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Price Levels, Size, Distribution and Growth of the World Economy: Insights from recent International Comparisons of Prices and Real Product

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Abstract

This paper analyzes the recently released macroeconomic aggregate data from the International Comparison Program (ICP) for the years 2011 and 2017 compiled using comparable and consistent survey methods and aggregation procedures. Focusing on the size of the real world economy, in purchasing power parity (PPP) terms, the paper presents estimates of global and regional growth, inflation and exchange rate effects over the period 2011 and 2017. The approach used here has implications for the regular compilation and dissemination of global growth and inflation statistics by organizations like the International Monetary Fund. Growth performance analysis is supplemented with estimates of global and regional inequality. The question about the largest economy is answered using real GDP estimates in PPP terms from the ICP with the conclusion that China and USA were almost at the same level in 2017. Based on the projections to 2019 from the Penn World Table 10.0 and the COVID affected growth rates of these economies in 2020 published by the IMF suggest that China is currently the biggest economy in PPP terms. The paper revisits Balassa and Samuelson in examining a long standing question of interest to economists since the first round of ICP in 1970, namely what determines the price levels measured as the ratio of PPP to exchange rates in different countries. Developing appropriate analytical tools and using macroeconomic aggregate data from the 1975, 2011 and 2017 rounds of the ICP, the paper examines evolution of economic structures of countries in terms of price similarity, the breakdown of services and commodities, and the global price structures. The paper in conclusion touches on the challenges due to COVID for international macroeconomic comparisons in the short to immediate term faced by national and international statistical agencies conducting these exercises.

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Section 1. Introduction

Covid-19 and its consequences have rightfully received the attention of the media and economists in 2020, with the effect that other important economic happenings have received short shrift. This paper focuses on one such happening, the release by the World Bank (2020) on May 19th of Purchasing Power Parities and the Size of the World Economies, a report on results from its 2017 International Comparison Program (ICP). The World Bank report presents snapshots of the world economy taken in 2011 and 2017 that are rich in detail of the real size, structure and distribution of real gross domestic product of 176 economies from all regions of the world. The successful completion of 2017 ICP took a strong commitment and cooperative spirit shown by participating countries, regional commissions and all the major international organizations, under the umbrella of ICP.

One reason the 2017 ICP report is particularly noteworthy is that in combination with the 2011 comparison, it is the first time in its 50 years' existence[1] that successive rounds have used almost identical survey frameworks and methodologies, a feature that is exploited in this paper. Remarking on this point Deaton and Schreyer (2020a) say, "Good news first. The 2017 results are a recognizable update of the 2011 update, and not a radical remapping of the world's economic geography. This is important because previous updates sometimes changed the relative size of countries and continents. The 2005 estimates, for example, made the world look much more unequal than previously believed; they also sharply increased some measures of poverty." In a longer piece Deaton and Schreyer (2020b) point out how with respect to health outcomes and distribution, there are limitations on what the ICP can tell us about well-being, an important caveat that applies to this paper as well.

Another reason is that Covid-19 has forced a change in the schedule of future ICP rounds and has made the current report more significant. The plan had been approved in 2017 within the ICP governance framework that the ICP should move to a series of 3 year rolling benchmark comparisons, with 2020 being the first round to be carried out under that plan. However, it became clear by April, 2020 that many country statistical offices were already overwhelmed by their routine field responsibilities and the additional data collection and processing would be beyond their capacity. The implication is that 2017 will be the last ICP round of the pre-Covid global economy and the last benchmark before 2021 or 2022.

The ICP governance structure has tried to make basic data as open as possible to academics and other researchers making it even more important that knowledge of the 2017 ICP Report is widely spread. The report provides a rich set of figures, tables and analysis in its own right. But the underlying price level and expenditures represent a level of detail that permits research across countries and over time that has not been possible before. Our purpose in this paper is to point out some of the main findings of the 2017 ICP report and to put some of these findings in the perspective of the half century of the project.

Section 2 focuses on the world economy beginning with the major geographic regions decomposing economic changes in current price estimates of real gross domestic product, in purchasing power parity terms, in 2011 and 2017 into inflation and real growth. The same is also done for income-based country groupings, classified by per-capita real GDP. Section 3 focuses on the largest of the 176 countries and particularly the top three, viz., China, India and the United States, treating specifically the issues on how this has continued to be the most controversial of the ICP estimates. Section 4 addresses a longstanding question arising from the first round of the ICP, namely what determines the price levels of countries, that is the percentage of the purchasing power parity of a country to its exchange rate. In section 5, we discuss what the ICP results can tell us about the evolving economic structure of countries in terms of price

[1] See World Bank (2020) and Asian Development Bank (2020) for a brief history and evolution of ICP which started in 1968 as a small research project at the University of Pennsylvania.

similarity and the breakdown of services and commodities. This section also presents an analytical framework to measure relative prices of goods and services at the global level. Rest of the section is devoted to a comparative analysis of international commodity price structures through the 1975, 2011 and 2017 benchmark comparisons. Section 6 discusses estimates of the global GDP at the end of 2019 as well as some of the questions surrounding how the post-covid-19 world economy may emerge. A few concluding remarks are offered in Section 7.

Section 2. Global GDP in 2017 reaches $120 trillion.

Since its inception it has been conventional for the ICP to use the US dollar as its reference currency, a practice that has no effect on the relative position of countries in the income chain. If the rupee or euro were used as the reference currency the total global GDP in Table 1 would of course be different but the relative sizes of Brazil and Germany would remain the same. The number of countries participating in the 2011 and 2017 benchmarks were 176, including most major economies in the world, with only a few small economies absent, like Cuba, N. Korea, Syria, Venezuela and Yemen. If the GDPs of these countries were included, the total GDP in 2017 after converting each country's GDP in its own local currency unit using PPPs from 2017 ICP would reach the $120 trillion of the section heading. A point worth noting here is that World Bank (2020) includes aggregate results for 2011 and 2017 for the geographic areas as used by the World Bank, as well as for the administrative groupings of countries that did the actual collection of the data.

2.1 Level and Growth in Geographic and Administrative Groupings of Countries

First, the change in real GDP, in PPP terms, of the East Asia and Pacific regions is $9310 billion (37235 – 27925) represents growth in both expenditures and the effect of movements in prices between 2011 and 2017, just as does the 33.3% growth in column (3). This is because each ICP round uses the reference currency prices of the benchmark year. (It is also true that if the Japanese yen instead of the US dollar were the reference currency the relative inflation would depend on the movement of Japanese prices. See Balk, Rambaldi and Rao, 2020). The second point is more subtle. In Table 1 the numbers are tied to the United States in another way. In both years, the US GDP is its actual GDP in 2011 and 2017, a choice made because that is most familiar to users. In any one year the choice of nominal reference makes no difference in the relative position of countries; it could be the US, China, or the average of all countries, an alternative that the ICP report offers along with the United States. However, when moving between years it is important to keep this in mind - a point we will return to below.

The World Economic Outlook (WEO), a flagship publication of the IMF, presents estimates of global and regional growth in output and inflation and it includes projections for the coming years. Up to 1992 the IMF weighted the national growth rate by its GDP share in the world, converted at exchange rates (three-year average) to dollars. This exchange rate based weighted average produced low rates for Asia, though the media, other observers and China experts all said the IMF was understating what was happening in East Asia's economies. Further, observers in Europe thought the low growth in Europe at the time was receiving too much weight because of their overstated GDP when converted at exchange rates. The IMF decided that it was time for a change and in 1993 began using PPP converted real GDP to weight country growth rates in preparing the WEO. We illustrate in column (4) the result of calculating such a weighted average growth calculation using the average of 2011 and 2017 PPP-converted GDP shares as weights. When column (3) is divided by column (4) we derive an inflation rate in column (5). This method is commonly used by international organizations to estimate growth rates for country groupings. However, these organizations derive inflation as weighted averages of domestic inflation rates shown in column (7), thus missing the vital effect of change in the PPP exchange rates. In Table 1 we present a complete and comprehensive analysis

of change in world real GDP over the two years. The analytical framework for the decomposition of change in real GDP at the country, regional and world level presented in Table 1 is outlined in Appendix 1.

Table 1: Real GDP, Growth and Inflation by Regions, 2011 and 2017

ICP Region	RGDP 2011	RGDP 2017	Change from 2011 to 2017	Real Growth	Inflation	Exchange Rate change effect	National Inflation Rate
	(billion $)	(billion $)	(2)/(1)		(3)/(4)		
Panel A: Geographic Regions	(1)	(2)	(3)	(4)	(5)	(6)	(7)
East Asia & Pacific	27925	37235	1.333	1.363	0.979	0.887	1.104
Europe & Central Asia	24027	30362	1.264	1.104	1.145	0.975	1.174
Latin America & Caribbean	7675	9198	1.198	1.103	1.087	0.703	1.545
Middle East & North Africa	6943	7131	1.027	1.195	0.859	0.700	1.227
North America	16973	21297	1.255	1.138	1.102	1.002	1.100
South Asia	6923	10123	1.462	1.478	0.989	0.756	1.308
Sub-Saharan Africa	2997	3743	1.249	1.244	1.004	0.692	1.451
World	**93463**	**119089**	**1.274**	**1.223**	**1.042**	**0.879**	**1.185**
Panel B: Adminsitrative (Agency) Region							
Eurostat-OECD	50588	63438	1.254	1.124	1.116	0.992	1.125
Asia and the Pacific	27535	38650	1.404	1.460	0.961	0.824	1.166
CIS	827	994	1.203	0.994	1.210	0.563	2.150
Caribbean	119	128	1.074	1.021	1.052	0.901	1.168
Latin America	4703	5364	1.141	1.057	1.080	0.609	1.772
Africa	3823	4607	1.205	1.234	0.977	0.712	1.371
Western Asia	5868	5908	1.007	1.194	0.844	0.673	1.254
World	93463	119089	1.274	1.223	1.042	0.879	1.185

Notes: RGDP denotes real GDP obtained by summing GDPs of all countries within a region after conversion using PPPs. Figures in columns 1 and 2 are based on ICP 2011 and 2017 results in World Bank (2020). Figures in the remaining columns are based on authors' computions using methodology in Balk, Rambaldi and Rao (2020).

The real GDP of the world, covered by the 176 ICP countries, increased from 93.4 to 119.09 trillion dollars over the period representing an increase of 27.4 percent. Of this change, global growth, which is a weighted average of growth of GDP in the countries, is of the order of 22.3 percent. The WEA measure of global inflation, shown in the last column, shows 18.5 percent. The WEA measures of global growth and inflation do not match-up with the change in the size of the world economy in column (3). This inconsistency goes unnoticed as the analytical framework for global growth and inflation computations used by the IMF are not explained in any detail.

The decomposition provided in Table 1 provides a coherent accounting of change in real GDP over the period 2011 to 2017. The global inflation measure, in column 5, includes domestic inflation rates as well the effects of changes in PPP exchange rates. In a recent paper Balk, Rambaldi and Rao (2020) have used the Sato-Vartia Index formula to decompose these two effects, the one due to changes in exchange rates, and the other due to domestic inflation. These are given in columns (6) and (7). Their product equals column (5) that we have labeled inflation, following the convention of IMF and others. It is instructive to compare columns (5) and (7) for Europe and Central Asia, Sub-Saharan Africa and the World. For Europe Inflation in column (5) was 14.5% and 17.4% in column (7) a relatively small difference associated with a small depreciation on PPP exchange rates of some of the countries. Sub-Saharan Africa also has exchange rate depreciation but much more substantial, over 30% leading to a rather misleading inflation index of 0.4% over the 6 years compared to the apparent price rise in the region of 45.1% for the period. The World is somewhat between the two with combined exchange rate and inflation changes of about 12%.

