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Purchasing Power Parity Based Weights for the *World Economic Outlook*

Anne Marie Gulde and Marianne Schulze-Ghattas[1]

Global economic analyses generally involve the aggregation of economic indicators across countries. In many instances, aggregates are defined as weighted averages of indicators for individual countries, with the weights reflecting the relative size of countries.[2] A widely employed approach is to define countries' weights as their shares in total GDP of the group considered.[3] To ensure that GDP weights reflect each country's share in real output, differences in price levels across countries need to be taken into account. The conversion factors used to convert data expressed in national currencies into a common numeraire currency should thus reflect each currency's purchasing power relative to the numeraire currency.[4]

For practical reasons, GDP data expressed in national currencies are usually converted at market exchange rates. Such conversions may be acceptable as long as differences between market rates and purchasing power parities (PPPs) are likely to be small and transitory. However, if market exchange rates diverge substantially and for extended periods from PPPs, conversion at market exchange rates may yield biased GDP weights and, hence, biased indicators of aggregate economic activity in groups of countries.

This study provides background information on the new set of weights introduced in the May 1993 *World Economic Outlook*. It reviews GDP weights based on market (or official) exchange rates and weights based on available estimates of PPPs and examines their impact on indicators of aggregate real GDP growth. The first section, which deals with exchange rate based GDP weights, provides a brief summary of the empirical evidence on the relationship between exchange rates and PPPs and discusses the implications of aggregating growth rates of real GDP with different sets of exchange rate based GDP weights. The study then examines an alternative weighting scheme derived from PPP-based GDP data generated by the International Comparison Program (ICP).[5] It briefly summarizes problems of PPP index construction and the main features of the ICP approach.[6] It also discusses issues relating to the intertemporal extension of PPP-based GDP data that are available only for individual benchmark years, and issues relating to the estimation of PPPs for nonbenchmark countries. Aggregate growth rates of real GDP derived from PPP-based GDP weights are then compared with aggregates derived from exchange rate based GDP weights. The concluding section contains a summary of the main findings.

The PPP-based GDP weights used in this study are derived from the Penn World Tables prepared by Summers and Heston (1991), which combine data from four ICP benchmark studies covering 80 countries with estimates for a large number of nonbenchmark countries. These estimates for nonbenchmark countries were supplemented by World Bank and IMF staff estimates and an independent estimate for China.[7] The authors wish to emphasize

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[1]Ms. Gulde was a summer intern in the Research Department of the IMF when an earlier draft of this study was prepared; she is now an economist in the European I Department. The authors are indebted to Prof. Robert Summers at the University of Pennsylvania for valuable comments and for making available the Penn World Tables, which contain national income data based on purchasing power parity for more than 130 countries. They also wish to acknowledge comments and suggestions from other IMF departments, and to thank Peter Clark, David T. Coe, Flemming Larsen, and Kenneth S. Warwick for comments, and Sheila Bassett, Mandy Hemmati, and Prem Pillai for research assistance.

[2]Indicators that are additive and expressed in a common unit of account, such as current account balances, can readily be aggregated by summing up individual country data.

[3] Other weights can be used to aggregate economic indicators. Weights based on population shares, for example, are discussed in World Bank (1991), Appendix B. The choice among alternative weighting schemes depends ultimately on the focus of the analysis.

[4]Comparisons and aggregation of economic data across countries are also complicated by other problems, such as differences in definition and coverage.

[5]The ICP is coordinated by the United Nations and is supported by a number of other international agencies.

[6]A detailed review of methodological problems encountered in the construction of PPP indices is beyond the scope of this paper. See United Nations, Statistical Office (1991), Kravis and others (1975), and Kravis, Heston, and Summers (1982) for a discussion of these issues.

[7]Summers and Heston (1991), World Bank (1992), Gulde and Schulze-Ghattas (1992), and Taylor (1991). Professors Summers and Heston have been associated with ICP for nearly two decades.

that the following review of PPP estimates focuses on their use as conversion factors and does not bear on issues relating to equilibrium exchange rates.

GDP Weights Based on Exchange Rates

Exchange Rates and Purchasing Power Parities

Comparison and aggregation of real GDPs across countries would pose less of a problem if market (or official) exchange rates were equal to the ratios of the weighted averages of prices (at the level of GDP) in the respective countries relative to a base country. In this case, price levels, defined as the weighted average of prices (at the level of GDP) expressed in a common unit of account, would be the same in all countries. Converting GDPs in terms of current domestic prices and national currencies at market (or official) exchange rates into a common unit of account would then yield GDP data that reflect cross-country differences in real output rather than price differences. Over time, changes in the weighted average of prices in any given country relative to the numeraire country would be offset by changes in the exchange rate and would not affect the country's GDP relative to the numeraire country or any other country.

The relationship between prices and exchange rates has been the subject of numerous theoretical and empirical studies.[8] PPP theories of exchange rate determination describe an equilibrium relationship between prices and exchange rates without specifying the mechanisms that bring about this relationship.[9] They are based on the notion that in the absence of transportation cost and trade barriers, the law of one price ensures that the prices of homogeneous goods are equalized across countries:

$$p_i = sp_i^*, \tag{1}$$

where

p_i = the price of good i; and
s = the market exchange rate defined as units of domestic currency per unit of foreign currency.

Variables relating to the foreign country are marked with an "*."

If all goods are tradable, the PPP rate can be defined as

$$s_{PPP} \equiv \frac{\prod_{i=1}^{m} p_i^{a_i}}{\prod_{i=1}^{m} p_i^{*a_i^*}} = \frac{s\prod_{i=1}^{m} p_i^{*a_i}}{\prod_{i=1}^{m} p_i^{*a_i^*}}, \tag{2}$$

assuming that the arbitrage condition described by equation (1) holds. According to equation (2), the market exchange rate s is equal to the PPP rate, s_{PPP}, if $a_i = a_i^*$; that is, if the weights are the same in both countries.

In the presence of nontradables, assuming that the law of one price holds for all tradable goods, the PPP rate can be defined as

$$s_{PPP} \equiv \frac{P_N^{\alpha} P_T^{(1-\alpha)}}{P_N^{*\alpha *} P_T^{*(1-\alpha *)}} = \frac{s(P_N/P_T)^{\alpha}}{(P_N^*/P_T^*)^{\alpha *}}, \tag{3}$$

where

$$P_N = \prod_{j=1}^{n} p_{Nj}^{b_j}$$

$$P_T = \prod_{i=1}^{m} p_{Ti}^{a_i}$$

and similarly for P_N^* and P_T^*. The share of nontradables in total output is represented by α. If some goods are nontradable, the market exchange rate s is only equal to the PPP rate, s_{PPP}, if $(P_N/P_T)^{\alpha} = (P_N^*/P_T^*)^{\alpha *}$, that is, if the relative prices and shares of nontradables are the same in both countries.[10]

Not all PPP theories of exchange rate determination refer to the concept of PPP described by equation (3). PPP theories can be formulated in absolute form, as in equation (3), relating the level of the exchange rate to relative price levels, or in relative form, relating changes in exchange rates to changes in relative price levels.[11] Also, PPP theories differ in the definition of the price level and the time horizon for which the equilibrium relationship between prices and exchange rates is expected to hold. Empirical tests of these various forms of PPP provide useful information about the relationship between prices and exchange rates. However, market (or official) exchange rates would be appropriate conversion factors for GDPs only if there was evi-

[8]See, for example, Officer (1976b), Levich (1985), Dornbusch (1989), Isard (1988), and Mussa (1990) for surveys of the literature.

[9]This point is emphasized in Frenkel (1981).

[10]McKinnon (1979) discusses the conditions that must be met for PPP to hold for the overall price level.

[11]See Officer (1976b) for a discussion of various forms of PPP theories.

dence that PPP holds for broadly defined price indices and in the absolute form described by equation (3).

