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Regression Estimates of Per Capita GDP Based on Purchasing Power Parities

Sultan Ahmad

How the Bank uses regressions to fill gaps in purchasing power parity based on estimates of per capita income.

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This paper — a product of the Socioeconomic Data Division, International Economics Department — is part of a larger effort in the Department to improve international comparability of national account aggregates and price structures. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Elfrida O'Reilly-Campbell, room S7-125, extension 33707 (August 1992, 22 pages).

The estimates of gross national product (GNP) per capita in U.S. dollars published in the *World Bank Atlas* are used throughout the world for comparing relative levels of income across countries. The *Atlas* method of calculating per capita GNP is designed to smooth the effects of fluctuations in prices and exchange rates. With this method, local currency values are converted to U.S. dollars by a form of average exchange rates.

Since exchange rates do not measure relative purchasing powers of currencies in domestic markets, the *Atlas* estimates can often show changes in the relative ranking of two countries from one year to the next even if there are no changes in real growth rates but if there are changes in exchange rates that are not in line with relative price changes.

Improved estimates can be obtained if purchasing power parities (PPP) rather than exchange rates are used as conversion factors. But PPP-based estimates of per capita income — usually associated with Irving Kravis of the University of Pennsylvania and with the UN's International Comparison Program — have yet to cover all countries and all years needed in the *Atlas*.

Attempts have been made to fill the gaps by short-cut estimates using regression techniques or by using a reduced set of information. In an attempt to fill these gaps, the World Bank has used regression estimates of its own and published them in the *World Development Indicators*.

Ahmad describes how the Bank makes these estimates.

Produced by the Policy Research Dissemination Center

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by

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I. Introduction

1. The estimates of gross national product (GNP) per capita in US dollars published in the *World Bank Atlas* are used throughout the world for comparing relative levels of income across countries. The *Atlas* method of calculating per capita GNP is designed to smooth effects of fluctuations in prices and exchange rates and consists of converting local currency values to US dollars by a form of average exchange rates[2]. Since exchange rates do not measure relative purchasing powers of currencies in domestic markets, the *Atlas* estimates can often show changes in the relative ranking of two countries from one year to the next even if there are no changes in real growth rates but if there are changes in exchange rates which are not in line with relative price changes. Improved estimates can be obtained if purchasing power parities (PPP)[3] rather than exchange rates are used as conversion factors. However, PPP-based estimates of per capita income, usually associated with Professor Irving Kravis of the University of Pennsylvania, and UN International Comparison Program (ICP)[4], are yet to cover all countries and all years needed in the *Atlas*. There have been attempts in the past to fill the gaps by short-cut estimates using regression techniques or by using a reduced set of information. In an attempt to fill these gaps, the World Bank has used regression estimates of its own and published them in the World Development Indicators (WDI)[5]. This paper describes how these estimates were made.

2. Sections II and III deal with choice of methods and explanatory variables. Section IV presents selected regressions and section V analyses the results. Section VI compares the results with those of the

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[1] D. C. Rao, John O'Connor, Jitendra Borpujari and Adnan Mazarei made helpful comments on the paper; Nam Pham and Taranjit Kaur helped with the statistical work.

[2] The Atlas method consists of converting current price local currency GNP to US dollars by a three-year average exchange rate. The average is computed as follows: the current year exchange rate is added to those of the previous two years after they have been extrapolated to the current year by relative rates of inflation between the country and US, and divided by three.

[3] PPP is defined here as the number of units of a country's currency required to purchase the same amounts of goods and services in the country as one dollar would buy in the United States.

[4] The ICP conducts benchmark surveys and publishes results in phases. So far five phases have been completed as follows: Phase I for 1970 (ten countries), Phase II for 1973 (sixteen countries), Phase III for 1975 (thirty four countries), Phase IV for 1980 (sixty countries) and Phase V for 1985 (about 62 countries). Phase VI for 1990 have been completed for the OECD and several East European countries; surveys in Africa, Asia and Latin America are being planned for 1993.

[5] See *World Development Report 1992*

Penn World Tables, version 5 (PWT5)[6], the latest such estimates available in the public domain. Section VII contains concluding remarks and directions for further work.

II. Methods

3. A preferred approach to making quick estimates for countries for which ICP benchmark estimates are not available is to collect prices for a reduced sample of carefully selected items and make ICP type calculations for GDP and a small number of its components. Such a method, termed "the reduced information method"[7], requires surveys and was not pursued here.

4. The paper follows the conventional method of making shortcut estimates which uses regression techniques, and offers a plausible rationale for explaining deviations between ICP and exchange rate based estimates of GDP. This involves developing an estimating equation linking ICP estimates of GDP per capita and a selection of easily observable explanatory variables for countries for which ICP estimates are available and using the equation to estimate ICP-type values for non-ICP countries.[8] Estimates made for a reference year (1985) are extrapolated to other years by real growth rates and adjusted for US inflation in order to bring them to current dollars.

III. Selection of variables

5. In making regression estimates of ICP type per capita GDP, the choice of variables was dictated by considerations of analytical relevance and availability of information for a large number of countries, especially those reported in WDI tables.

6. In general, per capita GDP converted at PPP tends to be higher for a poorer country than the corresponding exchange rate converted value. Two empirical facts stand out in this regard:

(a) the divergence grows inversely with per capita GDP; and
(b) the noise around this relationship increases inversely with income levels.

This is confirmed by Chart 1 which shows the deviations between ICP and exchange rate converted estimates of per capita GDP by plotting the price level (ratio of PPP to exchange rate, which is the same thing as the ratio of *Atlas* GNP to ICP GDP)[9] against *Atlas* GNP per capita for 1985. The data refer

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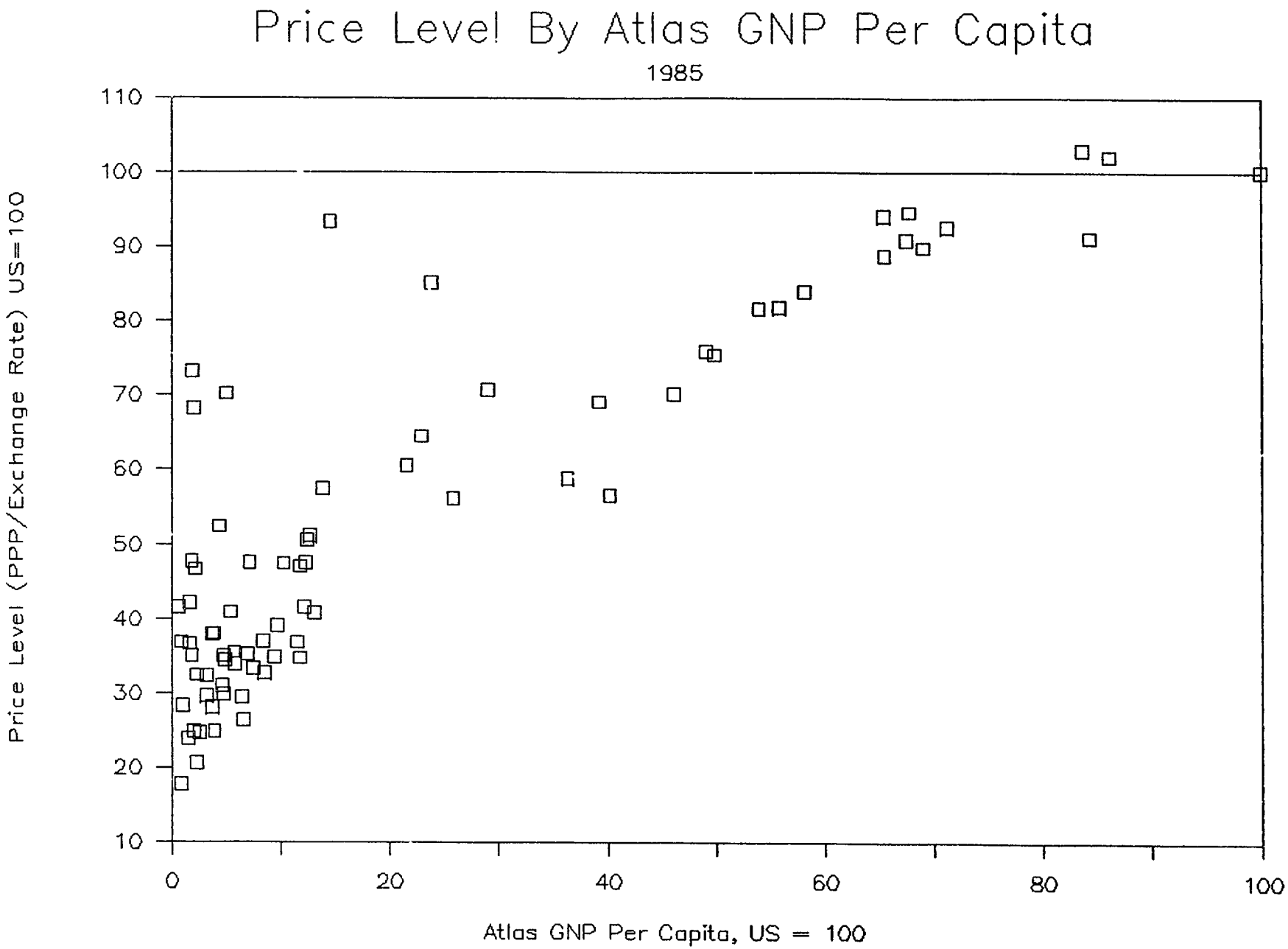
[6] Summers and Heston (1991)