Our analysis of change in real GDP of the world and its regions, presented in Table 1, has implications for the IMF in its compilation and dissemination of global and growth and inflation. First, we emphasize the need to clearly identify the countries that are included in global growth computations. We believe that IMF

could focus on 150 or so largest countries that roughly account for 99.99 percent of the world economy in PPP terms. Second, it is important to publish the size of the world economy in the years under comparison expressed in PPPs of respective years. Finally, publication of a complete decomposition of the change in real GDP into growth and inflation measures that clearly include a measure of the effect of changes in PPPs during the period would be helpful to the end-users.

Section 2.2 Level and Growth in Country Groups based on real per capita GDP

In Table 2, countries in the 2011and 2017 ICP rounds are grouped according to the World Bank (2020) per capita real GDP categories. It is not that surprising that the high-income group had the slowest real growth (column 4) over the 2011 to 2017 period because a number of those countries like Japan, have found it difficult to achieve high rates of growth in recent decades. But one remarkable result is that the two lowest income groups grew the most rapidly, even besting the upper middle GDP group on average by 10% for the period. We see evidence of income convergence in the real growth rates of the low, lower middle and upper middle income countries. How the severe economic shocks posed by the pandemic will affect this encouraging growth performance has to be a major concern.

Table 2. Decomposition for country groups based on per capita real GDP, 2011 and 2017

Country Groups by per capita real GDP	RGDP 2011	RGDP 2017	Change from 2011 to 2017	Real Growth	Inflation	Exchange Rate change effect	National Inflation Rate
	(billion $)	(billion $)	(2)/(1)		(3)/(4)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
High income	47587	58383	1.227	1.123	1.092	1.024	1.067
Lower middle income	13528	18991	1.404	1.383	1.015	0.732	1.386
Upper middle income	31610	40739	1.289	1.306	0.987	0.767	1.287
Low income	738	976	1.324	1.412	0.937	0.717	1.307
World	**93463**	**119089**	**1.274**	**1.223**	**1.042**	**0.879**	**1.185**

Notes: RGDP denotes real GDP obtained by summing GDPs of all countries within a region after conversion using PPPs.Figures in columns 1 and 2 are based on ICP 2011 and 2017 results in World Bank (2020). Figures in the remaining columns are based on authors' computions using methodology in Balk, Rambaldi and Rao (2020).

In terms of the price inflation, Table 2 mirrors Table 1. Most high-income countries were in Europe and North America where there were relatively small differences in either columns 5) or 7). In contrast the other income groups all show substantial exchange rate depreciation though tied to the price increases.

2.3 Level and growth in real GDP of selected countries

The decomposition of change in real GDP over the years 2011 and 2017 shown for country groupings is equally applicable to individual countries. This decomposition follows equation (A1) in appendix 1.

Table 3: Decomposition of change in real GDP for selected countries, 2011 and 2017

Countries	RGDP 2011	RGDP 2017	Change from 2011 to 2017	Real Growth	Inflation	Exchange Rate change effect	National Inflation Rate
	(billion $)	(billion $)	(2)/(1)		(3)/(4)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
United States	15542.58	19519.42	1.256	1.140	1.102	1.000	1.102
China	13882.96	19617.38	1.413	1.519	0.930	0.842	1.104
India	5482.87	8050.53	1.468	1.509	0.973	0.753	1.292
Germany	3415.02	4381.79	1.283	1.099	1.168	1.065	1.096
South Africa	639.19	733.69	1.148	1.099	1.044	0.743	1.405
World	93463	119089	1.274	1.223	1.042	0.879	1.185

Notes: RGDP denotes real GDP obtained by summing GDPs of all countries within a region after conversion using PPPs.Figures in columns 1 and 2 are based on ICP 2011 and 2017 results in World Bank (2020). Figures in the remaining columns are based on authors' computions using methodology in Balk, Rambaldi and Rao (2020).

Columns (1) and (2) Table 2 show real GDP of selected countries, expressed in US dollars (currency of the reference country), in years 2011 and 2017. It can be seen that real GDP of Germany increased from 3415.02 to 4381.79 representing an increase of 28.3 percent. This increase is driven by three factors: growth of GDP at constant prices over the period (column 4); domestic price change (column 7); and the effect of change in PPPs (column 6). It can be see than that domestic growth was 9.9 percent compared to the combined effect of domestic price change and PPP change effect together accounting for 16.8 percent. In the case of India and China the PPP effect is quite significant and the overall inflation effect is in fact negative. Both of these countries posted growth in GDP in excess of 50 percent over the six year period. The PPP effect for the reference country, United States, is equal to 1.

2.4 Change in global economic welfare

We make use of Sen (1976, 1979)'s measure of economic welfare to examine change in global welfare over the period 2011 to 2017. Sen's measure of welfare is given by:

$$W = \mu \times (1 - G)$$

where μ and *G* are respectively the mean or average income and the Gini measure of inequality. In order to compare global welfare over these two years, it is necessary to consider mean income in constant prices.

Table 4: Sen's Measure of Global Welfare, 2011 and 2017

	2011		2017	
Per capita real GDP in 2017 $	14551		16575	
Gini	0.4848		0.4721	
Sen's Welfare Measure	7497		8750	
Theil's measure	0.4364		0.4169	
Decomposition of Theil's measure - Geographic Regions		%		%
Within region	0.1274	29.19	0.1091	26.17
Between region	0.3090	70.81	0.3078	73.83
Decomposition of Theil's measure - Income groups				
Within region	0.0514	11.78	0.0406	9.71
Between region	0.3850	88.22	0.3765	90.29

Source: Authors' calculations based on World Bank (2020)

As shown in Table 4, the world per capita real GDP, or per capita income in PPP terms, has increased from $14,551 to $16,575 both expressed in 2017 prices. This represents an increase of 13.9 percent over the six year period. International income inequality, a population weighted inequality measure[2], based on the Gini coefficient shows a decline from 0.4848 to 0.4721.[3] The Sen's measure of global welfare increased from $7497 to 8750, a 16.7 percent increase during the same period.

In Table 4 we also present Theil's additively decomposable measure of inequality. Similar to the decline in Gini, Theil's measure shows a decline. We draw attention to two features of the contribution of within and between region inequalities. The within region inequality has declined irrespective of how countries are grouped and the contribution of between region inequality has risen which indicates a small increase in divergence in incomes of regions. As expected and by construction, within group inequality in the case of income groupings is quite small contributing around 10 percent to total inequality whereas between-group inequality is around 90 percent.

Results similar to those presented in Table 4 for each of the regions are available from the authors upon request. The region specific profiles exhibiting interesting region specific profiles.

2.5 Distribution of GDP by expenditure components

Thus far we have focused on real GDP and per capita incomes and inequality in the distribution of income. However if our focus is on the material wellbeing of people in different countries GDP may not be the most ideal measure. Instead, the focus would be on the levels of individual consumption expenditure by households (ICEH). Recognizing the role of government in the provision of services to the general population especially in the areas of health and education, a slightly extended measure would be the level of actual consumption expenditure by households (ACEH) which includes expenditure by households as well as that by the government on behalf of the households. While consumption measures are indicative of the current levels of material wellbeing, gross capital formation levels hold important information on the levels of capital stock and productive capacity of the economies in different countries.

Table 5: Inequality in GDP and its components – ICP 2011 and 2017
(Geographical Grouping of Countries)

Inequality Measure	GDP		Individual Consumption Expenditure by Households (ICEH)		Actual Consumption Expenditure by Households (ACEH)		Government Expenditure		Gross Capital formation	
	2011	**2017**	**2011**	**2017**	**2011**	**2017**	**2011**	**2017**	**2011**	**2017**
per capita real expenditure	14551	16575	7335	8934	8881	10797	2970	3352	3504	4204
Gini	0.4848	0.4721	0.5100	0.4701	0.5063	0.4770	0.5318	0.5415	0.4524	0.4779
Theil	0.4364	0.4169	0.4559	0.3859	0.4541	0.4013	0.5728	0.6064	0.4404	0.4940
Within	0.1274	0.1091	0.1318	0.0997	0.1289	0.1021	0.1624	0.1553	0.1596	0.1492
Between	0.3090	0.3078	0.3241	0.2862	0.3251	0.2993	0.4104	0.4510	0.2808	0.3448
% share of inequality between	70.81	73.83	71.09	74.16	71.60	74.57	71.65	74.37	63.76	69.80

Note: Per capita expenditures are expressed in constant 2017 US dollars.

[2] This measure is referred to as the "concept 2" measure of world inequality (Milanovic, 2002) which is the measure obtained with each country represented by its mean income and population size. The concept 3 measure of world inequality is more data intensive as it accounts for inequality within each country.

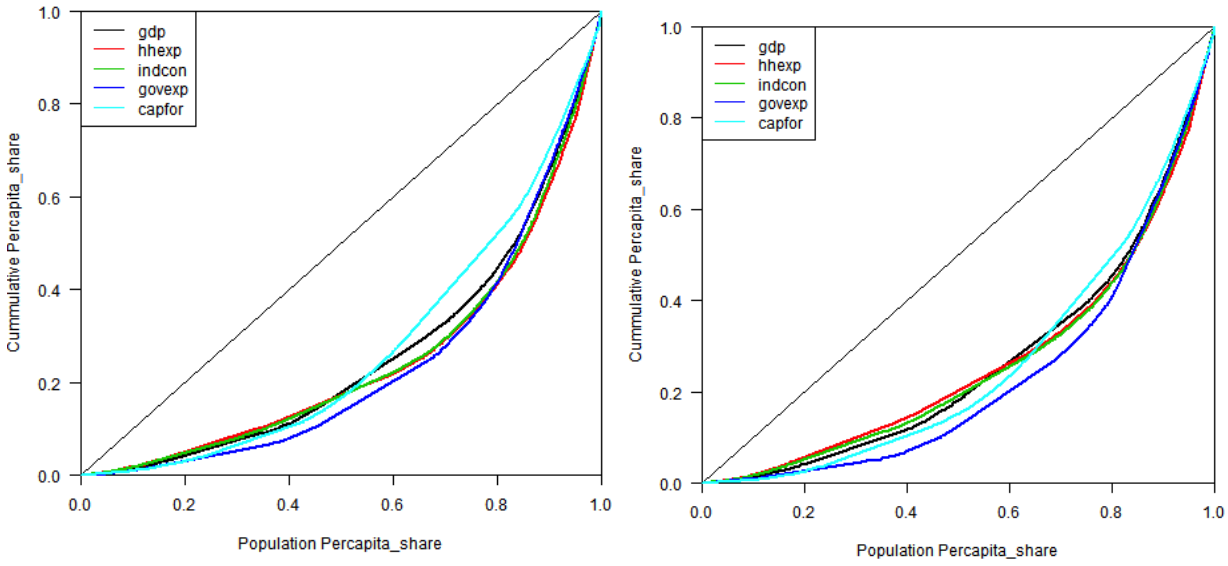
[3] The Lorenz curve for the distribution of income in 2017 dominates, by a small margin, the Lorenz curve for 2011 indicating an unambiguous decline in inequality. These figures are available from the authors upon request.

