 0.5 = 0.4960 \end{aligned}$$

The value of  $A(EKS)_B$  can then be estimated:

$$\begin{aligned} \hat{A}(EKS)_B &= \sqrt[6]{\frac{24.750495 \times 1.0758 \times 0.7272 \times 0.9615}{0.6455 \times 0.4960}} \\ &= \sqrt[6]{58.148784} = 1.9672 \end{aligned}$$

The figure 1.9672 is that for the purchasing-power parity of country B relative to country A within the multilateral comparison framework of the six-country region and for one particular category of items.

For regional comparisons of PPPs for per capita GDP, UNSO proposes that the G-K method should be used. To obtain regional quantity indexes, average regional prices must be used as weights.

#### 4. The core-country comparisons and the world-level aggregation

Regional comparisons are considered as building blocks for world comparisons and, in order to complete the entire edifice, links and bridges must be found between the various regions (the so-called core comparisons) and an aggregation at the world level made.

##### (a) The core-country comparisons

Core comparisons provide the links between the results for the various regions and between countries not participating in regional comparisons. Such linking comparisons are, in general, carried out by making binary comparisons between countries belonging to different regions, such as India and Kenya for example. If the number of regions is  $m$ , then at least  $m - 1$  core comparisons are needed in order to establish a direct or indirect connection between one region and another. If only the minimum number of core comparisons are made, the world comparisons will be defective inasmuch as the final results for each region will be affected by the choice of the core country acting as its representative and the corresponding core countries in other regions. ICP therefore recommends that, for Phase V, the number of core comparisons should be increased to include 20 countries. In that case, with the number of core countries exceeding the minimum, the  $K(EKS)_J$  formula will be applied as between core countries in order to ensure transitivity in the core comparisons. ICP has established the principal goal of the Phase V core comparisons as that of obtaining PPPs for every basic category of goods and services.

##### (b) The world-level aggregation

UNSO considers the following information to be necessary in order to make comparisons at the world level:

(a) From regional organizations; PPPs and expenditure figures, in the national currency and the currency agreed upon at the regional level, for each

of the basic categories of goods and services included in the international list of basic categories;

(b) From core countries; PPPs and expenditure figures for all basic categories, in the national currency and in ICUs, and the principal prices used in calculating PPPs common to both core countries.

The world-level aggregation will be carried out in accordance with the G-K formula, using average world prices as weights. Average world prices, in turn, will be determined using the supercountry-weight method by assigning to each region not only the weights of the Phase V countries but those of non-participating countries from the same region. UNSO notes that there is as yet no agreed solution for reconciling the fixity rule (which requires that the ratios between PPPs or quantity indices established in regional comparisons should also obtain in the world-level comparisons) with the basic ICP requirements of additivity and transitivity. There are other matters currently before UNSO and the statistical offices of OECD and EEC requiring the resolution of conflicting priorities, and it is hoped that agreement can be reached in the near future.

D. Report on the Workshop of Core countries of Phase V  
of the International Comparison Project

A workshop was held in Vienna from 2 to 11 September 1985 which was attended by representatives of the core countries expecting to participate in Phase V (Argentina, Austria, France, the Federal Republic of Germany, Hungary, India, Italy, Japan, Kenya, Pakistan, the Phillipines, Senegal, Spain, Tunisia, Turkey, the United Kingdom and the United States) and of interested international organizations (ECA, EUROSTAT, OECD, UNSO and the World Bank).

According to UNSO estimates, between 60 and 70 countries are expected to participate in Phase V: 22 OECD countries; 23 or 24 African countries; 5 Europe Group 2 countries; 8 to 10 ESCAP countries; 2 to 4 Latin American countries; and perhaps one ESCWA country. In order to establish a world-wide comparison, the regional comparisons will be linked by 10 or 11 binary comparisons between core countries.

The meeting discussed the lack of uniformity in specifications for goods and services in the core countries, and the following conclusions were accepted:

(a) The improvement in the description and selection of such similar products is an important means of avoiding adjustments;

(b) Where adjustment is still necessary, regression methods or imputing prices on the basis of well-defined quantitative parameters should be preferred;

(c) In cases where qualitative, subjective adjustments are necessary, the core countries being compared should agree to the adjustment;

(d) In comparisons in respect of health and education services and general government services, several methods should be applied simultaneously, for example number of teaching staff (input element) and number of pupils (output element) and the results contrasted;

(e) Whenever quality adjustments are made, the basis on which they are made must be explained in detail.