[7] Ahmad (1980, 1988)

[8] See Ahmad (1980); Beckerman (1966); Beckerman and Bacon (1966); Clague (1986); Clague and Tanzi (1972); Isenman (1980); Kravis, Summers and Heston (1978); Summers and Heston (1984, 1988 and 1991). etc.

[9] The deviation between PPP converted and exchange rate converted values has been described in the literature in two ways: (1) the ratio of PPP to exchange rate (ER) called *price level* or (2) the ratio of ER to PPP, popularly known as *exchange rate deviation index* or ERDI, which is the reciprocal of price level. Note that price level can also be measured by the ratio of exchange rate converted GDP to


Price Level By Atlas GNP Per Capita
1985
Price Level (PPP/Exchange Rate) US=100
110
100
90
80
70
60
50
40
30
20
10
0
20
40
60
80
100
Atlas GNP Per Capita, US = 100

to 76 ICP countries; for countries not in 1985 ICP, the figures are extrapolations of the latest year data available. If ICP and *Atlas* estimates of income were the same, PPP would be equal to the *Atlas* exchange rate, and the scatter would be on the 100 mark, the US value, on the Y-axis. The chart shows that the vertical distance of a data point from 100 tends to increase as one moves from right (high income) to left (low income) on the X-axis, and that the cluster is much more dispersed vertically at the lower end of the income scale than at the higher.

7. The relationship can also be pictured in another way as in Chart 2 which plots on a log-log scale *Atlas* GNP per capita on the X axis and ICP GDP per capita on the Y axis, both expressed as US = 100. Here the distance from the 45 degree line is the measure of deviation between the two estimates. Chart 2 shows that ICP estimates tend to be higher than Atlas estimates (indicated by points above the 45 degree line), that the difference between the two estimates increases as one moves from higher to lower end of the income scale, and that deviations tend to be more dispersed at the lower end of the income scale than at the higher.

Explanatory Variables

8. The list of candidate variables, therefore, includes *Atlas* estimates of per capita GNP to place countries on an income scale and others that would explain the noise around the broad trend set by *Atlas* estimates.

9. It is observed that generally price levels are relatively lower in poorer countries, and the divergence is more pronounced in services than in commodities. For instance, if the 1975 price index (PPP/ER) for the US is assumed to be 100 for total GDP, then it was 41 for the poorest group of countries and 108 for the richest. The price indices for commodities (defined here as all final product commodities excluding construction) and services (defined here as final product services and construction) were respectively 60 and 25 for the poorest group and 119 and 97 for the richest group[10]. Thus while commodity prices in poorer countries are approximately 50 percent (60/119) of those of the richer countries, service prices are only about 25 percent (25/97). In nominal terms, services account for nearly 30 percent of GDP for low income countries compared with about 50 percent in high income countries[11]. The effect of PPP conversion is to raise this share to levels comparable to those of richer countries. Since exchange rates are affected by relative prices of tradeables (commodities excluding construction), and since PPP measures relative prices of all goods and services, non-tradeable as well as tradeable, any explanation of the difference between PPP and exchange rate must include factors which relate to differences in price levels, especially those of services.

10. We hypothesize that the discrepancy between ICP and *Atlas* estimates reflects persistence of differences in factor productivity and wage differentials among nations due to constraints on international

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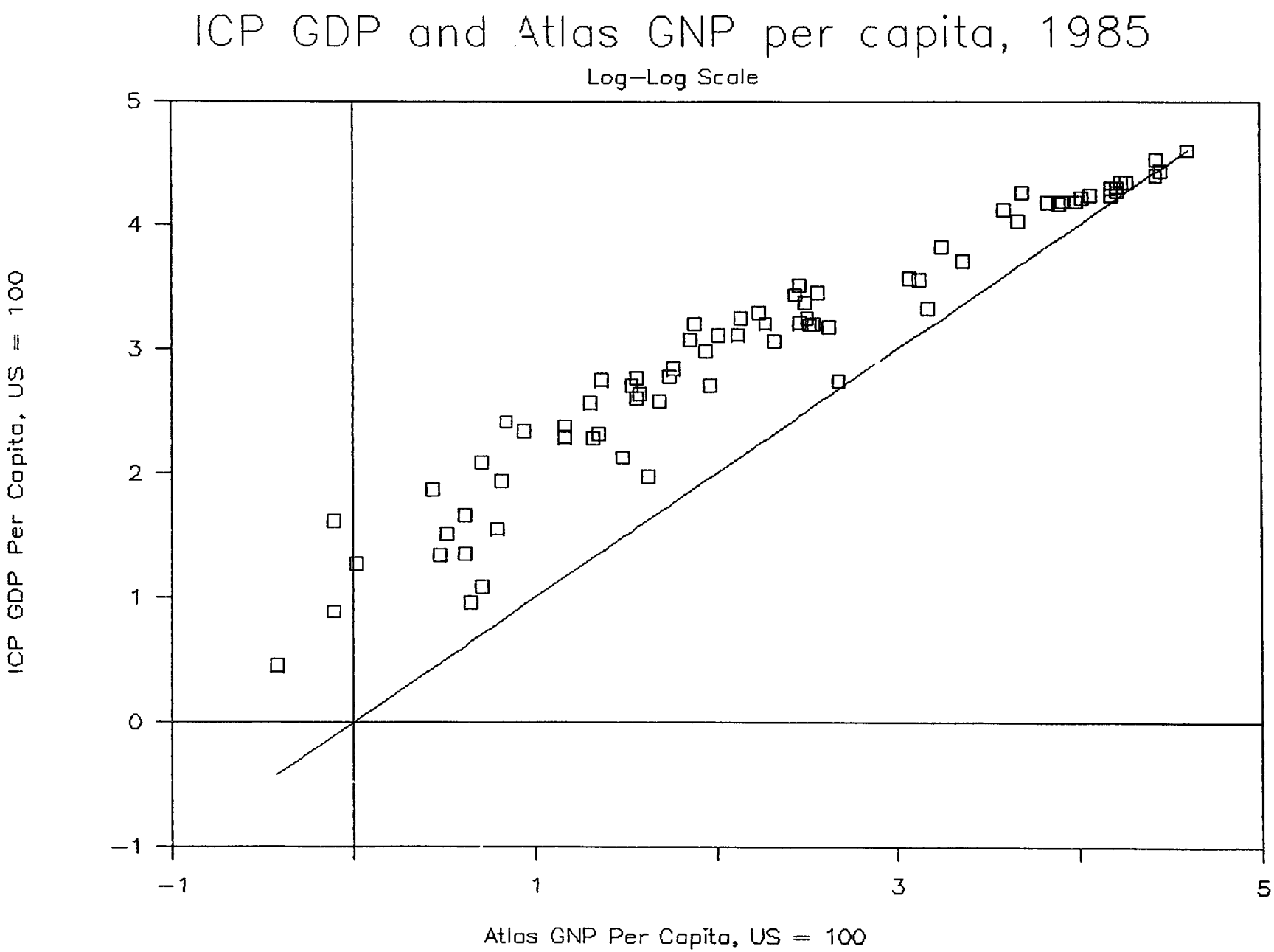
PPP converted GDP as follows: Price level = {(GDP/ER)/(GDP/PPP)} = PPP/ER, and its reciprocal, ERDI = {(GDP/PPP)/(GDP/ER)} = ER/PPP.