In Table 5 we seek to illustrate the richness of the ICP results. We focus on the distributional characteristics of ICEH, ACEH, government expenditure as well as gross fixed capital formation.

The first row of the table shows that, on average, consumption expenditure is the main component of GDP[4]. The difference between ICEH and ACEH reflects the contribution made by the general government and these figures suggest that this contribution can be significant. Our interest is primarily on the distribution of these expenditures. The general expectation is that distribution of household expenditure would be less unequal compared to GDP, we find this to be true for the ear 2017 where both Gini and Theil's measures are lower for ICEH and ACEH compared to the GDP distributional measures. We find a significant reduction in inequality for GDP, ICEH and ACEH components. In contrast, the government expenditure as well as gross capital formation show a significant increase in inequality. Lorenz curves for GDP and its components are shown in Figure 1.

Figure 1: Lorenz Curves for GDP and its Components – 2011, 2017

2011 2017



The last three rows of Table 5 show the within and between-region inequality for various aggregates. The share of between region inequality as a percentage of the overall Theil's measure has increased over the period 2011 to 2017. The results presented here show scope for further analysis and interpretation which is left for future research.

Section 3. The Political Economy of Size of GDP

Since the end of World War II Russia and China have posed problems for statistical authorities in international organizations as well as many countries, especially the United States. The world was adopting common measures of the economic size of economies, and despite its many limitations Gross Domestic

[4] We remind the reader that these components are not strictly additive as the GEKS aggregation procedure used in the ICP is not additively consistent.

Product was to win the day. GDP per capita became a measure of the affluence of a country and was used as a guide for country contributions to the UN, World Bank, WHO, etc. And total GDP became a measure of the total size of the economy on which to base assessments. In the case of the United States, which was the economically and militarily the strongest country in the world, there was great interest in the military and other agencies in knowing the economic size of other countries. The US government made research awards, contracted research through numerous agencies and did in house research, CIA, State Department and the military for example, from the mid1950s to 1970s that would have included aggregate measures of productive capacity of Russia and China. The Congressional Hearings during this period of the Joint Economic Committee (for example 1959 for the Soviet Union and 1967 for China) often had papers from agencies and research institutes.

With respect to Russia, the Marxist measure of the total economy, the Material Product System (MPS) was used and was adopted as an alternative to GDP in the United Nations Statistical Office. The differences from GDP were clearly spelled out, but the sources of data were less clear in the case of the USSR nor was there an annual or quarterly publication as had become custom in most large countries by the 1960s. In principle, China was following Marxist practice, but since they were not members of the UN, they were making little effort to build up national accounts. They were however building a local network of officials reporting economic activity, albeit not independent of those local authorities whose incentives were to fulfil plans from county and provincial authorities. All of this left measuring the economic size of China and the USSR very much an art of inference with minimal evidence. There were several articles on the relative size of the Indian and Chinese economies as both began their development plans circa 1950. The consensus was that on a per capita basis there was not much to choose at that time.

The CIA commonly made purchasing power estimates of the output of the USSR by valuing the physical output of Russia at US prices, which tends to make the soviet economy appear quite large relative to its size if US output were valued at soviet prices. The CIA did not present the latter estimates to Congress when requesting funding, wanting to justify a larger budget for itself and the military. With the break-up of the Soviet Union, Russia and the Commonwealth of Independent States moved to the UN System of National Accounts during the 1990s removing most of the mystery around their GDP.

China remained another matter. In a 1956 interview Mao Zedong referred to the United States as a "paper tiger" a Chinese expression to refer to someone who appeared very threatening but in fact was weak. This sort of linguistic excess seems to be associated with China both inside and out. During the India-China war in 1962 the media often referred to the Chinese hordes pouring over Himalayan passes, a very frustrating term for military experts who wanted to know how many battalions were in a horde. The US CIA did commission a RAND study to compare the Chinese and US GDP (Hollister 1958) that valued Chinese physical output at US prices as had been done for Russia, but also valued US output at Chinese prices. The difference between these valuations of output at own prices versus at US prices was greater than two, with China appearing twice as large at US prices than at its own. The pattern is an empirical generalization, a country will always appear richer when valued at another country's prices than their own. Or as Paul Samuelson put it, "it always pays to ride the other fellow's horse."

This background left the world even more curious about the Chinese economy especially as it began to open up in the 1970s with its reforms, special economic zones and entry into the international trade and organizations. The earliest PPP exercise from the expenditure side for China emerged from a post reform exchange tour by a group of US economists in 1980, one of whom, Irving Kravis, was a joint director of the first three rounds of the ICP in its research phase. While Kravis did obtain cooperation of the Chinese statistical office in obtaining estimates of the national expenditures and some national prices, much of the price matching to the 1975 US prices from the ICP Kravis personally supervised. It is a measure of how much such Chinese numbers filled a void by the extent this report (Kravis, 1981) came in for comment and spurred further research on the Chinese economy. In addition to studies by the World Bank, IMF, the

OECD and other research centers, the China statistical offices made a gesture toward participating in the ICP in the 1993 ESCAP benchmark, and their Beijing-Hong Kong comparison was published. (ESCAP, 1999).

Angus Maddison had like Colin Clark always included China in his historical economic studies and on behalf of the OECD Maddison (1998) prepared a long run study of the Chinese economy that included purchasing power estimates tied to the ICP results around 1990. China was included in the 2005 ICP although the price collection was limited to 11 cities and their immediate surroundings. The 2005 results were thought by the Bank to be much more than an improvement on earlier work and they were adopted by the international community as a basis for contributions to the IMF. However, the China ICP numbers for 2005 were widely questioned by poverty researchers and others like Chen and Ravallion (2010) because of how China was linked into the global economy. Maddison, while alive, (2013) was especially vocal on his preference for his own estimates that underlie his projection that China's GDP would pass the United States in 2030.

Against these uncertainties about the earlier purchasing power estimates, the results of the 2011 and 2017 ICP rounds are thought to be the best window we have on the size of the Chinese economy compared to India, Japan, the United States and other major countries.

Table 6: Per Capita GDP, and Total GDP for 25 largest Economies in 2017
(Per capita and total figures in current US$ and GDP in billions of US$)

Country Name	Real GDP 2017 (billions of dollars)	Real GDP 2011 (billions of dollars)	Real GDP 2011 at 2017 prices (billions of dollars)	per capita Real GDP 2017 ($)	per capita Real GDP 2011 ($)
	1	2	3	4	5
Netherlands	948.2	777.9	882.1	55349	46599
Argentina	1037.8	797.3	1017	23621	19295
Taiwan, China	1112.6	944.7	914.2	47223	40736
Poland	1145	869.8	957.9	29802	22576
Thailand	1203	912.8	975.5	17781	13785
Australia	1233.9	971.2	1050	50153	43474
Egypt, Arab Rep.	1263.4	905.5	1035.8	13327	11245
Iran, Islamic Rep.	1298.1	1584.8	1157.1	16012	21089
Saudi Arabia	1565.9	1586.7	1328.3	48015	56321
Canada	1778	1430.8	1583.2	48658	41663
Spain	1844	1486.4	1727.5	39627	31803
Korea, Rep.	2105.9	1625.3	1775.5	41001	32547
Turkey	2265.5	1443.3	1610.7	28209	19445
Mexico	2470.1	1911.3	2107.2	20023	16547
Italy	2529.5	2173.2	2558.6	41785	36183
Indonesia	2893.6	2229.5	2127.3	11049	9213
France	2994.5	2446.5	2812.4	44651	37448
Brazil	3017.7	2970.6	3025.6	14520	15040
United Kingdom	3037	2350.8	2686.5	45988	37146
Russia	3829.5	3268.5	3616.4	26079	22863
Germany	4381.8	3415	3988.1	53012	42542
Japan	5173	4573.2	4795.7	40827	35775
India	8050.5	5482.9	5336.3	6149	4508
United States	19519.4	15542.6	17129.6	59984	49811
China	19617.4	13883	12911.7	14150	10329

Source: Table is based on the numbers underlying Figures 1.14a. and b. in the 2017 ICP Report World Bank, 2020). Column 3 derived by dividing Column 1 by national growth rates from 2011-2017. National Growth Rates from WDI data base except Taiwan from national accounts of national statistics office.

Table 6 presents the main results for the 25 largest world economies ranked by their total GDP in 2017 (column 1), and 2011 (column 2) as revised for the 2017 Report. Columns 4 and 5 provide the per capita real GDPs in PPP terms. First, as noted in Section 1, the role of the United States is only to provide a reference currency. The relative sizes of China and India to each other and the US would be unchanged if the Euro or Rand were the reference currency. The 2011 and 2017 dollar figures in Table 6 are in current prices so cannot be directly compared over time (see discussion in Appendix 1). In 2011 the ICP put the US above China in GDP, and both well above India and Japan. Did this meet expectations? Certainly it was expected that China on a per capita basis was well above India 60 years after they began their development plans.

What about China's position relative the United States? China's economic size compared to the US was accepted by the international institutions, not so by some scholars, and not by China. China's position has always been easy to rationalize but hard to understand. In the 1980s China reported very high economic growth rates although they wanted to maintain that their per capita output remained very low and they needed international assistance. In addition China sought any trade concessions being provided for lower per capita income countries. From a public relations perspective this was the best of both worlds, their growth was high impressing their citizens and the world, while their financial responsibilities to the world remained low.

It is unclear why China wants to continue to appear poorer than they are. One way to suggest the paradox presented by China's statistics is to indicate how extrapolations of their output over ICP rounds compare with their actual position in the ICP ranking of countries. Columns 2 and 3 provide two estimates of the 2011 GDP for the 25 largest economies, the first the benchmark estimate as revised for the 2017 report, and the second an extrapolation backward of real growth and inflation from the 2017 ICP benchmark GDP in column 1. For countries with a tradition of national accounts statistics the difference between columns 2 and 3 is small, but for countries with less solid national accounts, and or high inflation or exchange rate fluctuations the extrapolations produce larger differences. Unfortunately, both China and India fall into the latter category where their national growth rates are much higher than implied by the relative positions of their GDPs in 2011 and 2017. In Table 6 this shows up in their 2011 GDPs being much lower than the reported 2011 ICP.

If the extrapolations had been from 2011 to 2017, the 2017 GDP estimate for China would have been 19 percent above the US in 2017 in contrast to the 2017 benchmark where the two are essentially the same size. Why might this large difference occur? An obvious problem is that the national growth rates depend on the prices underlying national accounts deflators, whereas each ICP benchmark relies on prices of final output. One line of explanation of the results is that China is thought to have often priced at more expensive outlets than other countries in Asia leading to estimates of their price level that are too high and total GDP that is lower than likely. However, Feenstra, Xu, and Antoniades (2017) have provided a more nuanced view of pricing in China albeit based on comparisons of scanner prices of the same groups of grocery items and scraped prices. These two lines of evidence are not necessarily in conflict since most items where selection of outlet or brand name affect the price collected for the ICP are not readily available for price scraping or with standardized bar codes. The results of the 2017 ICP for China and other countries need even more detailed examination now that the present economic effects of the pandemic and its consequences for future ICP comparisons of world production present us with more unknowns.