A number of empirical and theoretical studies suggest that the conditions for $s = s_{PPP}$ are likely to be violated frequently.[12] Although the law of one price is believed to hold for a subset of internationally traded goods, such as primary commodities, Isard (1977, p.942) concludes that it is "flagrantly and systematically violated" for manufactured goods.[13] Moreover, there is evidence that the ratio of the price levels of traded and nontraded goods differs systematically across countries and changes over time.[14]

A well-known explanation of differences in the relative prices of tradables and nontradables across countries is the "productivity difference model," which dates back to Ricardo and was developed mainly by Balassa (1964).[15] This model assumes that international productivity differences tend to be larger in the tradables than in the nontradables sector and that prices for tradables are determined in international markets.[16] With marginal cost pricing, intercountry differences in factor prices reflect productivity differences in the tradables sector, while unrestricted factor mobility within each country ensures equalization of factor prices across sectors. Under these conditions, relatively high productivity in the tradables sector translates into relatively high wages and prices in the nontradables sector.[17] The market exchange rate of a country with higher productivity than the numeraire country is thus likely to be more appreciated than the PPP rate, unless the differences in the relative prices of tradables and nontradables are fully offset by differences in their respective weights in total output.[18]

Direct empirical tests of PPP are generally based on time-series data, with prices in each country expressed in the form of intertemporal indices rather than ratios of weighted averages of prices as in equation (3). Unless the market exchange rate is known to be equal to the PPP rate in the base period, such tests cannot ascertain whether $s = s_{PPP}$; they only test whether there is a one-to-one relationship between the index of s and the ratio of the corresponding price indices over time (absolute PPP), or between the changes in the index of s and the changes in the corresponding price indices (relative PPP). The evidence from these tests is mixed,[19] illustrating, for example, significant short-run deviations from PPP, which are generally attributed to differences in the degree of price flexibility in goods and asset markets.[20] While several empirical studies confirm the validity of absolute PPP in the long run for major currencies during the 1920s,[21] and more recent analyses of the time-series properties of real exchange rates seem to suggest that some form of long-run PPP exists,[22] available evidence does not support the notion that PPP holds in its strong, absolute form over a reasonable time horizon.

To sum up, the direct empirical evidence on PPP theory indicates that market exchange rates differ frequently, and for extended periods, from PPP rates. Moreover, indirect evidence suggests that the conditions for PPP to hold in its strong, absolute form for broadly defined price indices are generally violated. In these circumstances, market exchange rates are unlikely to be good proxies for the conversion factors that are required to offset international differences in price levels and to derive real GDP data that are comparable across countries.

Aggregation with GDP Weights Based on Exchange Rates

Notwithstanding their shortcomings, market exchange rates are widely used in comparisons and aggregations of GDPs and related economic data. The weighting system used to aggregate time series of GDP growth rates, investment ratios, and con-

[12]See, for example, Samuelson (1984) for a theoretical discussion of the necessary conditions for $s = s_{PPP}$ to hold.

[13]Isard's conclusion is based on an empirical analysis at a disaggregated level of the dollar prices of German goods relative to their U.S. equivalents.

[14]Officer (1976b) and Kravis and Lipsey (1983) survey the most important studies in this area.

[15]For a discussion of the historical origins of the model, including a statement of the theory by Harrod, see Kravis and Lipsey (1983) and Marris (1984).

[16]Balassa (1964) discusses some indirect empirical evidence on international productivity differences in tradables and nontradables sectors.

[17]Bhagwati (1984) has proposed an alternative (or supplementary) explanation for international differences in prices for nontradables in the vein of the standard factor proportions model of international trade. The argument is based on the observation that nontradables, notably services, are relatively labor intensive in all countries. Since labor is highly productive and expensive in countries with a relative abundance of capital, prices of labor intensive services tend to be relatively high in such countries. The reverse argument can be made for countries with a relative abundance of labor. Bhagwati's argument presupposes that the countries compared do not lie in the same cone of diversification so that factor price equalization across countries fails.

[18]According to equation (3), the market exchange rate tends to be more appreciated than the PPP rate in countries where the ratio of the prices of nontradables to the prices of tradables is higher than in the numeraire country.

[19]See Officer (1976b), Dornbusch (1989), and Isard (1988) for surveys of empirical tests of PPP theory.

[20]See Frenkel (1981) for a discussion of these issues in the context of an analysis of deviations from PPP during the 1970s.

[21]See, for example, Frenkel (1978), and Taylor (1991).

[22]See McDonald (1992) for a summary of these studies.

sumer price inflation in the IMF's *World Economic Outlook*[23] was based on three-year moving averages of nominal GDPs converted into U.S. dollars at market (or official) exchange rates. These exchange rates were adjusted on a case-by-case basis to account for apparent anomalies in levels or changes, such as large, discrete changes in official exchange rates or large spreads between official and secondary market rates. In the World Bank's *Global Economic Prospects and the Developing Countries*,[24] growth rates of real GDP are aggregated on the basis of GDP weights, with GDPs in constant 1987 prices in national currencies converted into U.S. dollars at the period average market exchange rate of the base year. Constant GDP weights based on market exchange rates are, in principle, also used to aggregate time series of consumer price inflation and money growth in the IMF's *International Financial Statistics (IFS)*, but weights for a given base year are applied to subperiods of about five years, which are spliced to create a continuous time series.[25]

There are no well-established criteria for choosing between alternative forms of exchange rate based weights; choices of base years or certain averaging procedures are thus generally based on pragmatic considerations.[26] These largely arbitrary choices can have a significant impact on the weighting system and thus on the derived aggregates.

Table 1 illustrates how alternative exchange rate based weighting systems affect aggregate real GDP growth rates for major country groups in 1983–92. The table shows mean deviations and mean absolute deviations between the aggregates based on the weights used in the past in the *World Economic Outlook* and aggregate growth rates based on the same set of country data but different exchange rated based weighting schemes. Although the differences between the aggregate growth rates for the world and for the industrial countries are relatively small, considerable discrepancies exist between the aggregate growth rates for the developing countries as a group and, in particular, for certain developing regions, such as the Middle East and Europe, Africa, and the Western Hemisphere. For example, the aggregate growth rates for the developing countries based on real GDP weights with 1980 as base year differ, on average, by about ½ of 1 percentage point from the corresponding aggregate based on "old" *World Economic Outlook* weights; for the developing countries in the Middle East and Europe, aggregate growth rates differ for some weighting schemes on average by 1 to 2 percentage points. Even nominal GDP weights, which are conceptually the same as the old *World Economic Outlook* weights, but do not include the averaging and the case-by-case adjustments of the latter, yield aggregate growth rates that are in some cases significantly different from the aggregates based on old *World Economic Outlook* weights, particularly for the Middle East and Europe. While the means of absolute deviations are considerably larger than the mean deviations, suggesting that most discrepancies cancel out over time, the comparison indicates that the choice among alternative exchange rate based weighting systems can have significant implications for interpreting developments in output growth at the aggregate level.

GDP Weights Based on Purchasing Power Parities

Problems of PPP Index Construction

The International Comparison Program

Widespread interest in international comparisons of national incomes and recognition that conversion factors based on market exchange rates are poor substitutes for PPPs led to the creation of the International Comparison Project, later renamed the International Comparison Program (ICP). Its task was to estimate PPPs on the basis of price surveys for certain benchmark years. The ICP began in the late 1960s as a joint venture of the United Nations and the International Comparison Unit of the University of Pennsylvania, with initial support from the Ford Foundation and the World Bank.[27] Phases I and II of the ICP focused on methodological issues and produced PPP-based comparisons of national incomes for a small number of industrial and developing countries for the reference years 1967, 1970, and 1973. Beginning with Phase III, the ICP became a regular exercise that has generated benchmark estimates of PPPs in five-year intervals for an increasing number of countries.

[23]See, for example, International Monetary Fund (1991b).

[24]See World Bank (1991).

[25]See p.15 in International Monetary Fund (1991a), for a description of the weighting scheme.