[10] Kravis and Lipsey (1983), p.12.

[11] *World Development Report 1991*, Table 3.


ICP GDP and Atlas GNP per capita, 1985
Log–Log Scale
ICP GDP Per Capita, US = 100
Atlas GNP Per Capita, US = 100
5
4
3
2
1
0
−1
−1
1
3
5

mobility of labor[12]. Richer countries have higher labor productivity. Within a country, higher productivity in the trading sectors leads to higher wages in these sectors and competition tends to spread these wages to service sectors. Primarily because of the lack of labor mobility, wage differentials persist across international frontiers. Compared with poorer countries, richer countries, therefore, will tend to have higher prices of services, higher price levels (ratio of PPP to exchange rate) and lower deviation between PPP converted and exchange rate converted GDP[13]. Therefore, regression equations, a-priori, should include variables that can capture differences in labor productivity.

11. Among the variables considered here are indicators of natural resources, human capital, structure and openness of the economy, and price and exchange regimes.

12. *Natural resources:* Two countries with similar technology and capital stock but different natural resources could have different labor productivity and wage levels. However, reliable and consistent measures of natural resources for a large number of countries are not available.

13. *Human capital:* Indicators of human capital or labor skills include education variables, demographic variables and variables relating to health and nutrition. Among the education variables are index of education attainment or mean years of schooling, and school enrolment. Education attainment is a more appropriate measure of human capital than enrolment. While there is no uniform definition of education attainment, a proper measure of education attainment would have to include the number of graduates by levels of education and their quality. Such measures are not available on a consistent basis except for a handful of countries. One measure of education attainment, reported in the Bank's *Social Indicators of Development*, is mean years of schooling embodied in the labor force. This is based on population censuses and is available at ten-year intervals. Since data were not available for many developing countries, this variable was not used. Another measure is simply mean years of schooling of the population. This is available for a larger number of countries and was included. Following Isenman (1980), secondary school enrolment ratios was also used as a proxy variable for educational attainment.

14. Among the demographic variables that are expected to be closely associated with productivity differentials (levels of living) are life expectancy and infant mortality rates. As these variables contain model estimates based or income levels, they were tried but not chosen.

15. Supply of calories as percent of requirement is a good indicator of health which promotes productivity. However, since data on calories as percent of requirements are no longer available, gross supply of calories per person per day was used. Number of population per doctor as an indicator of access to health care is expected to be correlated with productivity. But it was not used because data for the base year were not available.

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[12] Bela Balassa (1964); Paul Isenman (1980)

[13] A recent study using data for developed countries has found confirmation of the productivity differential hypothesis. It concludes that "there is a long-run equilibrium relation between the productivity differentials and the deviation of purchasing power parity from the equilibrium exchange rate.." Mohsen Bahmani-Oskooee (1992).

16. The Human Development Index (HDI) published by the United Nations Development Program (UNDP) was also expected to be highly correlated with human capital. However, since the PPP-based estimate of per capita GDP was a component of this index, it was not retained in the final runs.

17. A more direct measure of productivity differential would have been hourly output per worker in manufacturing. However, such data are not available on the scale needed for this exercise.

18. *Structure and openness of the economy*: A country having a large manufacturing sector (or a small agricultural sector) or succeeding in exporting a large proportion of its manufactures, is likely to have high productivity and high wages. To capture these, we considered variables such as share of manufactures in exports and share of manufactured exports in value added in manufactures. Since data for exports of manufactures were not available except for a handful of countries, these variables could not be used. Share of agriculture in GDP is usually inversely related to level of development,, productivity and wages, and was included in the exercise. Openness of the economy measured by exports plus imports as share of GDP is usually associated with higher prices (Kravis and Lipsey, 1983) and was included in the list of variables.

19. *Price and exchange rates*: One reason for differences in PPP and exchange rate could be that countries with trade and payments restrictions would not allow exchange rates to adjust to price changes and would maintain an overvalued currency. As an indicator of currency overvaluation, we included the ratio of black market rate to official exchange rate. As a proxy for price differentials, we also included UN post adjustment index as one of the explanatory variables.

20. Thus, to summarize, the variables not used for lack of sufficient data were: natural resources, school attainment, hourly output per worker in manufacturing, exports of manufactures as proportion of either total exports or of value added in manufacturing, and population per doctor; those not used on a-priori reasons were : life expectancy, infant mortality and HDI.

21. A whole array of the so-called *physical indicators* popularized by Beckerman and Bacon[14] was not included because in past studies they were found to be highly inter-correlated and not much could be gained in explanatory power by including them. These are miles of roads, per capita consumption of electricity, energy, steel, milk, meat, newsprint, or numbers of radios, telephones, televisions or automobiles per capita.

22. Listed below are the explanatory variables that were used in the exercise:

(1)	ATLAS	=	*Atlas* GNP per capita;
(2)	MNSKL	=	mean years of schooling;
(3)	ENROL	=	secondary school enrollment ratio;
(4)	CALOR	=	supply of calories per person per day;
(5)	AGR	=	value added in agriculture as proportion to GDP;
(6)	OPEN	=	openness: sum of exports and imports as proportion of GDP;
(7)	BLKRTO	=	black market exchange rate as a ratio to official rate; and
(8)	UNADJ	=	UN post adjustment index.

[14] Wilfred Beckerman (1966); Wilfred Beckerman and R. Bacon (1966)

Dependent variable:

23. The dependent variable of the regression could take one of two forms: either (a) the deviation between ICP and *Atlas* estimates of per capita income (i.e., price level or ERDI as in Chart 1) or (b) ICP GDP per capita. It is more interesting to investigate why PPP differs from the exchange rate and use form (a) as the dependent variable. However, since the purpose of this paper is to estimate ICP-based numbers when such numbers are not available, form (b) as depicted in Chart 2 is more appropriate here. It has to be noted though that since in this formulation the same GDP data in local currency underlie the figures on both sides of the equation (in ICP estimates on the left hand side and *Atlas* estimates on the right), the coefficient of correlation will tend to be higher than in the other formulation. We try both variants and report on (b) to facilitate comparison with estimates in PWT5 which uses the same functional form.

24. Since ICP GDP per capita was available for a different set of countries in different phases, it was extrapolated to the reference year by the country's real growth rate and scaled up by US inflation. However, a choice had to be made whether to use the average of all available estimates for a country or only the latest. We concentrated on the latest. Thus the variants of dependent variable considered were the following:

(a) PL = Price level (ratio of *Atlas* to ICP estimates); and

(b) ICPL = ICP GDP per capita, latest available year extended to reference year by real growth rate and US inflation.

IV. Regressions

25. All variables (except BLKRTO, ratio of black market to official exchange rate) were first expressed as indices with US=100 and then converted to natural logs. The functional form of the equation was:

(1) $\ln Y = f(\ln x_1, \ln x_2, \ldots\ldots \ln x_k)$; where Y is ICPL and the X's are the various independent variables.

First, "leaps and bounds"[15] procedures were run to identify best subset regressions based on adjusted R-squares. Regressions were run separately for different data sets to check on the stability of the equations. The data sets related to different phases of ICP: 1975 with 34 countries, 1980 with 60 countries and 1985 with 56 countries[16]. These data were also pooled, with regional dummy variables for Europe and Africa and time dummy variables for 1975 and 1980 in order to separate the effects of

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[15] Leaps-and-bounds method of picking best subset regressions is, unlike step-wise regression, independent of the order in which the variables are introduced in the equation.