Section 4. Analysis of Price Levels, Balassa-Samuelson and the ICP

What takes all the resources, field work and data processing within the ICP is captured in the price level measures, the subject of this section. What emerged when the first ICP was presented for 10 countries with the reference year of 1970 was that the price level of a country rises with its per capita income (Kravis et al., 1975). The formula for the price level of India with respect to the United States is defined as:

$$PLI_{Ind,US} \equiv \frac{PPP_{Ind,US}}{XR_{Ind,US}} \quad (1)$$

where PPP is the purchasing power parity of the rupee to the dollar and XR is the exchange rate of the rupee to the dollar. The price level (or PL) of GDP for India in 2017 was 0.315 meaning that the bundle of goods and services that cost $100 in the United States would cost a little under $32 in India. Again, if a different currency were the reference all the price levels would change but the purchasing power of each country relative to each other would remain the same. A formal and a general concept of price level and its properties are presented in Appendix A2, "Analysis of Price Levels and Price Structures".

As the number of participating countries in the ICP has risen to 176 this finding has been robust, as we illustrate below for 2011 and 2017. A derivative data set, the Penn World Table (PWT), has been widely used in the growth and trade literature was built upon this finding. The most frequently accepted explanation of this result, the differential productivity model, was formulated independently by Balassa (1964) and Samuelson (1964). It builds on the proposition that the price of non-tradable goods (about half of GDP) tends to be lower than that of tradable goods for low-income countries and rises above tradable goods in high income countries. This proposition in turn builds on the observation that the productivity differentials between high and low-income countries are greater for tradables, like steel, than for non-tradables, like restaurant meals. There are other explanations like Bhagwati (1984) or Clague (1986) of why price levels rise with income but for present purposes we just want to make clear this relationship has become an expected and major finding of the ICP rounds. However, we discuss below the more recent paper by Zhang (2017) that argues that unmeasured differences in quality of tradable goods for higher income countries may explain the apparent violation of one price for traded goods.

4.1 Tradables and non-Tradables

The Balassa-Samuelson effect is anchored on the differential productivity hypothesis that assumes that productivity increases more rapidly for tradable goods than non-tradables. In fact a strong case could be made that Roy Harrod (1939. Ch. 4) had clearly spelled out the B-S explanation in his Cambridge Economics Manuel on International Trade. World War II interrupted the continuity of the flow of ideas in many fields including economics and Harrods work on comparative price levels as well as his growth model that pre-dated Domar. His discussion of the tradability of A, B, and C goods anticipates some more recent literature and should warrant for Sir Roy the label H-B-S as the attribution for what has been most usually termed the Balassa-Samuelson effect. The output per person in grain or steel production has increased faster than in personal services is a typical example offered. But increasingly this is countered with examples like financial services where there has been rapid growth in productivity and textiles where productivity growth has tended to plateau.

In this section we look at the price level indexes of tradables and non-tradables for 2011 and 2017 and see if the generalizations that seemed to hold before 2000 still appear valid. In order to conduct the analysis reported below, we had to compute separate sets of PPPs for tradables and non-tradables as these are not compiled by the World Bank as a part of ICP. The ICP results are all based on expenditure and PPPs at the basic heading (or elementary index) level, the ICP makes use of a classification with 155 basic headings. For our analysis, we have classified these 155 basic headings into: commodities; services and construction

related non-tradable basic headings[5]. We had to restrict our coverage to 173 countries for which detailed 155 basic heading level data are available, list available from the authors. As the price level indexes defined in (1) require PPPs, we have computed PPPs using the Gini-Elteto-Koves-Szulc (GEKS) method separately at the GDP level, for tradables and for the group of non-tradables, using USA as the reference country.

We begin with simple logarithmic relationships between the price level of tradables and per capita GDP in 2011 and 2017 re-examining what Kravis and Lipsey (1988) had found for the 1980 ICP round of 60 countries. They found that the price level of tradables for the lowest 15 real per capita GDP countries was 80 and highest 15 countries was 112. We give below the log-log regression coefficients of the PL of tradables against per capita GDP for 2011 and 2017.

Relationship between PL of Tradables (PL_TR) and per capita income (*NGDP_PC)*[6]

$$\begin{aligned} &2011: \quad \ln PL\_TR = \underset{(0.0071)}{0.0938} \ln NGDP\_PC - \underset{(0.0639)}{0.8714} \qquad R^2 = 0.568 \\ &2017: \quad \ln PL\_TR = \underset{(0.0067)}{0.0855} \ln NGDP\_PC - \underset{(0.0617)}{0.8409} \qquad R^2 = 0.480 \end{aligned} \tag{2}$$

Clearly the price level for tradables rises with income though as Kravis and Lipsey have noted, "despite the near unanimity found in the literature on real exchange rates the law of one price prevails for tradables." (1988, p.475). That is conventional trade theory would have expected the coefficient on GDP to be zero, not positive and significant.

Zhang (2017) provides even stronger evidence that the price level of tradables rises with income across countries based upon the 2005 ICP results. As noted, Zhang offers an alternative to the differential-productivity explanation of Balassa-Samuelson by empirically breaking down the ICP basic headings that are "pure" services and the rest. His idea is that B-S derive their result as an average of non-tradable and tradable goods, whereas Zhang breaks down non-tradables into services totally produced by local labor and the rest. He then regresses the price level of tradables on income and still finds a significant positive relationship with income even after removing pure non-tradables. In this, Zhang appears to be describing Harrod's type C. goods.

While it is expected that the coefficient on per capita GDP against tradables should be near zero that is clearly not the case for either of the recent ICP benchmarks. But the expectation from the differential productivity hypothesis that the coefficient on income for non-tradables should be larger than tradables and that relationship appears to hold. In both 2011 and 2017 the slope coefficients on income are more than twice as large for non-tradables as for tradables.

[5] Details of the classification used in the study are available from the authors. While there may be discussion about a few basic headings as to whether they belong to the class of tradables or non-tradables, we believe that the results reported here are robust to small differences in such classification. An alternative definition of tradables has been suggested that was illustrated with 2011 ICP basic headings for consumption (Vo, 2021). For each basic heading, the log of the basic heading parity for country B is subtracted from the log of country A. The sum of log differences is taken over all possible pairs of countries in a basic heading and a cut off chosen separating tradable and non-tradeable items. High values of the difference measure would be grouped into non-tradables. We have not tried this measure here.

[6] Unless and otherwise stated, throughout the paper we use per capita income or per capita GDP in nominal terms, i.e., converted using exchange rates.

Relationship between PL of non-Tradables (PL_NTR) and per capita income (NGDP_PC)

$$\begin{aligned} 2011: \quad & \ln PL\_NTR = 0.2645 \ln NGDP\_PC - 3.0941 \qquad R^2 = 0.649 \\ & \qquad\qquad (0.0176) \qquad\quad (0.1535) \\ 2017: \quad & \ln PL\_NTR = 0.2745 \ln NGDP\_PC - 3.3185 \qquad R^2 = 0.603 \\ & \qquad\qquad (0.0166) \qquad\quad (0.1497) \end{aligned} \tag{3}$$

Figure 2: Ln(PL NonTr/PL Tr) and Ln PC nominal GDP

Figure 2a - 2011

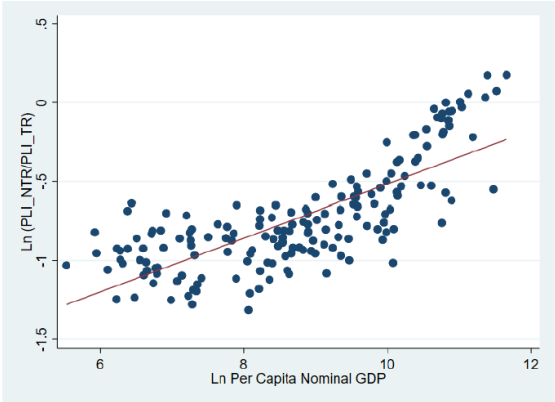
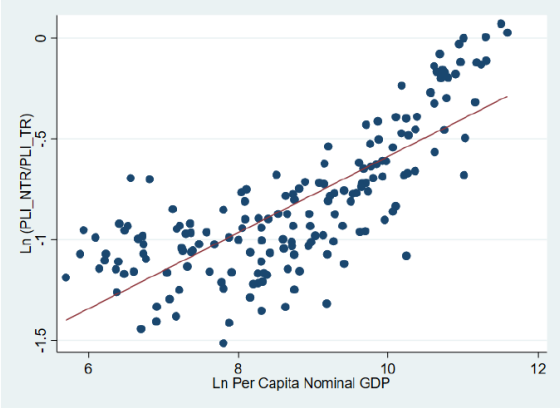


Figure 2b - 2017



The essential relationship that flows from the above results and from the differential productivity hypothesis is that the ratio of the price level of non-tradables to tradables rises with the per capita GDP of countries. This is shown in Figures 2a and 2b. The simple relationship for both years is strong with the correlation at least 0.6 in both years and becomes stronger with the addition of other variables[7]. We conclude that the basic pattern of price levels between tradables and non-tradables and GDP is consistent with that found in earlier ICP rounds.

The price level – income relationship

In examining the relationship for 2011 and 2017 we followed the literature and regressed the log of the price level of GDP against log of per capita GDP converted at PPPs, usually termed real GDP in contrast to the exchange rate converted GDP. (Figures 2a and 2d). As expected, the relationship between income and price level was strong and positive for both 2011 and 2017. While this is the customary form of the equation or figure illustrating the price level to income relationship, it could as well use the log of nominal income on the right-hand side as for example in Deaton and Heston (2010, Figure 1). What difference does it make? See Figures 2a vs. 2b and 2c vs 2d. The slopes are slightly higher in 2017 than 2011 but all the slopes fall between .210 and .218. In either form of the equation, the correlation is noticeably larger using the nominal per capita GDP. The reason for the higher correlation is that the nominal GDPs have a larger variance than do the real GDPs which is visual in the scatter diagrams.

[7] When square of per capita income is included, R^2 increased to 0.73.