[26]The choice between fixed and moving weights, however, depends on the specific focus of the analysis. Aggregation of GDP growth rates with fixed weights, for example, yields a weighted average of growth in individual countries, while moving weights yield an aggregate growth rate that reflects developments in total output of the group considered. Specifically, aggregating growth rates of real GDP with real GDP weights that are lagged one period is equivalent to calculating the growth rate of the sum of the GDPs considered.

[27]Antecedents of ICP comparisons include those done within the Organization for Economic Cooperation and Development (OECD) and among the former Council for Mutual Economic Assistance countries in the 1950s. For a brief history of the ICP, see United Nations, Statistical Office (1991).

Table 1. Effects of Alternative Exchange Rate Based Weighting Schemes on Aggregate Real GDP Growth
(In percentage points)

	Average Annual Growth of Real GDP 1983–92[1]	Mean Deviations, 1983–92							
		Nominal GDP weights[2]	Variable real GDP weights with base years[3]			Constant real GDP weights with base years[4]			*IFS* Weights[6]
			1980	1985	1987	1980	1985	1987[5]	
World	2.7								
Mean deviation		0.08	−0.11	−0.04	0.02	0.07	−0.01	0.01	−0.01
Mean of absolute deviations		0.13	0.17	0.13	0.09	0.15	0.15	0.09	0.12
Industrial countries	2.9								
Mean deviation		−0.02	0.10	0.04	0.01	0.10	0.03	0.01	0.03
Mean of absolute deviations		0.03	0.10	0.12	0.05	0.10	0.14	0.03	0.10
Developing countries	3.8								
Mean deviation		0.04	−0.48	−0.19	−0.01	−0.04	−0.27	−0.25	−0.27
Mean of absolute deviations		0.15	0.51	0.24	0.29	0.52	0.40	0.51	0.38
Africa	1.8								
Mean deviation		0.01	−0.31	−0.37	−0.02	−0.35	−0.38	−0.08	−0.30
Mean of absolute deviations		0.13	0.49	0.54	0.49	0.53	0.51	0.57	0.32
Asia	7.2								
Mean deviation		−0.02	−0.32	−0.02	0.10	−0.06	−0.05	−0.04	−0.03
Mean of absolute deviations		0.06	0.43	0.20	0.17	0.20	0.13	0.14	0.11
Middle East and Europe	1.5								
Mean deviation		−0.01	−0.25	−0.02	−0.20	−0.56	−0.61	−0.63	−0.60
Mean of absolute deviations		0.48	0.70	0.94	1.02	1.96	1.36	1.33	1.26
Western Hemisphere	1.8								
Mean deviation		0.15	−0.21	−0.17	0.01	−0.25	−0.21	−0.04	−0.20
Mean of absolute deviations		0.29	0.48	0.31	0.25	0.60	0.29	0.28	0.24
Former centrally planned economies	−0.9								
Mean deviation		0.02	0.04	−0.02	0.02	0.04	−0.03	0.01	−0.03
Mean of absolute deviations		0.06	0.14	0.15	0.09	0.17	0.18	0.11	0.16

[1]Average annual growth rates are derived from the World Economic Outlook country data bank of May 1993, and the weights used in the *World Economic Outlook* prior to the May 1993 issue. These weights are three-year moving averages of U.S. dollar GDPs derived from nominal GDPs in national currency, converted at market exchange rates, adjusted on an ad hoc basis, and lagged one period. Mean deviations are calculated as the arithmetic averages of the differences between aggregate growth rates based on these "old" World Economic Outlook weights and aggregates based on the same country data set and the weights indicated in the table. Means of absolute deviations refer to the arithmetic averages of absolute deviations.

[2]Nominal GDPs in national currencies converted into U.S. dollars at period average market exchange rates, lagged one period.

[3]Real GDPs in national currency converted into U.S. dollars at the period average exchange rate of the base year, lagged one period.

[4]Real GDPs of the base year converted into U.S. dollars at the average market exchange rate of the base year.

[5]Aggregate growth rates in the World Bank's *Global Economic Prospects and the Developing Countries* (May 1991) are based on constant 1987 GDP weights.

[6]*International Financial Statistics* (*IFS*) aggregates of changes in consumer prices are based on constant GDP weights for subperiods (1980 weights for 1978–83, and average 1984–86 weights for 1983 onward), which are spliced at overlapping years. See, for example, International Monetary Fund (1991a), p.15, for a description of this weighting system.

Interest in intraregional comparisons brought about a growing regionalization of the ICP during the 1980s, with regional organizations assuming a central role in ICP-related statistical work. Current work on PPP estimation in various regional centers, including the Organization for Economic Cooperation and Development (OECD) and the Statistical Office of the European Communities, is based on the methodological foundations developed in the context of the ICP. The program has now entered Phase VI, which is to produce estimates for the reference year 1990.

Desired Properties of a PPP Index

A PPP index is a type of international price index with a particular set of desired properties.[28] At the disaggregated level, PPP for a given pair of countries j and k refers to the ratio of prices for a well-defined item i:

$$PPP_{ijk} = p_{ij}/p_{ik}. \quad (4)$$

[28]Conversely, a price index can be regarded as a conversion factor used to convert income or output valued at the prices of

To determine the overall purchasing power of country j's currency relative to that of country k, a large number of prices for individual items must be aggregated to yield a ratio of weighted averages of prices. PPP at the level of GDP is thus a function of prices and weights:

$$PPP_{jk} = f(P, W). \qquad (5)$$

Evidently, the resulting *PPP* depends on the composition of P and W, as well as on the functional form of equation (5). For example, if *PPP* is derived from weighted arithmetic averages of prices in countries j and k, weights based on quantities in country j (corresponding to a Paasche formula) will normally yield a lower PPP_{jk} than weights based on quantities in country k (corresponding to a Laspeyres formula). This is because of substitution effects, which typically result in widely observed negative correlations between prices and quantities—a well-known problem in the literature on index numbers.[29]

The core problems in constructing a *PPP* index are choosing the appropriate sets of prices and weights and determining the precise form of $f(P, W)$. To evaluate solutions to these problems, it is useful to consider the desired properties of a PPP index.[30] In general, a PPP index should meet the following requirements:

Base country invariance. All countries included in a comparison should be treated in such a way that the resulting PPPs will be independent of the country chosen as the base (or numeraire) country.[31]

Transitivity. In a multilateral comparative study involving (at least) three countries (j, k, m), an index PPP_{jm} multiplied by another index PPP_{mk} should equal the directly calculated index PPP_{jk}.

Additive (matrix) consistency. Derived quantities (in value terms) for subaggregates should be stated in a way that allows for comparisons across subaggregates (within one country) and across countries (within any subaggregate).

Characteristicity. The quantity weights used for PPP index construction should be characteristic of the countries involved, that is, reflect the actual quantities consumed in those countries.

Unfortunately, it is not possible to construct a single index that satisfies all requirements simultaneously. In practice, for example, there is a tradeoff between transitivity and characteristicity.[32] If PPPs are estimated in order to derive internationally comparable real GDP data, then base country invariance and transitivity are important properties since they ensure a unique ordering of countries according to their PPP-based GDPs.[33] Characteristic weights are very desirable, but in worldwide comparisons characteristicity is constrained by the transitivity requirement.

In principle, a multilateral system of PPP indices can be derived from individual bilateral comparisons. To fulfill the transitivity requirement, all bilateral comparisons must be calculated using the same weights from a given base country. This approach—termed the "star country method"—results in indices that are not invariant to the choice of the base country. As a general rule, base country invariance and transitivity can be achieved only if each bilateral comparison in a multicountry framework uses information on prices and weights for all countries included in the comparison.