The meeting endorsed the pairing of countries for the core comparisons, as follows:

Between OECD and Africa

United Kingdom - Kenya  
France - Senegal  
Italy - Tunisia

Between OECD and ESCAP

United States - India  
United States - Phillipines

Between Africa and ESCAP

Kenya - India

Between OECD and Latin America

Germany, F.R. - Argentina

Since the representatives of Nigeria and Brazil were not present, no decision was taken on the proposed Pakistan-Nigeria and Spain-Brazil comparisons.

The meeting established a timetable for the further work of the core countries. It requested them to finalize the selection of specifications and to send the necessary supplementary information to their partners by 15 November 1985. Countries were requested to submit to UNSO the completed list of specifications with the corrected prices by 30 June 1986 in respect of the consumption items and by 30 September in respect of the other items. UNSO will compile per capita quantity indices for pairs of core countries for both basic categories and GDP. Core-countries were requested to agree with their partners on possible modifications by 28 February 1987. In March, April and May 1987 UNSO will confront the results of the various core comparisons and those of the regional comparisons. Finally, the meeting proposed that UNSO should convene a second Phase V core-country workshop in September 1987.



## CONCLUSION

The present study is the third in a series produced by ESCWA for the purpose of introducing its member countries to the subject of international comparisons of real gross domestic product and purchasing-power parities. In it, the author tries to present a brief description of the task undertaken by the countries participating in the various Phases of ICP and of the work of UNSO and the various regional organizations in preparing and conducting international comparisons over the last ten years (1975-1985).

The study began with a presentation of a theoretical framework for the methods used in making international comparisons avoiding, as far as possible, the mathematical proofs on which those methods are based. It is to be hoped that statisticians in the ESCWA countries will proceed to co-ordinate their efforts to elaborate and introduce a more evolved theoretical framework in keeping with the character of those countries and compatible with ICP.

As can be seen from the study, statisticians have achieved growing success in preparing and implementing the various phases of the project. From an enterprise limited in the number of countries involved (10) and further limited in respect of the methodology employed, the modest results obtained and the failure to arrive at comprehensive estimates, they have now come to use a special methodology, suitable for all economic sectors, in extrapolating results and distinguishing between regions. They have not, however, up to the time of writing, reached agreement on a definitive formula for reconciling the results of regional comparisons with those of world-level comparisons, and the formula provisionally in use is hedged about with caveats. This obstacle will nevertheless be overcome, since statisticians in the ICP countries and the regional organizations are continuing their theoretical and practical campaign to find solutions to problems as they arise and will eventually find a way of reconciling the results of regional and world comparisons. They will also make advances in overcoming impediments to the comparison of categories of expenditure on real GDP and will soon begin to compare real added values in order to establish real GDP by industrial source. Pursuit of such studies will lead to the elaboration of new aspects of national accounts, namely real cross-country national accounts and single-country national accounts at constant prices.

Both of these aspects make use of index theory, whether involving price, volume or value indices. Chronologically speaking, statisticians first became interested in the use of indices in estimating various components of national accounts at constant prices with a view to comparing such components over a number of years, and cross-country comparison of components of GDP has now created a need to make use of indices. The use of indices does not, however, require that the theory of comparisons over time should be adopted and transferred wholesale to international comparisons. There are, in fact, two basic differences between international comparisons and chronological comparisons. Chronological comparisons, that is to say comparisons between one year and another, are based on a single group of consumers for both the base year and the current year. With the mere passage of time from the base year to the current year, observed expenditure remains linked with the same group of consumers over the period of the comparison. In a cross-country comparison, however, the expenditure of each of the countries is linked with its own distinctive group of consumers, that is to say that there are two

different groups of consumers in two different situations. There is thus no close resemblance between comparisons over time and across countries.

The second basic difference relates to the size factor. In cross-country comparisons one country may be one hundred times the size of another in terms of GDP or population. One of the objectives of international comparisons is, for example, the aggregation of data at the level of the country group so as to study the structure of that group. In that case, greater weight is accorded some large countries in estimating the median price. In practice, such eventualities do not, of course, arise in chronological comparisons, firstly because it is not customary to aggregate data for a series of years and secondly, and more importantly, because the years all have the same almost unchanging duration in time and cover a single set of economic units. It is therefore rare if not inconceivable for greater weight to be accorded to statistical data for one year, the same as ten or a hundred others, than to data for another. This would happen extremely rarely, particularly since the time factor is linked with a single set of economic units.