Figure 3a

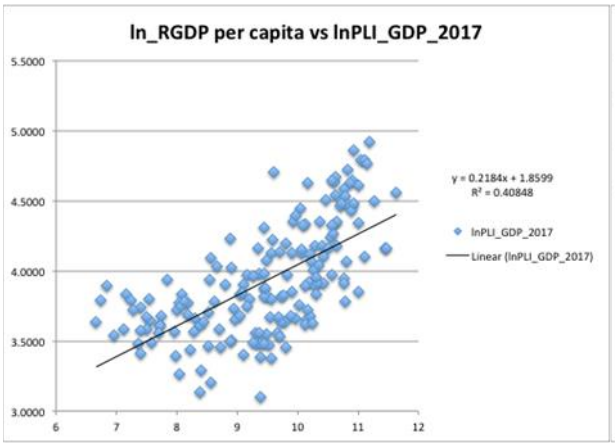


Figure 3b

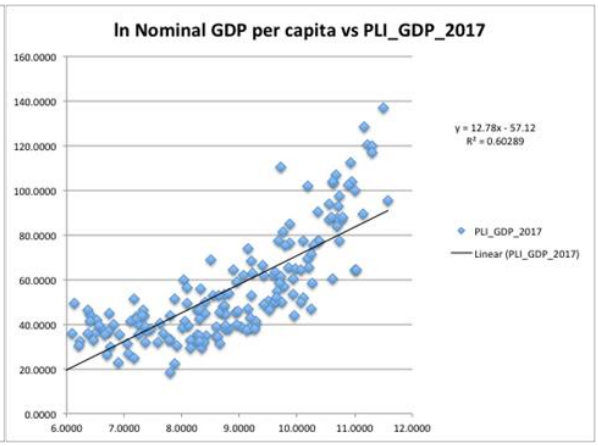


Figure 3c

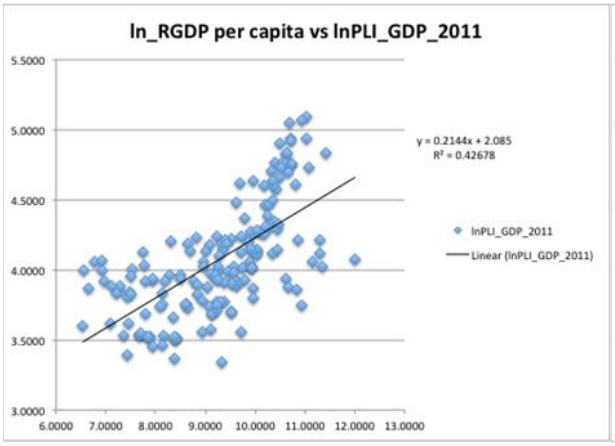
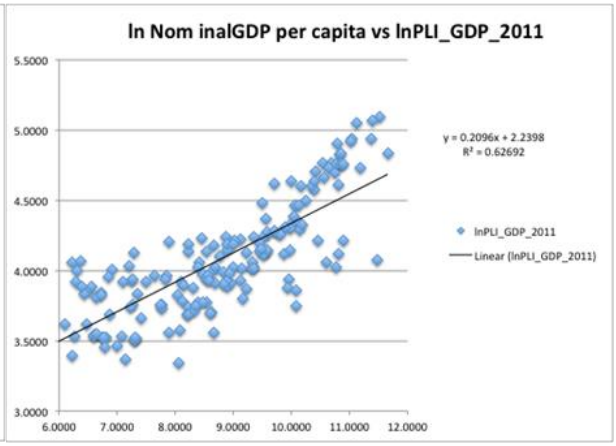


Figure 3d



The intuition for this result is that when using real GDP on the right-hand side, much of the effect of conversion to PPPs has been embodied in the conversion. Is there any reason to use one versus the other? Certainly not because of differences in slope coefficients. One reason to use nominal GDPs is unlike real GDP it does not have the price level on both sides of the equation. A second reason is that many studies attempt to explain the price level per se, where a measure of GDP per capita is one among several explanatory variables. Using nominal GDP allows better estimates of the effect of variables like openness to trade because it does not introduce the price level into one of the other explanatory variables. In any event the results above strongly suggest that the 2011 and 2017 ICP results have a consistent story to tell, which is in turn the story of the last 50 years (KHS, 1982 Figure1-1). This gives us further confidence in the various constructs like similarity indexes that we have provided for the countries in this paper.

Some additional analysis of the price level and income relationship is reported below because it appeared promising and suggestive of areas for further research. One surprise was that the addition of squared value of the nominal GDP per capita substantially improved R^2 for the equation. That is when (4) is estimated:

$$\text{Ln PLGDP} = \alpha + \beta\,(\ln \text{GDP}) + \eta\,(\ln \text{GDP})^2 \qquad (4)$$

R^2 for 2011 is 0.677 vs 0.575 without the squared term. For 2017 R^2 is 0.729 vs. 0.620. The quadratic form is convex with α and η being positive and β negative. The relationship is stronger for 2017 than 2011. We introduced the quadratic form primarily because to our knowledge it has not been used before in the literature explaining the national price level. Addition of the squared income variable is also consistent with Zhang (2017)'s hypothesis that quality of tradable goods are not fully measured as income increases across countries. We will consider another version of (4) that adds a quantity and price variable related to the involvement of countries in international trade.

The most obvious measure is termed openness that is the national currency total of exports plus imports divided by GDP. Openness by itself is not significant in most earlier studies and the same is true for the 2011 and 2017 benchmarks. Kravis and Lipsey (1983) have argued that the reason for this is that the effect of openness differs according to the relative level of per capita GDP. We have replicated their treatment, namely to use both openness (OP) and OP*GDP as variables with mixed results. Another measure of trade volume added to (4) was the share of tradables with the expectation that PL will be lower the larger the share of tradables.

As explained above the price level of tradables (PL_TR) to the price level of non-tradables (PL_NTR) is negatively related to GDP per capita. This means that if we introduce (PL_TR/PL_NTR) into (4), the collinearity is high and we cannot have both (PL_TR/PL_NTR) and PL_GDP in the same equation. When we introduce (PL_TR/PL_NTR) on the right-hand side on its own, the correlation is suspiciously high (>.85) and the coefficients are near 0.9. The main concern with (PLT/PLNT) as an explanatory variable is that for each country the PL of GDP is almost an arithmetically weighted average of PLT and PLNT. Almost because the GDP price level includes all basic headings and PLT and PLNT does not include basic headings that can be negative, and the variables in the correlations are in logs. When the relationship is estimated across countries other factors will further remove the relationship from being incestuous. We think at a minimum further research on the national price level should give the difference in price level of tradables and non-tradables a high place. One variation we have not explored here but has been tried by Kravis and Lipsey is to use PL_T and PL_NT from the production side.

$$\begin{aligned} &2011: \quad \ln PL\_GDP = -0.928 \ln(PL\_TR / PL\_NTR) + 0.199 \qquad R^2 = 0.887 \\ &\qquad\qquad\qquad\qquad\quad (0.026) \qquad\qquad (0.020) \\ &2017: \quad \ln PL\_GDP = -0.888 \ln(PL\_TR / PL\_NTR) + 0.130 \qquad R^2 = 0.857 \\ &\qquad\qquad\qquad\qquad\quad (0.028) \qquad\qquad (0.023) \end{aligned} \tag{5}$$

The relationships examined in this section suggest the 2011 and 2017 ICP results are explained in good part by the per capita income of countries as in earlier ICP rounds. We have also examined the price levels of tradables and non-tradables following earlier work of Kravis and Lipsey (1988) and Heston, Nuxoll and Summers (1994). As in earlier work, we find the price level of non-tradables rises faster with income than the price level of tradables. We believe that this would be a promising line of future research especially if estimates of the tradables:non-tradables price levels could be derived independently of ICP expenditure based basic heading price levels, say from the output side or in the approach implicit in equation 5. Finally, while the price level of tradables is lower than non-tradables and rises more slowly, it still shows a significant rise, contrary to the usual assumption in textbooks. It would certainly be valuable if this departure from one price could be explained, perhaps because of more non-tradable elements in traded items of higher income countries, and the like.

Section 5. Price Structures and Price Similarity

Price level and real expenditure comparisons are twin objectives of the ICP but for most users the focus is usually on levels and disparities in per capita real expenditures across countries. Though ICP produces a wealth of information on price levels, much of the attention to date has been on the explanation of price level differences at the GDP level – subject matter of our discussion in the previous section. In this section, we make a modest beginning in analyzing ICP results from the angle of price structures and similarity of price structures among the economies of the world.

5.1 Price level indices

Price level indexes, compiled and disseminated as a part of ICP, are mainly used in comparing price level differences across countries for a selected aggregate. In Table 7, we present PLIs for the main components of GDP.

Table 7: Price Level Indices for Major National Accounts Aggregates, 2017
(for selected countries), US Price Level Index = 1.00

	GDP	Individual Consumption by Households	General Government	Gross Fixed Capital Formation
	(1)	(2)	(3)	(4)
Australia	1.1234	1.1716	0.9655	1.1755
Brazil	0.6789	0.7240	0.5653	0.6307
China	0.6146	0.6091	0.5433	0.6774
Egypt, Arab Rep.	0.1817	0.1896	0.1126	0.3532
Germany	0.8354	0.8873	0.7069	0.8467
Hong Kong SAR, China	0.7657	0.7952	0.7083	0.7922
India	0.3148	0.2968	0.3521	0.3661
Kenya	0.3858	0.3997	0.2690	0.4857
Luxembourg	0.9515	1.0891	1.1387	0.7621
Mexico	0.4687	0.5210	0.2420	0.5799
South Africa	0.4786	0.4876	0.3474	0.5435
Spain	0.7103	0.7926	0.5998	0.6020
Switzerland	1.1955	1.3769	1.3495	0.9828
Thailand	0.3757	0.3887	0.2712	0.4254
United States	1.0000	1.0000	1.0000	1.0000
WORLD	0.6667	0.6978	0.5405	0.6935

Source: World Bank (2020), Tables 2.1, 2.3, 2.4 and 2.5

Column (1) shows that price levels, for GDP, across countries increase with real per capita GDP. For countries like India, Kenya and Thailand price levels are around a third. In the previous section we focused on PLI's in column (1) and on PLIs specially constructed for tradables and non-tradables.

While it is a common practice to compare GDP price levels across countries, figures down column (1), we believe that there are important insights to be gained by looking at price level indices across rows and examine price levels for different aggregates for a given country or at the world level. Appendix 3 describes the framework and presents formulae that underpin analyses presented here. While making comparisons of indices in any given row, it is important to keep in mind that all these indices are relative to levels in USA. Elements of first row suggest that, price levels in Australia are roughly 12 to 17 percent higher than those in USA for all the major aggregates except for general government where the price level is only 97 percent. This means that in Australia general government services are delivered relatively less expensively compared to USA but more importantly for Australia, price levels for general government are lower than

that for the remaining three aggregates. We observe similar pattern for several countries in Table 7. In contrast, in India the price level for general government is higher than that for GDP, a surprising finding. Switzerland and Luxembourg show lower price levels for GFCF than that of price level for GDP. The explanation is that the price of services are high in these countries while there are virtually no barriers to entry of capital equipment and much of construction can use foreign labor so is in effect traded. This quick glance at the differences across countries at their price levels of the main aggregates shows substantial variation and suggests the potential of exploring the ICP below the GDP level. The last row suggests that the world price levels for GDP, household consumption and GFCF are roughly two-thirds of that in USA but for government consumption price level is about 50 percent. In interpreting these results, it is important to keep in mind that the price level index for USA equals 1 for all the aggregates.

Table 7 is an illustrative example using four major aggregates and a set of selected countries. Users may request[8] and obtain PPPs, price levels and real expenditures at a highly disaggregated level down to 155 elementary or basic headings. Comparisons of price levels across countries for any given commodity group or across commodity groups for any given country or at the world level, similar to those reported in Table 7, are feasible but less reliable largely due to the sampling issues and the unweighted formula used in computing PPPs at that level.