Methodology of the ICP

The approach to multilateral PPP index construction chosen by the ICP is the Geary-Khamis method,[34] which is conveniently summarized in the following sets of simultaneous equations:

$$\pi_i = \sum_{j=1}^{n} \frac{p_{ij}}{PPP_j} \left[\frac{q_{ij}}{\sum_{j=1}^{n} q_{ij}} \right] \quad i = 1, \ldots, m \quad \text{and} \qquad (6)$$

$$PPP_j = \frac{\sum_{i=1}^{m} p_{ij}\, q_{ij}}{\sum_{i=1}^{m} \pi_i\, q_{ij}} \qquad j = 1, \ldots, n, \qquad (7)$$

where i denotes each of m categories of goods and j each of n countries included in the comparison, p_{ij} the price of good i in country j, q_{ij} the quantity of

different time periods (intertemporal price index) or the prices of different countries (international or PPP index) into income or output valued at the prices of a certain base period or a certain base country.

[29]See, for example, Allen (1975) and Marris (1984).

[30]These properties are discussed in Drechsler (1973), Allen (1975), and Kravis and others (1975).

[31]In a demand-theoretic context, imposing base country invariance is equivalent to requiring that the consumer utility function assumed for all countries is homothetic.

[32]In a multilateral framework, characteristicity requires that each bilateral comparison should ignore the outside world and focus on weights that are characteristic of only the countries compared. This results in a different set of weights for each bilateral comparison and thus indices that are not transitive.

[33]If PPPs are calculated for a different purpose, the preferred ordering of desired properties may well be different.

[34]This method was originally suggested by Geary (1958) and amplified by Khamis (1972); see Kravis and others (1975) and Kravis, Heston, and Summers (1982).

good i in country j, π_i the international price of good i, and PPP_j the PPP of country j.

The basic idea of the Geary-Khamis approach is to express PPP for a given country j as the ratio of total expenditure valued at country j's own prices p_{ij} to total expenditure valued at international prices π_i. These international prices are in turn a weighted average of the domestic prices of all countries included in the comparison, with domestic prices converted into the currency of the numeraire country at the individual country's PPP and the weights reflecting each country's share in the total quantity of each good. PPPs and πs can be derived simultaneously from the above system of $m + n$ equations, using prices and quantities in individual countries as inputs. Only $m + n - 1$ equations of the system described by equations (6) and (7) are independent, and PPP for the numeraire country is set equal to 1.

The Geary-Khamis method has been criticized by some ICP experts (Drechsler (1988)) because it implies that the structure of the derived international prices is closer to the price structure of large and rich countries than to that of small and poor countries. In comparisons dominated by large and rich countries, this results in an underestimation of the PPPs and an overestimation of PPP-based GDPs of small and poor countries relative to those of large and rich countries. In comparisons that include small and rich countries as well as large and poor countries, the bias is less likely. Also, empirical studies suggest that the impact of different structures of international prices on the estimates of PPP-based GDP is relatively small.[35]

To keep the system manageable, the number of prices included in each PPP calculation should be limited. The ICP approached this problem by dividing the main subaggregates of GDP into approximately 150 detailed categories of goods and services,[36] and deriving prices for these categories as simple geometric averages of the prices of several well-defined items.[37] The approach may be illustrated by a matrix (M) of prices of items in a given category, with the element P_{gn} representing the price of item g in country n.[38]

$$M = \begin{matrix} P_{11} & P_{12} & \cdots & P_{1n} \\ P_{21} & P_{22} & \cdots & P_{2n} \\ \cdot & \cdot & & \cdot \\ \cdot & \cdot & & \cdot \\ \cdot & \cdot & & \cdot \\ P_{g1} & P_{g2} & \cdots & P_{gn} \end{matrix} \quad . \tag{8}$$

The main problem in deriving a transitive system of category prices is the requirement that the prices should be based on the same set of items for each country—that is, the matrix M should have no empty cells. A possible solution would be to exclude items that cannot be priced in all countries. This would greatly reduce the number of items in each category, however, and unduly limit the characteristicity of the results. To overcome this difficulty, the ICP developed the Country-Product-Dummy (CPD) method,[39] which is a regression procedure for estimating the missing observations from the available price data.[40]

[35]Kravis and Lipsey (1990) have reaggregated Phase III (1975) ICP data using international prices based on equal weights for rich and poor countries. Their results suggest that changing the structure of international prices in this way has a relatively modest impact on the estimates of PPP-based GDP, ranging from 9 percent to 13 percent for the eight poorest sample countries where the potential upward bias of the Geary-Khamis method would be greatest.

[36]These include approximately 110 categories for consumption, 35 for investment, and 5 for government.

[37]The ICP surveys prices of between 400 and 700 items in the participating countries. Determining these prices is difficult, since quality differences as well as price differences between different types of outlets, regions, and seasons must be taken into account. Frequently it is not possible to derive perfectly matching national average annual prices on the basis of survey data alone, and adjustments need to be made to account for quality and other differences that influence prices. Problems of quality differences are particularly serious for certain categories (e.g., housing and cars), and in a number of cases ICP experts have used hedonic regression methods to estimate such prices. For a detailed discussion of problems relating to international price comparisons, see Kravis and others (1975); Kravis, Heston, and Summers (1982); United Nations, Economic Commission for Europe, and United Nations Statistical Commission (1988); and United Nations, Statistical Office (1991).

[38]The prices used are final product prices, which include explicit or implicit taxes and subsidies. The derived international prices thus reflect the average of such price distortions across countries. Valuing expenditures for a given country at these international prices (which is done by dividing expenditures in terms of national prices and currency by the PPP index) therefore eliminates the impact on real GDP of a price structure that is more distorted than price structures in the rest of the world.

[39]This method was developed by Robert Summers and is described in detail in Summers (1973) and in Kravis and others (1975). Since countries with many price observations have a greater influence on the estimated category prices than countries with only a few observations, price observations for each country were weighted by the reciprocal of the number of prices available for that country. The CPD approach is a genuinely multilateral method that makes optimal use of the basic price information available. Its main drawback is that it requires specification of items that can be priced in a relatively large number of countries, which can limit the characteristicity of the items chosen if the comparison covers a large set of very diverse countries.

[40]An alternative approach to the calculation of PPPs at the basic category level is the Elteto-Koves-Szulc (EKS) method, described in Kravis, Heston, and Summers (1982), p. 76. This method is a multilateralized bilateral approach that derives category PPPs from a large set of bilateral PPPs for all countries

For certain service categories, such as general government services and education, direct price comparisons are not possible because market prices are not observed. In these cases, the ICP has employed indirect estimation methods based on input cost or, in some instances, on output-related quantity information that has been used to derive implicit price comparisons. Although these methods are clearly less reliable than direct price comparisons, it is worth noting that they are also used in intertemporal comparisons where similar problems with "comparison resistant services" are encountered.[41]

With category prices and derived "notional quantities" as inputs,[42] the Geary-Khamis method described by equations (6) and (7) can be used to derive PPPs.[43] These PPPs are expressed in terms of the numeraire country's currency—usually the U.S. dollar—but they are invariant to the chosen base country. In addition, they fulfill the requirements of transitivity and matrix consistency. Dividing the sum of all expenditure categories valued at national prices and in national currencies by these PPPs yields expenditure valued at constant international prices (in terms of U.S. dollars).

As noted above, the ICP became increasingly regionalized, during the 1980s.[44] The emphasis on intraregional comparisons (covering the European Community and the OECD area, in particular) helped to enhance the characteristicity of the comparisons within a given group of countries. Inevitably, however, it was achieved at the cost of the quality of interregional comparisons. As the international prices used for estimating PPPs in regional comparisons are based on prices of countries in a particular region, GDP for a given country valued at international prices can vary considerably, depending on the specific region for which the analysis is carried out.[45] In order to avoid the proliferation of conflicting results, the ICP has accepted the principle of "fixity," which states that a result published for a regional comparison must remain unchanged if it is used in any other comparison involving a larger set of countries.[46] Fixity, however, cannot be achieved without cost. The methods developed to ensure fixity either produce the desired result only at the aggregate GDP level or result in subaggregates that meet the fixity requirement but are nonadditive, with components of GDP not adding up to total GDP.

Intertemporal Extension of Benchmark Data

Because of the considerable cost of benchmark studies, which require collecting and processing of a large amount of price and expenditure data, it is generally not feasible to produce benchmark data on an annual basis. Time series of PPP-based real GDP must therefore be derived from extrapolated benchmark data.