[16] In all 63 countries participated in ICP Phase V for 1985 (no Latin American country was included); data for seven Caribbean countries were not available at the time of performing these calculations. The remaining 56 countries participated in several regional exercises. The data reported here for these countries are likely to be revised when the regional estimates are officially linked together to form a global comparison which is expected to become available in the fall of 1992.

regions or time periods on the overall estimates. Another sample was all countries that ever participated in ICP, with 1985 as the base year, consisting of actual phase V (1985) numbers for countries participating in phase V and extrapolations of earlier phase data for others. Separate regressions were also run for sub-samples of low income (less than $1,000 of Atlas GNP per capita in 1985) and high income countries. In order to minimize the effect of extrapolations, 1985 was adopted as the base year. The best subset regression was picked on the basis of goodness-of-fit statistics and stability of the regression over various sub-samples, and the estimating equation was obtained from the sample of 76 ICP countries for which data for the chosen independent variables were available. The final estimating equation was:

(2)	ln(ICPL) =	.5726 ln(ATLAS)	+.3466 ln(ENROL)	+.3865	
		(.0319)	(.0540)	(.1579)	
		RMSE = .2240	Adj.R-sq = .9523	N = 76.	

26. The variables in the regression performed well in all data subsets consisting of different phases of ICP run separately as well as pooled; the coefficients are robust (with low standard errors) and the adjusted R-square (.952) and RMSE (.224) are no worse than those of PWT5 equations which have adjusted R-squares ranging from .926 to .976 and RMSE from .263 to .159 (see Table 4). The equation can be interpreted to support the hypothesis that the differences between exchange rate converted and PPP converted GDP can be explained reasonably well by productivity differentials as they are measured by secondary school enrolment ratios.

27. Although the equation with ATLAS and ENROL was chosen, there were close contenders. Combinations of ATLAS, ENROL and CALOR performed well in all data subsets. Other regression with ATLAS and CALOR or with ATLAS, ENROL and CALOR offered equally attractive alternatives. These other regressions are:

(3)	ln(ICPL) =	.6396 ln(ATLAS)	+.7728 ln(CALOR)	-1.7782	
		(.0405)	(.2689)	(1.087)	
		RMSE = .2655	Adj.R-sq = .9329	N = 76.	
(4)	ln(ICPL) =	.5280 ln(ATLAS)	+.4552 ln(CALOR)	+.3211 ln(ENROL)	-1.3802
		(.0385)	(.2289)	(.0545)	(.9014)
		RMSE = .2196	Adj.R-sq = .9541	N = 76.	

V. Results

28. Table 1 summarizes the results of regression estimates along with those of *World Bank Atlas* and Penn World Tables, Mark 5 (PWT5) for the year 1985. The numbers in a given column are a mixture of actual and estimated. The regression estimates are used only to fill gaps; they are tagged by footnote d. The rest of the countries for which ICP numbers are available show the latest such numbers extrapolated to 1985. These numbers have been presented in columns (3) and (4), termed ICP/REG (REG stands for regression estimates); these numbers and their extrapolations to 1990 have been presented in the WDI. The regression estimates in columns (3) and (4) are based on equation (2) above consisting of ATLAS and ENROL as explanatory variables. Columns (5) and (6), marked ICP/REG(2)

(REG(2) is a second version of REG), presents an alternative set of estimates derived by equation (4) above which uses CALOR in addition to ATLAS and ENROL as explanatory variables. Columns (7) and (8) are PWT5 estimates. *Atlas* estimates are GNP, while those ICP are GDP (ICP preferred to work with GDP rather than GNP). The table presents only those countries for which estimates are available from all three sources - *Atlas*, PWT5 and ICP/REG.

29. As expected, the numbers in columns showing ICP and regression estimates are invariably higher than those of *Atlas* except for one country (with the highest per capita income in *Atlas*), the differences being larger at the lower end of the income scale. Thus comparing absolute values is not meaningful since PPP-based numbers have a different scale or meaning as they are based on "international" average rather than national average prices. Comparing ranks is more meaningful.

30. A comparison of ranks is presented in Table 2. When considering the entire array, changes in ranks from one measure of per capita income to another are not significant on the average as demonstrated by high degrees of rank-order correlation. The correlation between *Atlas* and PWT5 is .971; between *Atlas* and REG is .975; and between PWT5 and REG is .983. However, the average hides some very big differences as shown in Table 3.

31. Table 3 lists all countries which changed ranks ten places or more between REG and *Atlas*, PWT5 and *Atlas*, and between PWT5 and REG. Several observations can be made for these outliers. First, big changes are concentrated among low income countries. Sixteen of the 28 countries in the table are ICP participants; these are the countries that show the largest changes in ranks between *Atlas* and ICP. Fourteen of these sixteen countries show up under the REG-Atlas column which means that REG for non-ICP countries has not had a big influence on the rankings vis-a-vis *Atlas*. Secondly, due to the influence of ATLAS, which alone accounts for about 90 percent of the variance and has greater weight in the equation, REG estimates are likely to be closer to the corresponding *Atlas* numbers than those estimated without ATLAS. For Gabon, which shows a big change in rank, it seems that oil prices keep the exchange rate strong resulting in a relatively high *Atlas* estimate, while low enrolment ratio signifies a considerably low level of human capital and low estimate under REG. Comments on the differences with PWT5 are made in the next section.

32. One note of caution while using the regression estimates. Since the table presents a mixture of actual ICP for some countries and regression estimates for others, it is possible that two countries with comparable levels of *Atlas* and enrolment values may show very different results - in level as well as rank - just because one shows the actual and the other the fitted value. This is to be expected because the regression estimates of some countries in the sample can have large residuals. It is sometimes suggested that to avoid these situations, one should present only the estimated values. That would solve the problem of comparability but ignore the known residuals. To throw away actual observations and replace them by fitted values is, however, not an accepted practice in econometric estimation.

Alternative Regression Estimates

33. To underscore the approximate nature of the regression estimates, the paper presents a second set of estimates which compared with REG are more or less equally plausible. These estimates, presented in Table 1, Columns (6) and (7) under ICP/REG(2) are made using the regression equation (4) above which uses CALOR in addition to ATLAS and ENROL as independent variables. Although equation (4) has a higher adjusted R-square and lower RMSE, equation (2) was picked as the preferred equation

because the latter was more stable from sample to sample. These alternative estimates are quite close to those of REG but are different for some countries. As can be seen in Table 2, column (8), some 27 out of 106 countries change ranks although the biggest change is only 5 places (for Ghana, for instance).

34. Finally, it is worthwhile reminding that large values of coefficients of determination are the result of placing GNP/GDP values on both sides of the equation; as mentioned earlier, they would be significantly lower if the equations were formulated with the ratio of PPP to exchange rate (PL) on the left hand side, and if the sample were restricted to low income countries.

VI. Comparison of REG with PWT5 Estimates

35. PWT5 provides estimates of PPP-based national accounts for 138 countries and for the period 1950-1988. It provides estimates of per capita GDP in several forms (at current prices, constant 1985 prices, constant chain linked prices, and at constant prices adjusted for changes in terms of trade) and its three major components (consumption, investment and government). In addition, it provides data on relative prices, within and between countries, and demographic data and capital stock estimates as well. Since these data are available in electronic form, these are being used widely in research and have somewhat over-shadowed the actual benchmark ICP numbers.

36. The PWT5 follows the earlier work of Summers and Heston on making regression estimates of ICP-type per capita GDP using various physical and monetary indicators[17]. Unlike in earlier efforts, the authors do not use exchange rate converted per capita GDP as an explanatory variable in PWT5. Instead, they take various post adjustment (PA) price indices to estimate price relatives, relate the dollar estimates of per capita GDP based on these price relatives to those of ICP, and use these relationships to estimate ICP-type values for countries for which PA data are available but ICP data are not. For each country, two estimates are made for 1985 and averaged, one based mainly on 1985 data and another on 1980 data. Extrapolations of benchmark data are made on the basis of "consistentized" growth rates which are obtained by adjusting both SNA and ICP growth rates to make them consistent with each other.

37. The PWT5 results for 1985 are presented in Table 1 columns (8) and (9). As in REG, actual ICP numbers (or, if necessary, extrapolations) are shown for ICP countries and regression estimates only for non-ICP countries. Consequently, for ICP countries, the values in PWT5 should be the same as those in REG. But they differ because ICP data used by PWT5 are their own estimates which are potentially different from those in the public domain (and used in REG) in three respects: (a) PWT5 uses current

[17] Summers and Heston (1984, 1988).

vintage national accounts data, (b) it re-estimates Geary-Khamis without maintaining "fixity"[18]; and (c) uses "consistentized" growth rates for extrapolations.