5.2 Price structures using world price levels

Measuring world price level for a given aggregate is more complicated than measuring price level at the country level where it is defined as the ratio of PPP to the exchange rate in equation 1 shown for India.

$$PLI_{Ind,US} = \frac{PPP_{Ind,US}}{XR_{Ind,US}}$$

Since there are no PPPs and exchange rate counterparts at the world level, price level index at the world level is defined using equation (1) in a slightly different form. PLI for India can be equivalently seen as the ratio of nominal (exchange rate converted) GDP to real (PPP converted GDP) since

$$PLI_{Ind,US} = \frac{PPP_{Ind,US}}{XR_{Ind,US}} = \frac{GDP_{Ind} \big/ XR_{Ind,US}}{GDP_{Ind} \big/ PPP_{Ind,US}} = \frac{\text{Nominal GDP of India}}{\text{Real GDP of India}} \tag{6}$$

This alternative representation of PLI is easy to implement at the world level:

$$PLI_{W,GDP} = \frac{\text{Nominal GDP of the world}}{\text{Real GDP of the world}} \tag{7}$$

where the numerator and denominator in (7) are simply the sum total of nominal and real GDP's of all the countries. The PLI measure in (7) can be applied to any aggregate of interest in which case the PLI needs to be appropriately indexed.

Intuition suggests that world PLI would be a weighted average of country specific PLIs. In fact the world PLI in equation (7) can be written, following equation (A2.8 in Appendix 2), as:

$$PLI_{W,GDP} = \sum_{j=1}^{176} PLI_{j,GDP} \times s_{j,GDP} \quad where \;\; s_{j,GDP} = \frac{GDP_j \big/ PPP_j}{\sum_{j=1}^{176} GDP_j \big/ PPP_j} \tag{8}$$

In columns (1) and (2) of Table 8, we present world PLIs for major aggregates and sub-aggregates of GDP for the years 2011 and 2017. For example, the world PLI at the GDP level was 0.777 implying that it was roughly 78 percent of the price level of USA, and in 2017 world PLI was only 67 percent of PLI of USA.

[8] From the Global ICP Unit at the World Bank.

Going down columns (1) and (2), caution must be exercised in drawing any conclusions on temporal movements of world price levels. Measuring global inflation and growth requires different apparatus, these measures were discussed in section 2. However the main focus here is on the comparison of price levels for different commodity groups/aggregates in any given year. What can we say about the world price structure in, say, 2017?

Table 8: World Price Levels for selected Expenditure Groups, 2011 and 2017

	World PLI, 2011	World PLI, 2017	World PLI with common GDP Weights, 2011	World PLI with common GDP Weights, 2017	Normalized World PLI with GDP Weights, 2011	Normalized World PLI with GDP Weights, 2017
	(1)	(2)	(3)	(4)	(5)	(6)
GROSS DOMESTIC PRODUCT	0.777	0.667	0.777	0.667	1.000	1.000
INDIVIDUAL CONSUMPTION EXPENDITURE BY HOUSEHOLDS	0.837	0.701	0.821	0.703	1.058	1.053
FOOD AND NON-ALCOHOLIC BEVERAGES	0.900	0.811	0.993	0.900	1.279	1.349
FOOD	0.885	0.806	0.995	0.904	1.281	1.354
NON-ALCOHOLIC BEVERAGES	1.026	0.857	0.981	0.876	1.263	1.313
ALCOHOLIC BEVERAGES, TOBACCO AND NARCOTICS	0.799	0.788	0.820	0.867	1.055	1.299
TOBACCO	0.573	0.562	0.666	0.720	0.857	1.079
CLOTHING AND FOOTWEAR	0.828	0.749	0.890	0.839	1.146	1.257
CLOTHING	0.843	0.770	0.903	0.862	1.162	1.292
FOOTWEAR	0.759	0.655	0.858	0.785	1.105	1.176
HOUSING, WATER, ELECTRICITY, GAS AND OTHER FUELS (Category)	0.742	0.592	0.750	0.623	0.965	0.933
ACTUAL RENTALS FOR HOUSING	0.799	0.726	0.648	0.555	0.834	0.831
ELECTRICITY, GAS AND OTHER FUELS	1.015	0.822	1.081	0.943	1.391	1.413
FURNISHINGS, HOUSEHOLD EQUIPMENT AND ROUTINE HOUSEHOLD MAINTENANCE	1.010	0.856	0.963	0.844	1.240	1.266
GOODS AND SERVICES FOR ROUTINE HOUSEHOLD MAINTENANCE	1.049	0.699	1.053	0.747	1.356	1.119
HEALTH - HHC (Category)	0.632	0.551	0.604	0.497	0.777	0.745
TRANSPORT	1.091	0.906	1.036	0.888	1.335	1.330
OPERATION OF PERSONAL TRANSPORT EQUIPMENT	1.196	1.044	1.163	1.025	1.497	1.537
TRANSPORT SERVICES	0.710	0.647	0.871	0.810	1.121	1.214
COMMUNICATION	0.690	0.494	0.756	0.560	0.974	0.840
RECREATION AND CULTURE - HHC (Category)	1.005	0.877	0.879	0.766	1.132	1.148
EDUCATION - HHC (Category)	0.359	0.277	0.543	0.455	0.699	0.683
RESTAURANTS AND HOTELS	0.947	0.784	0.879	0.740	1.132	1.109
MISCELLANEOUS GOODS AND SERVICES (Category)	0.911	0.766	0.821	0.723	1.058	1.083
PERSONAL CARE	0.835	0.773	0.783	0.761	1.008	1.140
INDIVIDUAL CONSUMPTION EXPENDITURE BY GOVERNMENT	0.538	0.454	0.550	0.494	0.709	0.740
COLLECTIVE CONSUMPTION EXPENDITURE BY GOVERNMENT	0.687	0.606	0.701	0.641	0.903	0.960
GROSS CAPITAL FORMATION	0.785	0.689	0.825	0.697	1.062	1.044
GROSS FIXED CAPITAL FORMATION	0.785	0.693	0.820	0.695	1.056	1.041
MACHINERY AND EQUIPMENT	1.162	1.098	1.160	1.116	1.493	1.673
CONSTRUCTION	0.493	0.379	0.651	0.495	0.839	0.741
OTHER PRODUCTS	1.049	0.926	0.991	0.912	1.276	1.367

Source: World Bank's Researchers' ICP Database and authors' own calculations

For example in 2017, world PLI for individual consumption expenditure by households (household consumption) was 0.701 compared to 0.667 at GDP level. It is tempting to conclude that PLI's of countries for household consumption are generally higher than PLI's for GDP. From equation (8) we see that the world PLI is influenced by PLI's from different countries as well as weights. Difference in PLIs for GDP and household consumption, 0.667 and 0.701 respectively, is driven by differences in PLIs for GDP and household consumption across countries as well as differences in country shares in world GDP and world household consumption.

In order to measure pure price level differences, we re-compute world PLIs for different aggregates using a common set of weights based on GDP shares of countries in PPP terms[9]. We present these in column (4) where PLI's presented are purely driven PLI's for different commodity groups. In order to examine the world price structure, we express world price levels for different aggregates relative to the GDP world price level shown in column (7). As expected, price levels for government consumption, construction and several of the services have ratios less than 1 indicating their world price levels are less than those for GDP. World

[9] It is possible to decompose the difference into the contribution from differences in PPPs (and price levels) and from differences in weights.

price structures for the years 2011 and 2017 indicate stable price structures over these years. We have compiled the price structure at re at the basic heading level, results are available from the authors upon request.

Our analysis of price structures thus far has been confined to the current ICP practice of measuring price levels through ratios of PPPs to exchange rates. A feature to note about this approach is the role of exchange rates in measuring price levels. The fact that exchange rates are the same irrespective of the aggregate under consideration, the proposed global price structure reflects the differences in PPPs for different aggregates.

5.3 Price structures based on international average prices

In this section we explore an alternative approach that does not rely on exchange rates to examine relative price structures at the global level. Instead we employ the notion of international average prices of commodities, a concept developed by Geary (1958) for the Food and Agriculture Organization that eventually led to the Geary-Khamis aggregation method[10].

The basic idea we pursue here is to compute international average prices for different commodities or commodity groups which are in turn used to examine the structure of relative prices. The idea of an international average price for a good or service is nothing new in a globalized world. Average price of a commodity in a city, or a country or in the world is simply defined as the total expenditure or money spent on the commodity divided by the total quantity purchased. In the context of international comparisons, total expenditure on a commodity in the world is not that straightforward to measure as expenditures in different countries are expressed in respective local currency units. We need to convert expenditures into a common currency unit. In the spirit of ICP, we make use of PPPs of currencies for conversion instead of exchange rates. Let $\left(e_{ij}, q_{ij} : i = 1,2,...,N; j = 1,2,...,M\right)$ denote expenditure and quantity of *i-th* commodity in *j-th* country, and PPP_j represent purchasing power parity of currency of country *j* used for conversion, then international average price of commodity *i*, Π_i, is defined as:

$$\Pi_i = \frac{\sum_{j=1}^{M}\left(\frac{e_{ij}}{PPP_j}\right)}{\sum_{j=1}^{M} q_{ij}} \qquad i = 1,2,...,N \tag{10}$$

Numerator of (10) is the sum of expenditures on the commodity across all the countries after conversion using PPPs. The PPP used here refers to GDP and hence the whole economy.

Equation (10) is straightforward to apply in the case of single commodities but a little bit more complex when it comes to composite commodities like household consumption. Here we follow the procedures established in the early stages of ICP (see Kravis, Heston and Summers, 1982 for details) and define quantities as real expenditures for that aggregate. Further details are in Appendix A2 and Appendix A4.

[10] This method was the main aggregation method used in early phases of the ICP and it was replaced by the GEKS method during the 2005 ICP round.

The international average prices in (10) are identical to what was proposed by Geary (1958) except that Geary had an additional equation that determined PPPs as a function of international average prices.[11]

Table 9 presents international average prices computed using equation (10) for the years 2011 and 2017 along with Geary international prices for the corresponding expenditure categories in 1975 drawn from KHS (1982). One striking result is that the relative price of food is 24% higher in 2011 and 34% higher in 2017 than in 1975. There is certainly a story to tell here about the substitution of more expensive foods, the relative cost of fish and meats (see beef in Table 9) and the increase in food away from home that we leave to others to tell. It is expected and reassuring to observe the rise in the relative prices of health services since 1975.