GDP at constant international prices can, in principle, be extrapolated using growth rates of real GDP in national currency. As these growth rates represent domestic rather than international price weights, however, they may cause distortions in the time series for GDP at constant international prices. To minimize such distortions, Summers and Heston (1988) suggest a method that extrapolates the principal components of GDP at constant international prices on the basis of the corresponding real growth rates from national sources; these components are then aggregated to GDP at constant international prices.

A special problem arises in relation to countries for which multiple benchmark studies are available. In theory, the rate of change of GDP at constant international prices derived from two benchmark studies should be equal to the rate of change over

included in a comparison. By building on bilateral comparisons, the EKS method can incorporate prices of items that are generally more characteristic of the countries compared than the prices used in the multilateral CPD method. The EKS method, however, is likely to be more resource intensive, because it requires a large number of bilateral pricing exercises. It has mainly been applied in comparisons among European Community and OECD countries. The United Nations' draft handbook on the ICP leaves open the question of possible future changes in ICP methodology; see United Nations, Statistical Office (1991).

[41]Even for services with observed market prices, comparisons tend to be less reliable than for goods because output and quality differences of services are more difficult to measure. Calculations by Kravis, Heston, and Summers (1982), p. 140, suggest that estimates of real GDP are, however, relatively insensitive to varying assumptions about productivity in comparison resistant services.

[42]"Notional quantities" are category quantities valued at corresponding U.S. prices, derived by dividing category expenditures by category price parities.

[43]In practice, the ICP has used a modified form of equations (6) and (7), with all prices are expressed relative to prices in the United States, that is, as category price parities relative to the United States, which serves as the numeraire country. The resulting international price for a category i is thus π_i/p_{ius}. This modification does not affect the PPPs. The procedure above does not apply to certain special components of GDP, such as changes in stocks and net exports of goods and services; treatment of these components is described in Kravis and others (1975).

[44]This development, related to a shift in funding for the project, is discussed in Drechsler (1988).

[45]In principle, this problem also arises in worldwide comparisons if the sample of countries considered is not representative of all countries. The ICP dealt with the problem by weighting individual sample countries according to their representativeness in the world.

[46]See Drechsler (1988) for a detailed discussion of the fixity issue.

the same period derived from the corresponding national accounts series in constant prices. In practice, however, this is frequently not the case, even when allowance is made for differences in methodology between individual benchmark studies.[47] Because international comparisons and national accounts data are both subject to error, Summers and Heston argue that there is no a priori reason for considering one system more reliable than the other. Therefore, instead of discarding information from multiple benchmark studies in favor of national accounts growth rates, they apply a special procedure that ensures the consistency of the data from both sources. This procedure is based on a general errors-in-variables model that produces adjustment factors for national accounts growth rates as well as for benchmark data.[48]

Estimation of PPPs for Nonbenchmark Countries

Cost constraints have also limited the number of sample countries for which benchmark comparisons have been undertaken. Extending the scope of PPP-based GDP data to a global system therefore depends on the quality of possible "short-cut" methods for estimating PPPs of countries not yet included in benchmark studies.

One such method is to estimate a simple model of the relationship between PPPs and exchange rates for benchmark countries and to use this "bridging equation" to predict PPPs for nonbenchmark countries. The theoretical arguments outlined in the previous section suggest that structural characteristics, such as relative productivity levels, may help to explain differences in the ratio of PPP to the exchange rate (real price level) across countries. In the empirical literature, real per capita GDP has been widely used as a proxy for productivity levels, and much of the research has focused on the relationship between real per capita GDPs and real price levels.[49] To use these price level equations as bridging equations, PPP-based per capita GDP must be replaced by exchange rate based per capita GDP as the explanatory variable. Alternatively, bridging equations that include real PPP-based per capita GDP as the dependent variable and exchange rate based per capita GDP as the main explanatory variable can be estimated directly. This approach was adopted in several studies by the ICP team.[50] Gulde and Schulze-Ghattas (1992) report estimation results for both types of bridging equations.[51]

Estimates of PPP-based per capita GDP for nonbenchmark countries in the World Bank's *World Development Report* are derived from bridging equations that include per capita GDP estimated by the Atlas method as well as secondary school enrollment as proxies for intercountry productivity differences.[52] Ahmad (1992) demonstrates that these bridging equations, while relatively simple, yield estimates for nonbenchmark countries with satisfactory statistical properties.

To improve the quality of PPP estimates for nonbenchmark countries, Summers and Heston (1988 and 1991) have developed an approach using price data from post-adjustment surveys.[53] While post-adjustment indices—based on price surveys for a special consumer basket (expatriates) in special areas (usually capital cities)—are not a perfect substitute for PPPs, they are probably more closely correlated with "true" PPPs than market exchange rates. Summers and Heston have estimated PPP-based GDPs for nonbenchmark countries on the basis of bridging equations that include PPP-based domestic absorption as the dependent variable and absorption based on the conversion factors implicit in the post-adjustment data as the explanatory variable.[54]

[47]To overcome the problem of differences in methodology, Summers and Heston (1988) re-estimated benchmark values for the years 1970, 1975, and 1980 on the basis of a common methodology and the same vintage of national accounts data.

[48]See Summers and Heston (1988) for a description of the approach.

[49]See, for example, Balassa (1964), Clague and Tanzi (1972), Officer (1976a), Kravis and Lipsey (1983), and Clague (1988). Some authors have examined the role of alternative indicators of relative productivity levels such as relative quantities or prices of skilled labor (Clague and Tanzi (1972)). Several other structural characteristics, including the relative abundance of natural resources (Clague (1988)), and openness (Kravis and Lipsey (1983)) have also been considered. Data on most of these variables, however, are not readily available for developing countries.

[50]See, for example, Kravis, Heston, and Summers (1978b and 1980) and Heston and Summers (1988).

[51]In addition to exchange rate-based GDP, Gulde and Schulze-Ghattas (1992) used openness and money growth in their bridging equations. Openness, defined as the ratio of exports and imports of goods and services to GDP, is generally expected to have a positive effect on the price level because a high degree of openness tends to raise the price of labor, and hence the prices of labor-intensive nontradables, in countries with a greater abundance of labor than the numeraire country. Money growth is expected to capture the transitory effects on relative price levels suggested by models of exchange rate overshooting.

[52]See World Bank (1992), Table 30, and pp. 299–300.

[53]Their estimations are based on the International Civil Service Commission (ICSC) index, published in the *Monthly Bulletin of Statistics* by the United Nations Statistical Office, as well as an index published by Employment Conditions Abroad (ECA), a London-based organization. In addition, Summers and Heston (1991) incorporate information on cross-country differences in housing cost from the U.S. State Department, since other post-adjustment indices tend to be weak in this area.

[54]Domestic absorption was chosen instead of GDP because the real expenditure shares required for the intertemporal extension of PPPs relate to domestic absorption rather than GDP. See Summers and Heston (1984 and 1988).

Table 2. Prediction Properties of Alternative Bridging Equations

	Percent Deviations Between Predicted and Actual Benchmark Values of PPP-Based Per Capita GDP[1]	
	Mean deviation	Mean absolute deviation
1985 benchmark values of PPP-based per capita GDP derived from bridging equation for (dependent variable, sample)		
Price level, all countries in 1980 benchmark study[2]	29.83	33.79
Price level, developing countries in 1980 benchmark study[3]	26.74	28.81
PPP-based per capita GDP, all countries in 1980 benchmark study[4]	−2.25	27.94
PPP-based per capita GDP, developing countries in 1980 benchmark study[5]	−1.79	34.65
Memorandum items[6]		
1985 benchmark values predicted by per capita GDP converted at market exchange rates	−61.22	61.22
1980 benchmark values predicted from bridging equation with exchange rate based domestic absorption as explanatory variable[7]	. . .	15.30
1980 benchmark values predicted from bridging equation with domestic absorption based on UN post-adjustment data as explanatory variable[7]	. . .	12.30

[1]Percent deviations were calcuated as [(predicted-actual)/actual]*100. Means refer to arithmetic averages for a sample of 13 developing countries that were included in the 1985 benchmark study but not in the 1980 benchmark study. The bridging equations yield predictions for 1980 PPP-based per capita GDP, which were extrapolated to 1985 using the growth rates of real per capita GDP from Summers and Heston (1991).