38. Compared with *Atlas*, PWT5 has only four more countries than REG with ranking differences of ten or more shown in Table 3. The biggest differences between REG and PWT5 are for low income non-ICP countries, some ranked higher in PWT5 (Somalia, Mozambique, China, Sierra Leone) and others lower (Uganda, Togo, Zaire, Ghana, Jordan, Algeria) than in REG. For most of the other countries in Table 3, REG and PWT5 are quite close to each other but both differ significantly from the *Atlas*. In order to highlight the patterns in these differences, Table 3 presents the countries in several groups, those at top of table having much higher ranks in REG than in PWT5, those at bottom of table showing the opposite tendency (PWT5 ranks much higher than those of REG), and the rest in the middle of the table which show quite close ranks between REG and PWT5 but both having large differences with the *Atlas* ranks.

39. While comparing PWT5 numbers with others, it has to be remembered that PWT5 authors have given quality ratings for all their estimates varying in descending order from A to D. Generally, countries with ICP experience rank higher than those without, although many ICP countries have been given low ratings. These quality ratings for countries in Table 3 are shown in the last column. Sixteen of the 29 countries in the table have a quality rating of D, meaning that the PWT5 authors do not have much confidence in the accuracy of these numbers.

40. Except for Iran, countries at the top of the table did not participate in ICP. The REG numbers are closer to *Atlas* because of the influence of *Atlas* numbers in the estimating equation. The national accounts of Zaire and Uganda have gone through major revisions, and much of the difference can be attributed to differences in the vintage of national accounts data used in these estimates. PWT5 ranks for Uganda and Togo are quite close to those of *Atlas*, but because they have relatively low enrolment ratios, their REG estimates are also relatively low. For Jordan, a potential source of difference could be the treatment of population. *Atlas* estimates are based on East Bank only data, while the earlier data base had an anomaly - Jordan showed population for both East and West Bank but GDP for East Bank only. Algeria and Iran (also Gabon), because of oil, have over-valued currencies (with high black-market premiums) raising *Atlas* estimates but high domestic prices lowering PWT5 values.

41. Countries in the middle of Table 3 are all ICP participants (except for Gabon) and not surprisingly the REG and PWT5 numbers agree with each other but differ from the *Atlas*. This is because for these countries both PWT5 and REG show actual ICP numbers. The differences in the ICP numbers themselves are due to the factors described in paragraph 37 above.

42. Except for Syria, all the countries at the bottom of the table are non-ICP countries. REG ranks Mozambique, Somalia, and China quite close to *Atlas* but PWT5 ranks them relatively higher. The China

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[18] "Fixity" refers to the practice of keeping the relative positions of countries in the European Communities (EC) in the regional comparison fixed or unchanged when they are linked with other regional comparisons to form a global comparison. A global comparison, which uses a global average price structure, would normally alter relative positions observed in regional comparisons based on regional average prices. Thus "fixity" introduces an element of incomparability between EC and other countries. In order to correct this incomparability, PWT5 re-estimates PPPs globally without maintaining "fixity", making the estimates potentially different from those published.

numbers in PWT5 are based on Kravis' estimates[19] which are widely regarded as too high. For Somalia and Mozambique, there is considerable uncertainty about national accounts, appropriate exchange rates and prices paid by UN staff so that both *Atlas* and PWT5 numbers are of poor quality. It is not apparent why the ICP estimate for Sierra Leone in PWT5 is so much higher than that in REG.

43. Which set of estimates is better? Based on the goodness-of-fit statistics, the choice is not clear (see Table 4). Among the twelve equations used in PWT5, adjusted R-square varies between .926 and .976 and RMSE between . 263 and .159. Compare those with REG: adjusted R-Square of .95 and RMSE of .224. The judgment has to be based on an evaluation of underlying assumptions, reliability of information used and, for Bank purposes, ease of updating the estimates.

44. PWT5 estimates are based on empirical evidence. It assumes that post adjustment prices differ from national price patterns uniformly in every country. Intuitively, this is hard to accept because post adjustment data refer to a fixed basket of mostly goods consumed by foreigners living in a capital city and not adjusting to local conditions. Empirically, however, the relationship is quite strong. REG, on the other hand, assumes that the average exchange rates underlying *Atlas* estimates equate prices of tradeable goods, and that secondary school enrolment explains the difference between PPP and *Atlas* exchange rate. The choice of school enrolment (or calorie) as an explanatory variable is supported by an analytical reasoning. Although, empirically, exchange rates do not usually equate prices of tradeable goods especially in the short run and although not everybody is convinced of the analytical reasoning behind including enrolment as proxy for human capital, the relationship computed from available data and depicted by the REG equation is quite robust.

45. The advantage of PWT5 is that it is more comprehensive than REG. It has estimates for other concepts of income and several components of GDP (the table has estimates for twenty seven variables); REG has only one - GDP per capita. PWT5 numbers are estimated on the basis of observed differences in exchange rate and actual (post adjustment) prices and should have an advantage over REG which seeks to estimate that difference indirectly through proxy variables. Since enrolment ratios (or calorie supply) are slow to change over time, changes in the regression estimates from time to time will more or less follow the pattern in the *Atlas* estimates. PWT5 numbers, on the other hand, could conceivably be more sensitive to actual price movements.

46. However, the Bank will not be able to update the PWT5 numbers at the same time it updates other GNP numbers because all the adjustments made to the post adjustment data for PWT5 estimates are not known. Also, PWT5 estimates do not advance our goals for integrating ICP with national statistical data base as the post adjustment data are "foreign" to national statistical offices.

VII. Conclusions and directions for further work

47. The REG procedure attempts to explain why PPP and exchange rates differ - a procedure attempted earlier but not pursued in more recent studies[20]. There are doubts about the validity of the statements that (a) *Atlas* exchange rates equate prices of tradeable goods primarily because capital

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[19] Kravis (1980).

[20] Summers and Heston (1984, 1988); Clague (1986)

movement based on differential interest rates, political security, etc have greater influence on exchange rates in the short run than relative prices, or that (b) enrolment (or calorie supply) is a good proxy for human capital; but the goodness-of-fit statistics are quite robust. However, the method can produce different but equally defensible results so that these estimates should be used for broad tendencies for groups of countries; estimates of individual countries should be used with caution.

48. Further work in this area could take the form of introducing new variables (e.g., cost of basic sustenance instead of ATLAS, averaging enrolment for a number of years, physical capital as contributing to productivity); finding a better explanation at the lower end of income scale, and may be choosing different variables for different income or regional groups. However, based on past experience, this line of investigation is unlikely to bring dramatically different results because very little variance is left to be explained.

49. A much more reliable procedure would be to use reduced information techniques to survey a small number of prices and come up with estimates at regular intervals.

50. The most rewarding direction of further work, however, has to be to make ICP benchmark surveys regular and universal, and improve the quality of the estimates. To do this we have to integrate ICP with regular national statistical work, make detailed data accessible to all users, and demonstrate the relevance of the data for country policy work. The World Bank is pursuing these goals vigorously in cooperation with United Nations and other international organizations.

TABLE 1: Comparison of Atlas and Regression Estimates of PPP-Based per Capita GDP, 1985