Table 9: International Average Prices, 1975, 2011 and 2017

Item Name	International Average Prices, 2011	International Average Prices, 2017	Geary International Average Prices, 1975
	column (1)	column (2)	column (3)
GROSS DOMESTIC PRODUCT	1	1	1
INDIVIDUAL CONSUMPTION EXPENDITURE BY HOUSEHOLDS	1.0547	1.0481	0.96
FOOD AND NON-ALCOHOLIC BEVERAGES	1.4142	1.5228	na
FOOD	1.4129	1.5286	1.14
NON-ALCOHOLIC BEVERAGES	1.3235	1.413	na
ALCOHOLIC BEVERAGES, TOBACCO AND NARCOTICS	1.0118	1.2495	1.26
TOBACCO	0.7383	0.9272	1.23
CLOTHING AND FOOTWEAR	1.1285	1.2199	1.14
CLOTHING	1.144	1.2526	1.17
FOOTWEAR	1.0556	1.0712	1.01
HOUSING, WATER, ELECTRICITY, GAS AND OTHER FUELS (Category)	0.8793	0.8347	0.94
ACTUAL RENTALS FOR HOUSING	0.8112	0.8689	0.87
ELECTRICITY, GAS AND OTHER FUELS	1.31	1.3015	1.22
FURNISHINGS, HOUSEHOLD EQUIPMENT AND ROUTINE HOUSEHOLD MAINTE	1.2632	1.2857	1.07
GOODS AND SERVICES FOR ROUTINE HOUSEHOLD MAINTENANCE	1.3138	1.0832	na
HEALTH - HHC (Category)	0.7258	0.6859	0.61
TRANSPORT	1.3577	1.3859	na
OPERATION OF PERSONAL TRANSPORT EQUIPMENT	1.3886	1.521	1.27
TRANSPORT SERVICES	1.0248	1.1523	0.61
COMMUNICATION	0.9201	0.7795	0.89
RECREATION AND CULTURE - HHC (Category)	1.0882	1.1337	1.03
EDUCATION - HHC (Category)	0.496	0.4384	0.53
RESTAURANTS AND HOTELS	1.109	1.0806	na
MISCELLANEOUS GOODS AND SERVICES (Category)	1.056	1.0788	na
PERSONAL CARE	0.9928	1.1293	1.06
INDIVIDUAL CONSUMPTION EXPENDITURE BY GOVERNMENT	0.6201	0.6358	0.91
COLLECTIVE CONSUMPTION EXPENDITURE BY GOVERNMENT	0.857	0.9051	0.91
GROSS CAPITAL FORMATION	1.1011	1.0768	1.23
GROSS FIXED CAPITAL FORMATION	1.0868	1.069	1.23
MACHINERY AND EQUIPMENT	1.6367	1.7427	1.45
CONSTRUCTION	0.7039	0.6002	1.07
OTHER PRODUCTS	1.2533	1.2655	1.22

Note: Figures in column (3) are drawn from Summary Multilateral Table 6.3 (KHS, 1982, p. 179). Columns (1) and (2) are computed using formulae in Appendix A3 and the detailed data supplied by the World Bank.

We are reassured to observe stability and closeness in international prices in 2011 and 2017. This may in part be due to the use of identical survey and aggregation methodologies in the two benchmark years.

[11] Geary defined PPPs used in equation (10) using: $PPP_j = \frac{\sum_{i=1}^{N} e_{ij}}{\sum_{i=1}^{N} \Pi_i q_{ij}} \quad j = 1, 2, ..., M$. This equation ensures that real expenditure, expenditure converted using PPP, is the same as the value of the commodities at international average prices.

Notable differences are observed for construction, communication and personal care. What is quite surprising to us is the similarity in relative price structures observed in 1975 and 2017. A striking difference is observed for construction. Price of construction was 7 percent higher than GDP in 1975 but dropped to 60 percent in 2017. This difference is largely attributable to the methodology used for making price and real quantity comparisons for construction. The KHS (1982) approach for construction in 1975 comparisons was based on bills of quantities – an approach similar to what is currently in use by Eurostat and OECD. In contrast the 2011 and 2017 ICP rounds make use of prices of construction materials and labor and builds an input side price measure for comparisons.

Though the results in Table 9 show an impressive degree of consistency over time, a part of the discrepancy between price structures are likely can be attributed to the differences in aggregation methodology used in 1975 and in more recent 2011 and 2017 comparisons. The 1975 comparisons for each of the aggregates in Table 9 were based on the Geary-Khamis method, an additively consistent approach In contrast the aggregates in 2017 and 2011 are based on GEKS procedure which is non-additive. The choice of aggregation method may have contributed in part to the differences in international average prices. With the view of eliminating any influence of the aggregation method, we have also computed international average prices at the basic heading level where the same country-product-dummy method was used in the 1975, 2011 and 2017 benchmark years.

International average prices for the 155 basic headings computed using equation (10) for the years 2011 and 2017 are presented in Appendix Table A1. The basic heading classification has undergone some changes since 1975. We attempted to map the 2017 basic headings to the 1975 classification by finding the best match based on the description. We have been able to find 93 matches where we believe comparisons of international average prices can be made.

Table 10: International Average Prices, 2011 and 2017; GK International Prices, 1975
(for selected basic headings)

Item - ICP 2011, 2017	International Average Prices, 2011	International Average Prices, 2017	GK International Prices , 1975	Name of item in 1975
Rice	0.8936	1.2771	1.09	Rice
Beef and veal	1.4987	1.3117	0.93	Fresh beef and veal
Mineral waters, soft drinks, fruit and vegetable juices	1.2616	1.2957	1.35	non-alcoholic beverages
Garments	1.1826	1.2837	1.1	Men's clotjhing; Women's clothing - 1.29; Boys and girls clothing - 1.32; men's and boys' underwear - 1.48; women's and girls' underwear - 1.13; Haberdashery, millinery - 0.97; clothing rental and repair
Major household appliances whether electric or not	1.2293	1.3741	1.44	Refigerators and freezers; Washing appliances - 1.49; cooking appliances - 1.24; heating appliances - 1.33; cleaning appliances - 1.5; other household appliances - 2.01
Medical services	0.8666	0.8384	0.54	Physicians' services
Passenger transport by railway	0.9248	1.0982	0.26	Rail transport
Pharmaceutical products	1.1061	1.0812	0.93	Drugs, medical prepartions
Hairdressing salons and personal grooming establishments	0.5554	0.5029	0.56	Barber and beauty shops
Intermediate consumption, government	1.2533	1.2655	1.21	Commodities of government
Road transport equipment	0.446	0.9513	1.53	Trucks, buses, trailers
Residential buildings	0.5336	0.5302	1.09	one and two-family dwellings; multi-family dwellings - 1.07
Non-residential buildings	1.6198	1.92	1.49	Industrial buildings; commercial buildings - 1.15; office buildings - 1.12;
Civil engineering works	0.9845	0.8229	0.86	Roads, streets, highways

Table 10 presents results for a set of basic headings which were selected with the aim of showing that international average prices remained similar for some commodity groups but have shown dramatic shifts for some others. For example, why is it that international prices for non-residential buildings remained similar over the 50 year period whereas residential buildings show a dramatic reduction, by almost 50 per cent. As pointed out earlier, this could be due to the input cost approach for construction used in the 2011

and 2017 ICP, where as in 1975 the final price of specific types of buildings were priced. But why should residential and non-residential structures be different, an interesting question to research. Road transport equipment raises questions across all three years although the decline from 1975 is consistent with the general decline in trade barriers during the period. Our calculations for all the basic headings are available to researchers who wish to explore some of these questions in more detail.

5.4 Price similarity and convergence

After exploring global price structures, it is a natural question to examine as to whether there has been any convergence in price and quantity structures. We have chosen to use the price, quantity and income similarity indices proposed by KHS (1982) in their analysis of 1975 international data covering 34 countries[12]. . Our similarity indexes are measures of the closeness of countries to each other in their pattern of prices or quantities across the basic headings of expenditure of GDP for each pair of countries in an ICP benchmark. The formulas for both methods are given below for both price and quantity similarity indexes. The equation for income similarity, which is the same for either version of price or quantity similarity, is also given.

In what follows, we make use of the following notation. Let $\{e_{ij}, p_{ij}, q_{ij} : i = 1,2,...,N; j = 1,2,...,M\}$ represent expenditure (in LCU), price and quantity of commodity *i* in *j-th* country. As the analysis is conducted at the basic heading level, the price here is the PPP for country for the given basic heading and quantity is the real expenditure for the basic heading. Thus:

$$p_{ij} = PPP_{i,j} \; ; \; q_{ij} = \frac{e_{ij}}{PPP_{i,j}} \; ; \; PPP_{i,USA} = 1 \; for \; all \; i = 1,2,...,N \; and \; j = 1,2,...,M \tag{11}$$

We use the price and quantity similarity indices in KHS (1982, page 348) and the formulae are given below. The nominal and real shares of commodity *i* and country *j*, denoted by ns_{ij} *and* rs_{ij} are defined as:

$$ns_{ij} = \frac{e_{ij}}{\sum_{i=1}^{N} e_{ij}} \; ; rs_{ij} = \frac{\Pi_i q_{ij}}{\sum_{i=1}^{N} \Pi_i q_{ij}} \quad for \; all \; \; i = 1,2,...,N; \; j = 1,2,...,M \tag{12}$$

where $\{\Pi_i : i = 1,2,...,N\}$ are international average prices. In the next step, for each basic heading and country, compute the ratio, $r_{ij} : i = 1,2,...,N \; and \; \; j = 1,2,...,M$

$$r_{ij} = \frac{ns_{ij}}{rs_{ij}} \tag{13}$$

These r_{ij}'s serve as a measure of relative price structures. A value above 1 for a given *i* for a particular country indicates that relative to the relationship of the countries prices to international prices for GDP as a whole, its price for *i* is high (KHS, 1982, p. 348).

The KHS(1982) price, quantity and income similarity indices for any given pair of countries *j* and *k* are given by:

[12] We have also computed similarity indices proposed by van Ark, Monikoff and Timmer (1999) but found the results to be quite similar to those from KHS similarity indices and hence are not reported here.

$$S_{jk}^{P-KHS} = \frac{\sum_{i=1}^{N} gs_i \cdot r_{ij} \cdot r_{ik}}{\sqrt{\left(\sum_{i=1}^{N} gs_i . r_{ij}^2\right)\left(\sum_{i=1}^{N} gs_i . r_{ik}^2\right)}} \; ; S_{jk}^{q-KHS} = \frac{\sum_{i=1}^{N} q_{ij}\, q_{ik}}{\sqrt{\sum_{i=1}^{N} q_{ij}^2 \sum_{i=1}^{N} q_{ik}^2}} \qquad for\ all\ j,k = 1,2..,\mathrm{M} \qquad (14)$$

and $S_{jk}^{y} = \frac{2.\min(y_j, y_k)}{y_j + y_k}$ *where* $y_j = real\ per\ capita\ GDP\ of\ country\ j \quad j = 1,2,..,\mathrm{M}$

where $gs_i = \frac{\sum_{j=1}^{M} \Pi_i\, q_{ij}}{\sum_{i=1}^{N}\sum_{j=1}^{M} \Pi_i\, q_{ij}} \quad i = 1,2,...,N$ is the global share of *i-th basic heading*.

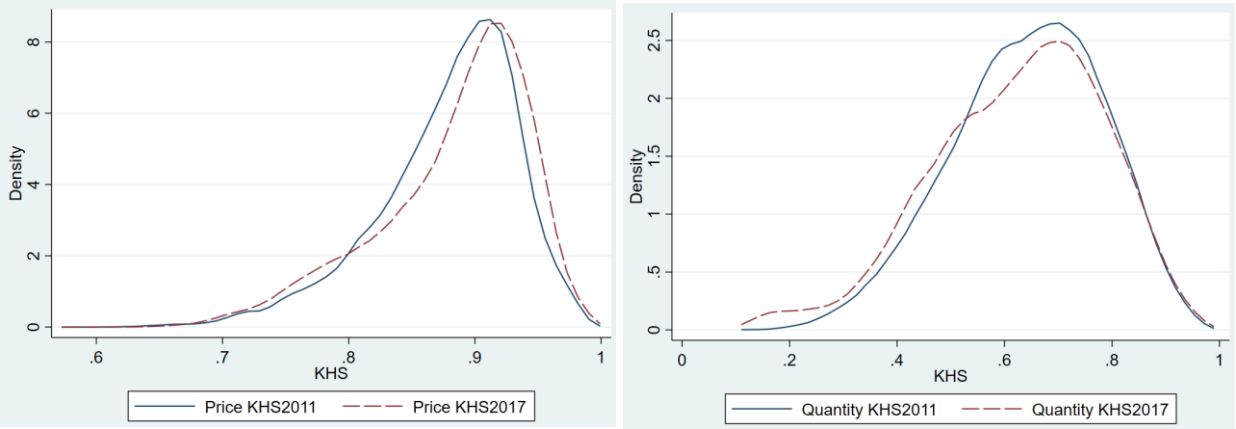
For the 2011 and 2017 ICPs the number of similarity index observations is all pairs of countries except countries with themselves, that is (172*173/2=14878). Summary measures of these observations are presented in Table 11 for the KHS measures of price and quantity similarity. The mean similarity measure is given for each benchmark along with standard deviation for prices, quantities and incomes.