[2]Based on equation (1), Table 7, in Gulde and Schulze-Ghattas (1992). The price level is defined as the ratio of the PPP rate to the market exchange rate. Predicted values for the price level were used to derive PPPs, which then were used to convert per capita GDP in national currency.

[3]Based on equation (6), Table 7, in the appendix to Gulde and Schulze-Ghattas (1992).

[4]Based on equation (1), Table 8, in the appendix to Gulde and Schulze-Ghattas (1992).

[5]Based on equation (5), Table 8, in the appendix to Gulde and Schulze-Ghattas (1992).

[6]Corresponding data are not available for World Bank estimates. See World Bank (1992) and Ahmad (1992) for an evaluation of the World Bank approach.

[7]The mean absolute deviations reported here are taken from Kravis and Lipsey (1990), who estimated alternative bridging equations with PPP-based domestic absorption as the dependent variable for two subsets of the 1980 (Phase IV) benchmark countries. The results were used to predict PPP-based domestic absorption for the other subset. GDP was derived by adding the foreign balance (converted at the market exchange rate) to domestic absorption. See Kravis and Lipsey (1990), Table 4.

Table 2 examines the out-of-sample prediction properties of alternative bridging equations. For a set of countries included in the benchmark study for 1985 but not for 1980, benchmark values of PPP-based per capita GDP for 1985 are compared with predictions from alternative bridging equations that were estimated for the sample of 1980 benchmark countries. Mean deviations between exchange rate based per capita GDPs and the ICP benchmark values are included for comparison. In addition, the table shows the results from an evaluation by Kravis and Lipsey (1990) of the prediction properties of bridging equations that include as explanatory variables exchange rate based data and data based on post-adjustment indices.

Three main conclusions emerge from Table 2. First, while predictions from bridging equations are subject to substantial errors, the errors are considerably smaller than those resulting from approximating PPPs by exchange rates. Second, while predictions based directly on per capita GDPs converted at market exchange rates entail a marked downward bias, there is no strong bias in the predictions derived from the bridging equations with PPP-based per capita GDP as the dependent variable. Third, the information incorporated in the post-adjustment data improves the prediction properties of the bridging equations.

Aggregation with GDP Weights Based on PPP

With five benchmark studies completed to date, the ICP has produced estimates of PPP-based GDP for 80 countries for at least one, and in most cases several, of the benchmark years. Extended over time and supplemented by estimates for non-benchmark countries, these data represent a possible alternative to exchange rate based GDP weights.

As a result of the regionalization of the ICP, worldwide comparisons have, unfortunately, lagged behind. In 1986 and 1987, the United Nations Statistical Office and the European Community published an international comparison based on linked regional comparisons of the 1980 benchmark study.[55] There is, to date, no similar

[55]See United Nations, Statistical Office, and Commission of the European Communities (1986–87).

Box 1. Dollar GDP Estimates for China

Dollar GDP estimates for China by Taylor (1991) are similar to estimates by Kravis (1981) and the Penn World Tables Mark 5 (PWT5) of Summers and Heston (1991) in that they are based on detailed PPPs. They differ in that Taylor's PPPs were of more recent vintage and were far more extensively documented than in other studies, and his dollar GDP estimates were developed by industry of origin rather than by final expenditure, which conform better with the manner in which China's official GDP data are compiled and published.

Taylor first calculated a benchmark dollar GDP estimate for 1981 by using PPPs to convert all intermediate flows in the State Statistical Bureau of China's 1981 input-output table into U.S. dollars. PPPs (yuan/dollar price ratios) for over 200 items were used in this exercise, with detailed documentation of sources. These intermediate flows were then subtracted from similarly converted gross output statistics for each sector, yielding "double-deflated" PPP estimates of value added in dollars. The detailed dollar estimates were then aggregated to primary (agriculture), secondary (industry and construction), and tertiary sectors (transport, post, and telecommunications; wholesale and retail trade; and services), then summed to obtain a dollar GDP estimate for the benchmark year. Dollar GDP estimates for earlier and later years were then calculated by applying constant price output indices published by China to the three sectors of GDP, and summing. The resultant dollar GDP series was converted to 1990 prices using the U.S. implicit price deflator for GDP.

Consistent with the valuation basis used in the 1981 input-output table, the yuan prices used in calculating Taylor's PPPs were Chinese producer prices or farm-gate procurement prices. Dollar prices were either prices on world markets, Japanese or U.S. producer prices, or import unit values (adjusted to remove insurance and freight margins). Taylor's PPPs differ from those used in other dollar GDP estimates in two respects. First, underlying data sources and actual prices used are published in much fuller detail than in other studies on China. Second, Taylor's PPPs are based on published data rather than an ICP-style survey of prices for standard products, as attempted by Kravis (1981) and, by extrapolation, Summers and Heston (1991). Taylor acknowledges that his approach could contribute to an upwardly biased dollar GDP figure if prices of low quality Chinese products were inadvertently compared with prices of higher quality goods abroad, but estimated this distortion at less than 5 percent.

Taylor approached estimating China's GDP in dollar terms from the production side rather than simply applying PPPs for each year to GDP final expenditure flows for a number of reasons. First, GDP estimates by final expenditure have not been published by China's State Statistical Bureau; official GDP statistics are available only by broad industry of origin. Second, 1981 was used as the benchmark year for Taylor's dollar GDP estimates because it corresponded to the latest official input-output table then available (a 1987 input-output table has since been published). Moreover, a 1981 benchmark estimated

comparison based on the 1985 benchmark results.[56] Summers and Heston, however, have produced a worldwide comparison based on the ICP's detailed price and expenditure composition data.[57] They have extrapolated the benchmark values according to the procedures described above using growth rates from national accounts sources. They have also estimated PPPs for nonbenchmark countries on the basis of information on post-adjustment indices. These data are included in the Penn World Tables (PWT), the most recent of which is the Penn World Table Mark 5 (PWT5). PWT5 provided the data base for this study. It contains data on GDPs at constant international prices (PPP-based GDP) for 138 industrial and developing countries, with data for 80 countries based on ICP benchmark studies, including in some cases the 1985 benchmark data. The Summers and Heston estimates for nonbenchmark countries were supplemented by World Bank estimates[58] and by estimates based on the bridging equations discussed in Gulde and Schulze-Ghattas (1992).[59] Because the PWT5 estimate of U.S. dollar GDP for China, which is based on a partial price survey in 1975 seemed less reliable than a more recent estimate produced by Taylor (1991), and the latter was used to calculate the weight for China (see Box 1). All time series on PPP-based GDPs were extended using growth rates of real GDP from the World Economic Outlook data base.[60]

[56]After the completion of this study, ICP produced a preliminary, and as yet unpublished, worldwide comparison for the 1985 benchmark study by linking individual regional comparisons. See World Bank (1992), p. 300, for a brief discussion of this approach.

[57]See Summers and Heston (1988 and 1991).

[58]See World Bank (1992).

[59]See Gulde and Schulze-Ghattas (1992), appendix, Table 8, equation 1.

[60]These growth rates are not fully compatible with benchmark data because they incorporate expenditure weights based on national rather than international prices. Results from ICP benchmark studies, however, suggest that differences between the two sets of growth rates are usually not very large;

incorporated data from post-1979 agricultural price reforms, unlike the 1975 estimates of Kravis (1981) and possibly estimates based on Kravis' data (such as PWT-5). Finally, extrapolating the benchmark estimate to earlier and later years using official GDP growth rates was necessary because of the unavailability of PPPs and input-output tables for years other than 1981.