		ATLAS(GNP), 1985		ICP/REG, 1985		PRICE LEVELICP/REG(2), 1985			PWT5, 1985	
		$$ (1)	US=100 (2)	$$ (3)	US=100 (4)	US=100 (5)	$$ (6)	US=100 (7)	$$ (8)	US=100 (9)
1	Ethiopia	110	0.7	260	1.6	41.6	260	1.6	320	1.9
2	Chad	150	0.9	400	2.4 d	..	379	2.3 d	511	3.1
3	Mali	150	0.9	400	2.4	36.9	400	2.4	477	2.9
4	Somalia	150	0.9	510	3.1 d	..	496	3.0 d	828	5.0
5	Bangladesh	160	1.0	830	5.0	19.0	830	5.0	688	4.2
6	Nepal	160	1.0	740	4.5 d	..	706	4.3 d	716	4.3
7	Malawi	170	1.0	590	3.6	28.3	590	3.6	564	3.4
8	Mozambique	180	1.1	500	3.0 d	..	451	2.7 d	816	5.0
9	Burkina Faso	190	1.1	460	2.8 d	..	436	2.6 d	501	3.0
10	Niger	230	1.4	550	3.3 d	..	565	3.4 d	615	3.7
11	Uganda	230	1.4	650	3.9 d	..	642	3.9 d	422	2.6
12	Burundi	250	1.5	500	3.0 d	..	494	3.0 d	531	3.2
13	Togo	250	1.5	890	5.4 d	..	861	5.2 d	653	4.0
14	Zaire	260	1.6	910	5.5 d	..	877	5.3 d	351	2.1
15	Central African Rep.	270	1.6	840	5.1 d	..	773	4.7 d	686	4.2
16	Rwanda	270	1.6	630	3.8	42.1	630	3.8	719	4.4
17	Benin	280	1.7	1,070	6.5	25.7	1,070	6.5	1,083	6.6
18	India	280	1.7	750	4.5	36.7	750	4.5	684	4.2
19	Kenya	310	1.8	870	5.3	35.0	870	5.3	831	5.0
20	Madagascar	310	1.8	640	3.9	47.6	640	3.9	665	4.0
21	Haiti	320	1.9	950	5.8 d	..	911	5.5 d	909	5.5
22	Tanzania	320	1.9	430	2.6	73.2	430	2.6	472	2.9
23	China	330	2.0	1,260	7.6 d	..	1,311	7.9 d	1,850	11.2
24	Pakistan	340	2.0	1,340	8.1	24.9	1,340	8.1	1,426	8.7
25	Sierra Leone	340	2.0	490	3.0	68.2	490	3.0	999	6.1
26	Ghana	370	2.2	1,390	8.4 d	..	1,296	7.9 d	838	5.1
27	Sudan	370	2.2	1,090	6.6 d	..	1,043	6.3 d	930	5.6
28	Zambia	370	2.2	780	4.7	46.6	780	4.7	749	4.5
29	Senegal	380	2.3	1,150	7.0	32.5	1,150	7.0	1,136	6.9
30	Lesotho	390	2.3	1,180	7.2 d	..	1,179	7.2 d	1,215	7.4
31	Sri Lanka	390	2.3	1,850	11.2	20.7	1,850	11.2	1,928	11.7
32	Mauritania	410	2.4	1,050	6.4 d	..	1,040	6.3 d	910	5.5
33	Bolivia	430	2.6	1,712	10.4 c	..	1,712	10.4 c	1,539	9.3
34	Liberia	470	2.8	1,330	8.1 d	..	1,319	8.0 d	927	5.6
35	Philippines	540	3.2	1,790	10.9	29.7	1,790	10.9	1,718	10.4
36	Indonesia	550	3.3	1,637	9.9 c	..	1,637	9.9 c	1,675	10.2
37	Morocco	620	3.7	2,160	13.1	28.2	2,160	13.1	1,977	12.0
38	Zimbabwe	630	3.8	1,630	9.9	38.0	1,630	9.9	1,410	8.6
39	Egypt, Arab Rep.	660	3.9	2,610	15.8	24.9	2,610	15.8	1,898	11.5
40	Cote D'Ivoire	670	4.0	1,680	10.2	39.2	1,680	10.2	1,423	8.6
41	Honduras	740	4.4	1,388	8.4 c	..	1,388	8.4 c	1,219	7.4
42	Papua New Guinea	740	4.4	1,358	8.2 c	..	1,358	8.2 c	1,641	10.0
43	Nicaragua	760	4.5	2,075	12.6 d	..	1,905	11.6 d	1,857	11.3
44	Dominican Rep.	790	4.7	2,470	15.0 c	..	2,470	15.0 c	2,065	12.5
45	Thailand	800	4.8	2,630	15.9	29.9	2,630	15.9	2,472	15.0
46	Cameroon	810	4.8	2,310	14.0	34.5	2,310	14.0	1,761	10.7
47	El Salvador	840	5.0	1,595	9.7 c	..	1,595	9.7 c	1,736	10.5
48	Nigeria	850	5.1	1,190	7.2	70.2	1,190	7.2	1,047	6.4
49	Jamaica	910	5.4	2,188	13.3 c	..	2,188	13.3 c	2,340	14.2
50	Botswana	960	5.7	2,660	16.1	35.5	2,660	16.1	2,511	15.2
51	Peru	980	5.8	2,845	17.3 c	..	2,845	17.3 c	2,683	16.3
52	Congo, People,s Rep.	1,040	6.2	2,710	16.4	37.7	2,710	16.4	2,600	15.8
53	Turkey	1,080	6.4	3,600	21.8	29.5	3,600	21.8	3,150	19.1
54	Mauritius	1,100	6.6	4,090	24.8	26.4	4,090	24.8	3,690	22.4
55	Tunisia	1,170	7.0	3,270	19.8	35.2	3,270	19.8	3,051	18.5
56	Ecuador	1,180	7.0	3,271	19.8 c	..	3,271	19.8 c	2,727	16.5
57	Colombia	1,270	7.6	3,717	22.5 c	..	3,717	22.5 c	3,244	19.7
58	Costa Rica	1,400	8.3	3,729	22.6 c	..	3,729	22.6 c	3,549	21.5

TABLE 1: Comparison of Atlas and Regression Estimates of PPP-Based per Capita GDP, 1985

		ATLAS(GNP), 1985		ICP/REG, 1985		PRICE LEVELICP/REG(2), 1985			PWT5, 1985	
		$$ (1)	US=100 (2)	$$ (3)	US=100 (4)	US=100 (5)	$$ (6)	US=100 (7)	$$ (8)	US=100 (9)
59	Chile	1,420	8.5	4,267	25.9 c	..	4,267	25.9 c	3,697	22.4
60	Uruguay	1,580	9.4	4,459	27.0 c	..	4,459	27.0 c	4,442	26.9
61	Brazil	1,630	9.7	4,107	24.9 c	..	4,107	24.9 c	3,926	23.8
62	Syrian Arab Rep.	1,740	10.4	3,565	21.6 c	..	3,565	21.6 c	4,931	29.9
63	Jordan	1,880	11.2	4,410	26.7 d	..	4,177	25.3 d	2,685	16.3
64	Hungary	1,930	11.5	5,150	31.2	36.9	5,150	31.2	5,081	30.8
65	Malaysia	1,970	11.7	4,119	25.0 c	..	4,119	25.0 c	4,668	28.3
66	Portugal	1,970	11.7	5,570	33.8	34.8	5,570	33.8	4,457	27.0
67	Yugoslavia	2,040	12.2	4,820	29.2	41.6	4,820	29.2	4,408	26.7
68	Panama	2,060	12.3	4,266	25.9 c	..	4,266	25.9 c	3,592	21.8
69	Poland	2,080	12.4	4,040	24.5	50.6	4,040	24.5	3,751	22.8
70	Argentina	2,130	12.7	4,091	24.8 c	..	4,091	24.8 c	3,913	23.7
71	Mexico	2,180	13.0	5,258	31.9 c	..	5,258	31.9 c	5,241	31.8
72	South Africa	2,210	13.2	4,910	29.8 d	..	4,909	29.8 d	4,330	26.3
73	Korea, Rep.	2,320	13.8	3,970	24.1	57.5	3,970	24.1	3,791	23.0
74	Paraguay	2,440	14.5	2,569	15.6 c	..	2,569	15.6 c	2,305	14.0
75	Algeria	2,590	15.4	4,590	27.8 d	..	4,337	26.3 d	3,155	19.1
76	Gabon	3,560	21.2	3,928	23.8 d	..	3,725	22.6 d	4,137	25.1
77	Greece	3,610	21.5	5,880	35.7	60.3	5,860	35.5	5,613	34.0
78	Venezuela	3,830	22.8	5,838	35.4 c	..	5,838	35.4 c	5,562	33.7
79	Iran, Islamic Rep.	3,990	23.8	4,610	28.0	85.1	4,610	28.0	3,496	21.2
80	Spain	4,330	25.8	7,590	46.0	56.1	7,590	46.0	6,322	38.3
81	Ireland	4,680	27.9	6,700	40.6	68.7	6,750	40.9	5,903	35.8
82	Hong Kong	6,090	36.3	10,190	61.8	58.8	10,190	61.8	10,008	60.7
83	Trinidad and Tobago	6,130	36.6	8,684	52.7 d	..	8,256	50.1 d	7,350	44.6
84	Israel	6,570	39.2	9,351	56.7 c	..	9,351	56.7 c	9,134	55.4
85	New Zealand	6,740	40.2	10,050	60.9	66.0	10,050	60.9	9,963	60.4
86	Singapore	7,120	42.5	9,260	56.2 d	..	9,301	56.4 d	10,237	62.1
87	Oman	7,550	45.0	7,290	44.2 d	..	7,009	42.5 d	9,663	58.6
88	Italy	7,720	46.0	10,830	65.7	70.1	10,820	65.6	10,402	63.1
89	Belgium	8,230	49.1	10,670	64.7	75.8	10,670	64.7	10,278	62.3
90	United Kingdom	8,360	49.9	10,900	66.1	75.4	10,900	66.1	10,494	63.6
91	Germany	8,620	51.4	12,170	73.8	69.6	12,170	73.8	11,446	69.4
92	Saudi Arabia	8,640	51.5	8,560	51.9 d	..	7,926	48.1 d	9,376	56.9
93	Austria	9,040	53.9	10,900	66.1	81.6	10,900	66.1	10,113	61.3
94	Netherlands	9,360	55.8	11,260	68.3	81.7	11,250	68.2	10,748	65.2
95	France	9,750	58.1	11,440	69.3	83.9	11,430	69.3	11,180	67.8
96	Finland	10,970	65.4	11,460	69.5	94.1	11,460	69.5	11,032	66.9
97	Denmark	11,310	67.4	12,240	74.2	90.9	12,240	74.2	11,774	71.4
98	Japan	11,350	67.7	11,800	71.5	94.7	11,800	71.6	10,595	64.3
99	Australia	11,580	69.1	11,720	71.1	97.1	11,720	71.1	12,333	74.8
100	Sweden	11,940	71.2	12,680	76.9	92.6	12,680	76.9	12,168	73.8
101	Canada	14,140	84.3	15,260	92.5	91.1	15,260	92.5	14,754	89.5
102	Norway	14,450	86.2	13,910	84.4	102.1	13,920	84.4	13,261	80.4
103	Kuwait	15,010	89.5	15,060	91.3 d	..	13,797	83.7 d	12,465	75.6
104	Switzerland	16,240	96.8	16,600	100.7 d	..	16,061	97.4 d	14,142	85.8
105	United States	16,770	100.0	16,490	100.0	100.0	16,490	100.0	16,490	100.0
106	United Arab Emirates	22,220	132.5	16,350	99.2 d	..	15,399	93.4 d	20,176	122.4