In a recent OECD study, Peter Hill has cautioned against the use of certain of the index formulae applied to chronological comparisons in international comparisons, after distinguishing between two basic approaches to index theory. The first is the statistical approach, of which Irving Fisher is one of the pioneers, and the second the economic approach. The difference between the two is that in the statistical approach all prices and all corresponding quantities are considered as independent variables, while in the economic approach economic theory regards quantity as a function of price or the form of the function as being dependent on consumer weights and consumer incomes. Indices of this kind have been used by Samuelson and Swamy. Naturally, matters relating to index theory cannot be further addressed here. It is to be hoped that statisticians in the ESCWA countries will pursue their research in this field within the national comparison framework, particularly since statistical organizations in the region have already published valuable studies on indices.

The development of ICP since Phase IV has been marked by the growing participation of regional organizations, each of them working in co-ordination with UNSO to prepare and conduct regional comparisons, while Phases I to III were restricted to a limited number of countries. Then, each country based its research on the benchmark years 1970, 1973 and 1975 and followed a uniform international classification agreed upon with UNSO. When the required data were obtained they were transmitted to UNSO and tabulated with those of other countries. UNSO, in co-operation with the World Bank and the University of Pennsylvania, analysed the results and published the international comparisons in a series of volumes, of which there are so far three. Some of the regional commissions, ESCAP, ECA and ECLAC, played no major role. When the Syrian Arab Republic was a participant in ICP, UNSO would from time to time notify ESCWA that the international expert entrusted with liaison with that country would be passing through Beirut to inform the Commission of progress made in the collection of data; he did not, in fact, visit Beirut because of the security situation. Nevertheless, in spite of its difficult circumstances, ESCWA remained in continual contact with the Central Bureau of Statistics in Damascus and kept abreast of its activities. The Commission was also involved in organizing, together with the Arab Institute for Training and Research in Statistics, a training course on price statistics and index numbers that was held in Damascus in November 1978. It presented a number of

lectures on international comparisons of real GDP and purchasing power and issued two documents on the subject.

Given that ICP has now come to be based principally on regional comparisons, that most of the regional organizations are participating in Phase V and since there is a growing number of highly qualified statisticians both in central statistical organizations and universities in the ESCWA region, it is an encouraging sign that the heads of statistical organizations in the region have agreed to include the subject of international comparisons in the agenda of their meeting to be held before the end of 1985. If they agree that regional comparisons should be made, ESCWA can invite member countries to a seminar on international comparisons jointly organized by UNSO and EUROSTAT.<sup>13/</sup> The Director of UNSO, in a letter of May 1985 addressed to heads of statistical organizations, has expressed his readiness to organize such a seminar and to send an expert to any interested country for consultations on international comparisons. The ESCWA Statistics Unit, which co-operates with all the statistical organizations of member countries, will, of course, make its expertise available to all countries participating in regional comparisons and will be responsible for co-ordinating the work of the UNSO experts. It will also prepare a list of goods and services for the ESCWA region and undertake training courses on international comparisons. It will follow up implementation of the statistical work, ensuring consistency in lists of goods and services, and will receive data for analysis from member countries. The results will be discussed with those countries before publication and transmission to UNSO. UNSO, in turn, will first review the figures for the ESCWA region and then link the results with those of the other regional commissions in the light of the core-country comparisons in order, finally, to obtain adjusted world-level figures for the ESCWA countries.

International comparisons of real GDP, are, as stated above, one aspect of national accounts. Those responsible for national accounts in the statistical organizations of the ESCWA countries should therefore be actively involved, together with those responsible for price statistics, in all stages of the preparation, implementation and compilation of studies. Non-participation by those responsible for national accounts in international comparison work has in the past led to deficiencies in the data collected.

Finally, the author would like to express his gratitude to the officials concerned at ESCWA for confiding to him the preparation of the present study. Despite his desire that it should not be too unwieldy, the ramifications of the various methodologies involved and their evolution in accordance with the special circumstances of each country and region required that most of them should be mentioned. He would like to conclude by commending the enormous contribution made by Dr. Salem Khamis in his international comparison studies. ICP has, of course, adopted the formula developed by him and by Dr. R.G. Geary. Dr. Khamis is from the ESCWA region and has served the countries of the region for 35 years and will no doubt continue to do so.

I am very hopeful that the statisticians of the ESCWA region will achieve notable success in this field in the near future.

<sup>13/</sup> EUROSTAT is co-operating with ECA in analysing the results of the regional comparisons in Africa.

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