Various PPP-adjusted dollar GDP estimates for 1991 are compared in the table below (all of which were extrapolated from their benchmark years using the real growth rate for GDP, and adjusted to current prices using the U.S. GDP deflator). As one might expect, all the PPP-adjusted figures are much higher than the exchange-rate conversion of China's GDP to dollars. However, there are also considerable differences among the PPP-adjusted GDP estimates, which range from a low of $1,278 billion (Field (1993)) to a high of $3,439 billion (PWT5). Differences in sectoral PPPs (particularly for services) are primarily responsible for these results, as are differences in estimation methodology. It should, nonetheless, be clear that Taylor's figures are among the most conservative of PPP-adjusted dollar GDP estimates for China, notwithstanding the fact that their use for regional weighting purposes in the *World Economic Outlook* increases the country's share of world output from 2 percent to over 6 percent.

There is, of course, some degree of uncertainty regarding any of these PPP-based estimates, despite the care with which authors such as Taylor compiled their PPPs and laid out their assumptions. However, until the fruits of China's participation in Phase VI of the ICP are available, estimates such as Taylor's will have to serve as the basis for PPP-adjusted weights.

Alternative Estimates of China's GDP

(In billions of current U.S. dollars)

		PPP-Adjusted Estimates			
Year	Converted at Official Exchange Rate	Field (1993)	*World Economic Outlook* (Taylor (1991))	World Bank (1993)	Penn World Table Mark 5.5
1991	379	1,278	1,413	1,931	3,439

Note: World Bank (1993) estimates are based on Ren and Chen (1993), and the Penn World Table Mark 5.5 estimates are a revised and updated version of estimates originally published in Summers and Heston (1991). Estimates by Field (1993) are based on Taylor (1991) but use a more detailed sectoral decomposition of GDP.

Estimates of GDP in terms of U.S. dollars or any other common foreign currency are particularly difficult to obtain for the former centrally planned economies. These countries typically used a large variety of exchange rates and special conversion factors, which made converting national data into foreign currency virtually impossible.[61] Given the difficulties of choosing from a large number of conversion factors that bear no resemblance to market exchange rates, most attempts to derive GDPs in terms of a common foreign currency for the formerly centrally planned economies have relied on some approximation of PPPs.[62]

ICP benchmark data are available for Hungary, Poland, and the former Socialist Federal Republic of Yugoslavia for 1980. In addition, there are data for Romania from the 1975 ICP benchmark study. For Bulgaria, the former Czech and Slovak Federal Republic (Czechoslovakia), and the former U.S.S.R., estimates of U.S. dollar GDP based on the physical indicators global (PIG) method are available from a study published in 1980 by the United Nations Economic Commission for Europe.[63] The PWT5[64] estimates of U.S. dollar

they tend to be significant only in countries where the spread between growth rates derived from base and current period weights tends to be large. In the latter case, growth rates based on national price weights are also difficult to interpret. See Summers and Heston (1991) for a more detailed discussion.

[61]In addition, national statistics in these countries were historically based on the net material product (NMP) concept, which covers only value added in the "material" sectors and thus excludes most services. However, although NMP data can be adjusted to a GDP concept in a relatively satisfactory manner, there is no generally accepted solution to the conversion problem. See Marer (1985) for a detailed discussion of this issue.

[62]See, for example, Alton (1989); Central Intelligence Agency (1990); and PlanEcon Inc. (1990).

[63]See United Nations, Economic Commission for Europe (1980) and Fink and Havlik (1989) for a description of the PIG method. PIG estimates are usually adjusted to levels that are comparable to PPP-based estimates. This adjustment procedure is described in Alton (1989).

[64]PWT5 data for Hungary, Poland, and the former Socialist Federal Republic of Yugoslavia are based on ICP Phase V

Tabl e 3. Comparison of GDP Weights Based on Exchange Rates and Purchasing Power Parities[1]
(In percent of world GDP)

	1983		1985		1992	
	Exchange Rate Based Weights	PPP-Based Weights	Exchange Rate Based Weights	PPP-Based Weights	Exchange Rate Based Weights	PPP-Based Weights
World	100.00	100.00	100.00	100.00	100.00	100.00
Industrial countries	68.37	55.45	69.28	55.19	73.95	54.63
Major industrial countries	58.19	47.68	60.14	47.55	63.13	47.08
United States	26.10	23.06	29.62	23.30	25.19	22.39
Japan	9.73	7.17	10.15	7.24	14.14	7.95
Germany[2]	6.31	4.46	5.54	4.31	6.93	4.32
France	5.28	3.73	4.52	3.55	5.13	3.57
Italy	3.69	3.54	3.54	3.44	4.75	3.43
United Kingdom	4.53	3.56	3.97	3.49	4.35	3.30
Canada	2.54	2.16	2.80	2.22	2.64	2.12
Other industrial countries	10.19	7.77	9.14	7.64	10.82	7.54
European Community	24.97	19.32	21.94	18.69	26.68	18.61
Developing countries	23.06	32.05	22.03	32.66	18.30	36.99
Africa	3.18	4.37	2.98	4.26	1.68	4.09
Asia	7.91	13.99	8.28	14.92	7.20	19.83
Middle East and Europe	4.83	4.76	4.83	4.62	4.80	4.55
Western Hemisphere	7.14	8.92	5.95	8.86	4.62	8.52
Four newly industrializing Asian economies	1.39	1.72	1.58	1.82	2.34	2.65
Fuel exporters	8.30	8.73	7.76	8.49	5.85	8.47
Non-fuel exporters	14.76	23.32	14.27	24.18	12.45	28.52
Net creditors	3.59	2.64	3.57	2.50	3.98	2.60
Net debtors	19.47	29.42	18.47	30.16	14.32	34.38
Countries in transition	8.56	12.49	8.69	12.15	7.75	8.39
Former Soviet Union[3]	6.35	9.09	6.50	8.77	6.40	6.16
Central Europe	2.22	3.40	2.19	3.38	1.35	2.23

[1]The exchange rate based GDP weights are three-year moving averages converted at market or official exchange rates, lagged by one period.
[2]Exchange rate based weights are for western Germany only; PPP-based weights are for unified Germany.
[3]The exchange rate based weights for the former Soviet Union are derived from estimates of approximate PPP exchange rates.

GDP for the Eastern European countries and the former U.S.S.R.—like other published estimates for these countries—are derived from these sources.[65]

The available set of PPP-based GDP weights is complete but not perfect. Estimates derived from ICP benchmark studies cover between 75 percent (PPP-based GDPs) and 90 percent (exchange rate based GDPs) of world output. Only the estimates for the industrial countries, however, are likely to be very reliable. Estimates for the developing countries are probably subject to much larger errors, owing to the paucity of data in many countries and the effects of a potential bias toward the prices of large or rich countries in the structure of the estimated international prices. For those countries whose PPP-based GDPs are derived from relatively simple bridging equations, and, in particular the former centrally planned economies, the errors are likely to be even larger. However, while errors for individual countries may be substantial, there is no indication that the estimates are systematically biased. Moreover, it appears that the available estimates for the developing countries are much closer to the "true" PPP-based GDPs than data converted at market (or official) exchange rates.

Table 3 compares, for illustrative purposes, the shares in world GDP based on PPPs and exchange rates for major country groups in the *World Economic Outlook*. The most striking difference between the two weighting schemes is that the PPP-

(1980) benchmark estimates. For Bulgaria, the former Czechoslovakia, Romania, and the former U.S.S.R., Summers and Heston provide only estimates of 1985 per capita GDP as a percentage of per capita GDP in the United States. For Bulgaria and the former Czechoslovakia, these estimates are derived from United Nations Economic Commission for Europe (1980); the figure for the former U.S.S.R. is based on Edwards, Hughes, and Noran (1979); the estimate for Romania is derived from the 1975 ICP benchmark study. (See Summers and Heston (1991), Appendix B, for a more detailed description of the methodology.)