Sources:
Col (1),(2): World Bank
Col (3),(4): ICP and regression estimates
Col (5) : Price level, col(2)/ col(4), for ICP participants only
Col (6),(7): ICP and regression estimates by a second equation
Col (8),(9): Penn World Tables, Mark 5: QJE, May 1991

Note: c. Extrapolated from earlier years; d. regression estimates.

TABLE 2: Comparison of Atlas and Regression Estimates of PPP-Based per Capita GDP, 1985

		Rankings in 1985				Changes in Ranks: Difference in Ranks, 1985			
		ATLAS (1)	REG (2)	PWT (3)	REG2 (4)	REG-ATL (5)	PWT-ATL (6)	PWT-REG (7)	REG2-REG (8)
1	Ethiopia	1	1	1	1	0	0	0	0
2	Chad	2	2	7	2	0	5	5	0
3	Mali	3	3	5	3	0	2	2	0
4	Somalia	4	9	20	9	5	16	11	0
5	Bangladesh	5	18	15	19	13	10	-3	1
6	Nepal	6	15	16	15	9	10	1	0
7	Malawi	7	11	9	11	4	2	-2	0
8	Mozambique	8	8	19	6	0	11	11	-2
9	Burkina Faso	9	5	6	5	-4	-3	1	0
10	Niger	10	10	10	10	0	0	0	0
11	Uganda	11	14	3	14	3	-8	-11	0
12	Burundi	12	7	8	8	-5	-4	1	1
13	Togo	13	21	11	20	8	-2	-10	-1
14	Zaire	14	22	2	22	8	-12	-20	0
15	Central African Rep.	15	19	14	17	4	-1	-5	-2
16	Rwanda	16	12	17	12	-4	1	5	0
17	Benin	17	25	29	26	8	12	4	1
18	India	18	16	13	16	-2	-5	-3	0
19	Kenya	19	20	21	21	1	2	1	1
20	Madagascar	20	13	12	13	-7	-8	-1	0
21	Haiti	21	23	23	23	2	2	0	0
22	Tanzania	22	4	4	4	-18	-18	0	0
23	China	23	30	42	31	7	19	12	1
24	Pakistan	24	32	35	33	8	11	3	1
25	Sierra Leone	25	6	27	7	-19	2	21	1
26	Ghana	26	35	22	30	9	-4	-13	-5
27	Sudan	27	26	26	25	-1	-1	0	-1
28	Zambia	28	17	18	18	-11	-10	1	1
29	Senegal	29	27	30	27	-2	1	3	0
30	Lesotho	30	28	31	28	-2	1	3	0
31	Sri Lanka	31	42	45	42	11	14	3	0
32	Mauritania	32	24	24	24	-8	-8	0	0
33	Bolivia	33	40	36	40	7	3	-4	0
34	Liberia	34	31	25	32	-3	-9	-6	1
35	Philippines	35	41	39	41	6	4	-2	0
36	Indonesia	36	38	38	38	2	2	0	0
37	Morocco	37	44	46	44	7	9	2	0
38	Zimbabwe	38	37	33	37	-1	-5	-4	0
39	Egypt, Arab Rep.	39	49	44	49	10	5	-5	0
40	Cote D'Ivoire	40	39	34	39	-1	-6	-5	0
41	Honduras	41	34	32	35	-7	-9	-2	1
42	Papua New Guinea	42	33	37	34	-9	-5	4	1
43	Nicaragua	43	43	43	43	0	0	0	0
44	Dominican Rep.	44	47	47	47	3	3	0	0
45	Thailand	45	50	50	50	5	5	0	0
46	Cameroon	46	46	41	46	0	-5	-5	0
47	El Salvador	47	36	40	36	-11	-7	4	0
48	Nigeria	48	29	28	29	-19	-20	-1	0
49	Jamaica	49	45	49	45	-4	0	4	0
50	Botswana	50	51	51	51	1	1	0	0
51	Peru	51	53	53	53	2	2	0	0
52	Congo, People,s Rep.	52	52	52	52	0	0	0	0
53	Turkey	53	57	57	57	4	4	0	0
54	Mauritius	54	63	63	63	9	9	0	0
55	Tunisia	55	54	56	54	-1	1	2	0
56	Ecuador	56	55	55	55	-1	-1	0	0
57	Colombia	57	58	59	58	1	2	1	0

TABLE 2: Comparison of Atlas and Regression Estimates of PPP-Based per Capita GDP, 1985

		Rankings in 1985				Changes in Ranks: Difference in Ranks, 1985			
		ATLAS (1)	REG (2)	PWT (3)	REG2 (4)	REG-ATL (5)	PWT-ATL (6)	PWT-REG (7)	REG2-REG (8)
58	Costa Rica	58	59	61	60	1	3	2	1
59	Chile	59	68	64	69	9	5	-4	1
60	Uruguay	60	70	72	71	10	12	2	1
61	Brazil	61	65	68	65	4	7	3	0
62	Syrian Arab Rep.	62	56	75	56	-6	13	19	0
63	Jordan	63	69	54	67	6	-9	-15	-2
64	Hungary	64	75	76	75	11	12	1	0
65	Malaysia	65	66	74	66	1	9	8	0
66	Portugal	66	77	73	77	11	7	-4	0
67	Yugoslavia	67	73	71	73	6	4	-2	0
68	Panama	68	67	62	68	-1	-6	-5	1
69	Poland	69	62	65	62	-7	-4	3	0
70	Argentina	70	64	67	64	-6	-3	3	0
71	Mexico	71	76	77	76	5	6	1	0
72	South Africa	72	74	70	74	2	-2	-4	0
73	Korea, Rep.	73	61	66	61	-12	-7	5	0
74	Paraguay	74	48	48	48	-26	-26	0	0
75	Algeria	75	71	58	70	-4	-17	-13	-1
76	Gabon	76	60	69	59	-16	-7	9	-1
77	Greece	77	79	79	79	2	2	0	0
78	Venezuela	78	78	78	78	0	0	0	0
79	Iran, Islamic Rep.	79	72	60	72	-7	-19	-12	0
80	Spain	80	82	81	82	2	1	-1	0
81	Ireland	81	80	80	80	-1	-1	0	0
82	Hong Kong	82	88	87	88	6	5	-1	0
83	Trinidad and Tobago	83	84	82	84	1	-1	-2	0
84	Israel	84	86	83	86	2	-1	-3	0
85	New Zealand	85	87	86	87	2	1	-1	0
86	Singapore	86	85	89	85	-1	3	4	0
87	Oman	87	81	85	81	-6	-2	4	0
88	Italy	88	90	91	90	2	3	1	0
89	Belgium	89	89	90	89	0	1	1	0
90	United Kingdom	90	92	92	92	2	2	0	0
91	Germany	91	98	97	98	7	6	-1	0
92	Saudi Arabia	92	83	84	83	-9	-8	1	0
93	Austria	93	91	88	91	-2	-5	-3	0
94	Netherlands	94	93	94	93	-1	0	1	0
95	France	95	94	96	94	-1	1	2	0
96	Finland	96	95	95	95	-1	-1	0	0
97	Denmark	97	99	98	99	2	1	-1	0
98	Japan	98	97	93	97	-1	-5	-4	0
99	Australia	99	96	100	96	-3	1	4	0
100	Sweden	100	100	99	100	0	-1	-1	0
101	Canada	101	103	104	103	2	3	1	0
102	Norway	102	101	102	102	-1	0	1	1
103	Kuwait	103	102	101	101	-1	-2	-1	-1
104	Switzerland	104	106	103	105	2	-1	-3	-1
105	United States	105	105	105	106	0	0	0	1
106	United Arab Emirates	106	104	106	104	-2	0	2	0
	Rank Correlation					98.5%	98.3%	99.0%	100.0%

TABLE 3: Countries with Big Differences in Ranks

Comparison of Atlas and Regression Estimates of PPP-Based Per Capita GDP, 1985

		ATLAS(GNP)	Rankings in 1985				Difference in Ranks, 1985				PWT5 Grade
		$$ (1)	ATLAS (2)	REG (3)	PWT (4)	REG2 (5)	REG-ATL (6)	PWT-ATL (7)	PWT-REG (8)	REG2-REG (9)	(10)
14	Zaire	260	14	22	2	22	8	-12 **	-20 **	0	D
63	Jordan	1,880	63	69	54	67	6	-9	-15 **	-2	D
26	Ghana	370	26	35	22	30	9	-4	-13 **	-5	D
11	Uganda	230	11	14	3	14	3	-8	-11 **	0	D
13	Togo	250	13	21	11	20	8	-2	-10 **	-1	D
75	Algeria	2,590	75	71	58	70	-4	-17 **	-13 **	-1	D
79	Iran, Islamic R	3,990	79	72	60	72	-7	-19 **	-12 **	0	C-
39	Egypt, Arab Rep	660	39	49	44	49	10 **	5	-5	0	D+
66	Portugal	1,970	66	77	73	77	11 **	7	-4	0	A-
5	Bangladesh	160	5	18	15	19	13 **	10 **	-3	1	C-
48	Nigeria	850	48	29	28	29	-19 **	-20 **	-1	0	D+
22	Tanzania	320	22	4	4	4	-18 **	-18 **	0	0	C-
74	Paraguay	2,440	74	48	48	48	-26 **	-26 **	0	0	C
64	Hungary	1,930	64	75	76	75	11 **	12 **	1	0	B
6	Nepal	160	6	15	16	15	9	10 **	1	0	D+
28	Zambia	370	28	17	18	18	-11 **	-10 **	1	1	D+
60	Uruguay	1,580	60	70	72	71	10 **	12 **	2	1	C-
24	Pakistan	340	24	32	35	33	8	11 **	3	1	C-
31	Sri Lanka	390	31	42	45	42	11 **	14 **	3	0	C-
47	El Salvador	840	47	36	40	36	-11 **	-7	4	0	C
17	Benin	280	17	25	29	26	8	12 **	4	1	D+
73	Korea, Rep.	2,320	73	61	66	61	-12 **	-7	5	0	B-
76	Gabon	3,560	76	60	69	59	-16 **	-7	9	-1	D
8	Mozambique	180	8	8	19	6	0	11 **	11 **	-2	D
4	Somalia	150	4	9	20	9	5	16 **	11 **	0	D
23	China	330	23	30	42	31	7	19 **	12 **	1	D
62	Syrian Arab Rep	1,740	62	56	75	56	-6	13 **	19 **	0	C-
25	Sierra Leone	340	25	6	27	7	-19 **	2	21 **	1	D+

Source: Table 2.

Note: PWT5 places quality ratings against its estimates for each country from highest A to lowest D (Col.10). Rating A is usually reserved for OECD countries; B and C are applied to countries with ICP experience, although there are many ICP countries with D; and D is generally applied to countries without ICP experience.

** indicates change of ten or more ranks.

Comparison of Goodness-of-fit Statistics of PWT5 and IECSE Equations

PWT5 EQUATIONS

		RMSE	R-Sq Adj)
	For 1985 based on 1985 benchmark		
1	ln (r) = f(ln [r(UN)])	0.263	0.926
2	ln (r) = f(ln [r(ECA)])	0.199	0.957
3	ln (r) = f(ln [r(USS)])	0.219	0.950
4	ln (r) = f(ln [r(UN)], ln [r(ECA)])	0.204	0.954
5	ln (r) = f(ln [r(UN)], ln [r(USS)])	0.228	0.944
6	ln (r) = f(ln [r(USS)], ln [r(ECA)])	0.193	0.960
	For 1985 based on 1980 benchmark		
7	ln (r) = f(ln [r(UN)], AD	0.231	0.948
8	ln (r) = f(ln [r(ECA)], AD	0.166	0.974
9	ln (r) = f(ln [r(USS)], AD	0.186	0.968
10	ln (r) = f(ln [r(UN)], ln [r(ECA)], AD	0.168	0.972
11	ln (r) = f(ln [r(UN)], ln [r(USS)], AD	0.194	0.963
12	ln (r) = f(ln [r(USS)], ln [r(ECA)], AD	0.159	0.976

IECSE EQUATIONS

1	ln (r) = f(ln (ATLAS), ln (ENROL), AD)	0.171	0.973 (1980 benchmark countries, 1980)
2	ln (r) = f(ln (ATLAS), ln (ENROL))	0.213	0.965 (1985 benchmark countries, 1985)
3	ln (r) = f(ln (ATLAS), ln (ENROL))	0.203	0.957 (Input of dep. var. same as in PWT5, 1985)
4	ln (r) = f(ln (ATLAS), ln (ENROL))	0.224	0.952 (All ICP countries extrapolated to 1985)
5	ln (r) = f(ln (ATLAS), ln (ENROL). ln (CALOR))	0.220	0.954 (All ICP countries extrapolated to 1985)

Where

r	= percapita GDP based on ICP PPP and expressed as US=100
r(UN)	= r but based on PPP computed from UN's cost of living index of of expatriates living in capital cities
r(ECA)	= same as r(UN) except the expatriates' cost of living data are from Economic Conditions Abroad (ECA)
r(USS)	= same as r(UN) except the expatriates cost of living data are from US State Department
AD	= Dummy variable for Africa
p	= price level as measured by the ratio of PPP to exchange rate, US=100
ATLAS	= per capita GNP estimated by the World Bank Atlas method.
LIFEX	= Life expectancy, US=100
IMR	= Infant mortality rate, US=100
ENROL	= Secondary school enrolment ratio, US = 100
CALOR	= Supply of calorie per person per day, US = 100

Note: 1 PWT equations 1-6 refer to 1985 based on 1985 benchmark data for 57 countries in 1985 benchmark plus 20 countries from 1975 and 1980 that did not participate in 1985, brought up to 1985 by 'consistentized' growth rates and US inflation.

2 PWT equations 7-12 refer to 1985 based on 1980 benchmark data for 60 countries in ICP phase IV, brought up to 1985 by consistentized growth rates and US inflation, and six countries that participated in Phase V for the first time.

3 IECSE equations refer to different country samples as noted against each equation. Estimates using equation (4) are presented in the paper under REG and in WDI; those using equation (5) are presented in the paper as alternative estiamtes under REG(2).

4 PWT5 estimates are weighted averages of two estimates for each country based on 1980 and 1985 data.

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