[65]See Alton (1989); Central Intelligence Agency (1990); and PlanEcon Inc. (1990). Discrepancies reflect differences in the growth rates that were used to extrapolate the data as well as differences in the adjustment of PPP and PIG method estimates. The estimates for the former U.S.S.R. by the U.S. Central Intelligence Agency, however, are derived independently and differ significantly from the other sources.

Table 4. Differences Between Aggregate Real GDP Growth Rates: PPP-Based Weights and Exchange Rate Based Weights[1]
(In percentage points)

	Average (1983–92)	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
World	0.4	0.3	0.3	0.3	0.5	0.5	0.4	0.1	−0.1	0.5	1.0
Industrial countries	−0.1	0.1	—	—	—	—	−0.1	−0.1	−0.3	−0.3	0.1
Major industrial countries	−0.1	0.1	—	—	—	—	−0.1	−0.2	−0.3	−0.3	—
Other industrial countries	0.1	−0.1	−0.2	−0.1	0.1	0.1	0.1	0.1	—	0.1	0.1
European Community	—	—	—	—	—	0.1	—	—	−0.1	—	—
Developing countries	0.8	0.9	1.0	0.7	1.1	0.9	1.5	0.3	—	1.0	0.4
Africa	0.3	0.9	0.9	−0.5	0.1	0.5	0.5	0.2	0.7	0.1	−0.2
Asia	0.1	−0.3	−0.1	0.3	−0.1	−0.1	0.1	−0.1	−0.1	0.1	1.1
Middle East and Europe	1.4	1.4	1.7	1.0	3.2	2.7	2.6	−0.4	−1.2	1.6	0.9
Western Hemisphere	0.4	−0.2	0.2	0.4	0.3	0.3	0.2	0.6	0.6	0.2	0.5
Four newly industrialized Asian economies	—	0.1	—	—	—	—	0.2	−0.1	0.2	—	−0.1
Fuel exporters	1.0	0.7	1.6	0.4	1.6	1.0	2.1	0.5	−0.8	2.6	−0.7
Non-fuel exporters	0.4	0.4	0.2	0.4	0.1	0.1	0.6	0.3	0.4	0.2	1.2
Net creditors	0.5	1.9	1.7	0.4	2.9	1.2	2.9	0.5	−1.3	0.7	3.8
Net debtors	0.6	0.9	0.5	0.4	0.2	0.4	0.8	0.4	0.8	1.4	0.5
Countries in transition	0.1	—	—	—	—	−0.1	−0.3	−0.1	−0.5	−0.3	1.5
Former Soviet Union	0.1	—	—	—	—	—	—	—	—	0.1	0.6
Central Europe	0.6	0.2	−0.1	—	—	0.1	0.2	0.4	−0.2	0.4	4.0

[1]Differences between aggregate growth rates derived from weights based on PPP and exchange rates.

based GDPs imply a substantial increase in the weight for the developing countries. In interpreting this result it is helpful to recall the "productivity difference model" discussed briefly earlier in the study, which suggests that GDP data converted at market (or official) exchange rates generally understate the position of countries with relatively low productivity and hence low per capita income. This is because the market (or official) exchange rates in these countries tend to be more depreciated than the PPP rates that would offset differences in price levels across countries. The difference between PPP-based GDP weights and exchange rate based weights is particularly pronounced for the developing countries in Asia, whose share in world GDP in 1990 based on PPP weights is nearly two and a half times larger than in the "old" *World Economic Outlook* weighting system. Between 1983 and 1992, the share of the developing countries in Asia in world GDP based on PPPs increased by 6 percentage points, reflecting real GDP growth in many countries of East and Southeast Asia that was well above the world average. By contrast, the old *World Economic Outlook* weights, which are strongly influenced by movements in real exchange rates, suggest that the share in world GDP of the developing countries in Asia actually declined during 1982–90.[66]

To illustrate the impact of PPP-based weights on aggregate real GDP growth for major country groups, the country data underlying the May 1993 *World Economic Outlook* were re-aggregated using the set of PPP-based GDP weights described above. Table 4 presents the differences between these aggregates and the aggregate growth rates derived from the exchange rate based weights used previously in the *World Economic Outlook*. For the years 1989–90, there is almost no difference between world real GDP growth derived from PPP-based weights and the growth rates based on the old *World Economic Outlook* weights. For the years 1983–88, however, PPP-based GDP weights yield world GDP growth rates that are generally higher than those derived from exchange rate based *World Economic Outlook* weights. Deviations average almost ½ of 1 percentage point over the entire 1983–92 period. This increase in average world GDP growth results from the larger PPP-based GDP weight for the developing countries and the fact that these countries grew more rapidly than the industrial countries during 1983–88. In 1989–91, the growth differential disappeared, and the impact of different weighting schemes on world GDP growth became negligible.

Table 4 shows that for the industrial countries as a group, the impact of PPP-based GDP weights on aggregate real GDP growth is marginal, except for the years 1990–91. For these years, average GDP[67]

[66]The problem of fluctuating weights owing to real exchange rate movements could be overcome by adopting exchange rate based weights with a fixed base year. However, as shown earlier, movements in real exchange rates would then cause large shifts in the weights whenever the base year is changed.

[67]The World Economic Outlook data base contains GNP data for the United States, Japan, and Germany and GDP data for all other industrial countries.

growth in the seven major industrial countries derived from PPP-based weights is almost ¼ of 1 percentage point lower than the aggregate growth rates derived from old *World Economic Outlook* weights, reflecting differences in the relative weights of the United States and Japan. While the relative shares of both countries in total industrial country GDP are relatively stable over time when PPPs are used as conversion factors, they shift considerably when exchange rate based conversion factors are used. Moreover, the old *World Economic Outlook* weighting system implied a smaller U.S. share in industrial country GDP and a larger share for Japan than PPP-based weights. Because growth slowed significantly in the United States and remained strong in Japan in 1990–91, PPP-based GDP weights result in lower aggregate growth rates for both years for the major industrial countries and, consequently, for the industrial countries as a group.[68]

For the developing countries as a group, PPP-based GDP weights result in substantial increases in aggregate GDP growth rates, averaging nearly 1 percentage point during 1983–92. These increases mainly reflect a larger weight for the developing countries in Asia, many of which were growing at considerably faster rates than countries in other developing regions. Even though PPP-based GDP weights imply larger shares in world GDP for all developing regions, they imply a larger share in total developing country GDP only for Asia. For all other developing regions, the corresponding shares in total developing country GDP are smaller than in the current *World Economic Outlook* weighting system.

[68]Real GDP weights based on market exchange rates with 1985 as the base year generate aggregate GDP growth rates for the major industrial countries that are similar to those derived from PPP-based weights.

Conclusion

The available evidence on the relationship between exchange rates and PPPs suggests that exchange rates are poor proxies for the PPPs that are required to derive internationally comparable national income data. Even so, exchange rate based GDP weights in a variety of forms are widely used in aggregations of output growth and related economic data. The choice among these various sets of exchange rate based GDP weights is largely arbitrary, but it can have a significant impact on aggregate indicators of economic activity.

Estimates of PPP-based GDPs are a valuable alternative to conventional exchange rate based weighting systems and have been used for several years by such institutions as the EC Commission and the OECD, albeit only for industrial countries where reliable PPP estimates have been available for some time. PPP estimates for many developing countries are considerably weaker, and deviations from true PPPs are likely to be even larger for the countries where benchmark studies are not available. Notwithstanding these shortcomings, however, PPP-based GDP weights, as considered in this study, are probably a better measure of real output shares than exchange rate based weights, which are likely to be biased because of systematic discrepancies between PPPs and exchange rates.

The PPP estimates discussed in this study are appropriate conversion factors for GDP and related economic data. As such, they are broadly defined for a whole range of prices of tradables and nontradables, and they are unrelated to the concept of equilibrium exchange rates. Also, PPPs are not necessarily the right conversion factors for all purposes. The conversion and aggregation of international transactions valued at current market prices, such as current account and capital flows, require conversion factors that represent the actual price at which one currency is exchanged against another currency in foreign exchange markets, namely, market exchange rates.

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