Table 11: Descriptive Statistics of Similarity Measures

Variable	Obs	Mean	Std. Dev.	Min	Max
qkhs2011	14878	.6427	.141	.1285	.971
pkhs2011	14878	.8786	.0556	.5794	.9924
y2011	14878	.411	.2946	.0043	1
qkhs2017	14878	.6259	.1593	.0881	.9773
pkhs2017	14878	.8827	.0606	.6313	.9939
y2017	14878	.4181	.2923	.0055	.9999

We find that the mean of the price similarity index has increased slightly indicating a small degree of convergence in price structures. In contrast the quantity similarity index has decreased showing a divergence in quantity structures (see Figure 4 below). The income similarity index has shown a degree of convergence which is consistent with the reduction in income inequality indicated by Gini and Theil measures of inequality we reported in Section 2. The left panel in Figures 4 provides a sense of the stability and slight convergence of the price similarity indexes between the two benchmarks, and right panel shows a slight divergence in the quantity similarity indices.

Figure 4: Kernel Densities for KHS Similarity Indices, 2011 and 2017



Our attempts to replicate the KHS (1982) analysis of 1975 price and quantity similarity indices have shown no strong relationships between these indices. We attribute these results to the large and diverse nature of the countries covered in the 2011 and 2017 rounds.

We have also explored the possibility of identifying clusters of countries based on the KHS price similarity index using a non-hierarchical clustering method with four clusters. As is often the case with cluster methods, membership of the countries of clusters is somewhat unstable and therefore we have not opted to present these results. It is worth pointing out that the clusters formed generally resembled groups based on real per capita income which may be labelled low, middle, upper middle and high income countries – an intuitive finding consistent with the expectation that countries at comparable income levels are likely to have similar price structures.

6. Bringing the Story to 2020

Due to variation in health infrastructure, national traditions in communal actions, and domestic public health policies, world economies have been affected quite differently in 2020. China is a notable example of a country with a large initial setback followed by an extended recovery while on the other hand the United States experienced early setbacks, followed by recoveries and then deeper setbacks. When the world economy finally recovers from the pandemic, it will be useful to have a benchmark, like the end of 2019 from which to judge the impact of COVID-19 and variants on the world economies and regions. We call attention to the release of the Penn World Table 10.0 produced by the Groningen Growth and Development Center (GGDC, January, 2021), which integrates the results of the 2017 ICP and updates PWT to 2019.

There are a number of differences between PWT and the ICP notably in the method in which the world is put together, by country in the former and by region in the latter, in making estimates from both the expenditure and output side in PWT, and some smaller methodological matters. However, we think it useful to prepare a distribution of world expenditures by income groups. The 183 countries in PWT have been grouped by level of per capita GDP in 2019 into 5 bins of 36 or 37 countries. The total GDP and population have been given in Table 12 along with the share of each group in the world. Column 5 provides the average GDP per capita of each quintile, an overall familiar and still disturbing picture. The bottom

two quintiles with almost half the world's population have less than 20% of the world's GDP. Unfortunately, when we have comparable numbers for 2021 it does not appear likely that the picture will show any improvement for the lower income countries.

Table 12 World GDP by Country Quintiles Grouped by PC GDP, 2019

	Total GDP	Total pop	GDP share	Population share	Per capita GDP
Quintile	1	2	3	4	5
Top	52186114	965	41.4	12.7	54101
4	18655614	615	14.8	8.1	30327
3	32252176	2248	25.6	29.7	14348
2	21113464	2962	16.8	39.1	7129
1	1742539	792	1.4	10.4	2201
World	125949906	7581	100.0	100.0	16614

Note: The 183 countries in PWT have been grouped by level of per capita GDP in 2019 into 5 bins (quintiles) of 36 or 37 countries.

We now turn to the issue of the size of the economies and the largest economy in the world and examine relative positions of some of the largest economies in the world in 2020.

The 2019 real GDP for these economies are drawn from the "*rgdpna*" column of PWT 10.0. Growth rates used in column (2) are drawn from IMF's *World Economic Outlook*, 2021. These growth rates are probably subject to revisions over the coming months but are indicative of differential effects on Covid-19 ravaged economies and their ability to respond to the challenges posed by the pandemic. The last column shows that China has cemented its position as the largest economy in size as measured by real PPP-converted GDP and it is 6.5 percent larger than the USA. Prior to the pandemic, India aspired to double the size of its economy within five years but this goal has no doubt experienced a setback. However, if the Indian economy recovers and manages growth rates that come anywhere close to its goal, then the Indian economy would become a major economic power in the coming years.

Table 13: Projected Real GDP in 2020 of Selected Large Economies
(in 2019 US dollars and PPP terms)

Country	GDP in 2019 (in US PPP dollars)	Growth rate 2019-2020	GDP in 2021 in 2019 US dollars)
	(1)	(2)	(3)
China	20,571,246	1.9	20,962,100
Germany	4,312,350	-6	4,053,609
India	9,164,505	-10.3	8,220,561
Indonesia	3,110,751	-1.5	3,064,090
Japan	5,098,248	-5.3	4,828,041
Korea, Republic	2,192,752	-1.9	2,151,090
United Kingdom	3,015,784	-9.8	2,720,237
United States	20,563,592	-4.3	19,679,358

Notes: Figures in column (1) are from PWT 10.0; Growth rates (in column 2) are from World Economic Outlook, IMF, 2021

7. Conclusions

In summary, we showed the aggregate GDP by geographical areas, a feature of the 2017 report as opposed to reporting by administrative institutions like the OECD as in earlier ICP reports. Further, the distribution of world GDP was provided by income groups displaying the substantial inequalities existing between countries. In comparing the 2011 and 2017 results in current prices, a decomposition of real growth and price changes was provided that allowed separation between exchange rate and price changes. In this section we observe that there is scope for improvements in the analysis and presentation of global growth and inflation estimates by the IMF in its annual *World Economic Outlook publications*. In particular, our exposition suggests that it is important to clearly indicate what constitutes the global economy and the countries covered in the computation. The WEO purpose would be better served by inclusion of world real GDP or GDP in PPP terms in its flagship publication. We have provided estimates of global growth, domestic price change effect as well as the PPP exchange rate change effect – three components of change in real GDP over time.

The frequently asked question regarding the relative rankings of the US and China was discussed in section 3 of the paper. Starting with the prediction of Angus Maddison that China will overtake USA in 2030, we trace the historical developments in the measurement of real GDP of China in PPP terms. Evidence from the report released by World Bank (2020) suggests that in 2017 and in PPP terms USA and China are at the same level. Given the uneven growth prospects for USA and China, our discussion in Section 6 suggests that in real GDP in China in 2020 is likely to be 6.5 percent larger than real GDP in USA.

Much of the paper focused on the strong support the two latest benchmarks provide for the basic finding of the ICP, the positive relationship between the price level of GDP and the per capita level of GDP. First put forward in 1975 in the first ICP report referring to 1970 benchmark, this relationship has now stood up to empirical verification for almost 70 years. Sometimes it is termed the "Penn" effect because the first ICP report originated there. In 1964 Balassa and Samuelson had independently published a differential productivity explanation of the price level-income relationship based upon the distinction between tradable goods whose prices across countries tend to the exchange rate and non-tradable goods whose prices tend to the level of productivity of labor in tradable goods. Several simple models that had been developed using earlier ICP vintages were tested with 2011 and 2017 data and the results were similar. Further models that introduced squared values of the log of per capita GDP seemed to improve the fit.

Another finding that had been stressed by Kravis and Lipsey (1988) based on the 1975 and 1980 ICPs is that the price level of tradables clearly rises with the incomes of countries. It is a common assumption in many international trade models that the price level of tradables should be constant across countries. However, the empirical findings of Kravis and Lipsey are that as is expected the price level of non-tradables rises faster than tradables, but the rise for the tradables is also positive and significant. Zhang (2017) carried out a more detailed analysis based on the 2005 ICP and his work partly supported Kravis and Lipsey but he offered an explanation for why there should be a positive relationship between the price level of tradables and income. Using the 2011 and 2017 data, we offer further support to the findings of these earlier studies.

Another aspect of our study was to look at the country prices in relation to the international prices across all the countries for the detailed basic headings and summary categories. ICP 1975 was the only benchmark that had attempted to estimate international prices and it turns out those results were not base country invariant. But a method has been developed in this paper that permitted estimation of comparable international prices for all basic heading in 2011 and 2017 and for most of the headings in 1975. These results seem quite plausible and other researchers may build on this work to address issues that we have not attempted here. Our analysis of the international price levels suggests that there are number of areas, including construction where further research aimed at improving the estimation of PPPs and real expenditures is needed. The results support received views on that the relative prices of health, transport,

and most other services have risen 40 years, and that relative prices of most appliances and automobiles have fallen.

The paper has called attention to the release of the 2017 benchmark comparison of the International Comparison Project in May,2020 at the World Bank where a major rollout and festivities were planned but as with so many others was canceled by COVID-19. Because the 2017 ICP methodology was the same as that in the 2011 ICP, the new report could confidently compare the two benchmarks, which was not usually the case with earlier ICP rounds. Before Covid-19 variants it had been planned to make revisions of the ICP methodology in 2020 including its frequency, but that has now been postponed at least until 2021, still another reason to call special attention to the 2017 report.

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Appendix 1

Decomposition of change in real GDP

A useful starting point for this exposition is the decomposition of change in GDP of a country, expressed in local currency units, over a period. For purposes of illustration the period 2011 and 2017, which represent the benchmarks for the last two ICP comparisons.

Decomposition of change in GDP of a country measured in local currency units

At the country level, let $GDP_{2011,j}$ and $GDP_{2017,j}$ represent GDP of country *j* in current 2011 and 2017 prices respectively. Further let $\left\{Def_{s,t,j} : s,t = 2011,2017\right\}$ represent GDP deflator for period *t* with period s as the base. Then the change in GDP at current prices can be decomposed as follows:

$$\frac{GDP_{2017,j}}{GDP_{2011,j}} = \frac{GDP_{2017,j}/Def_{2011,2017,j}}{GDP_{2011,j}/Def_{2011,2011,j}} \times \frac{Def_{2011,2017,j}}{Def_{2011,2011,j}} = \frac{CGDP_{2011,2017,j}}{CGDP_{2011,2011,j}} \times \frac{Def_{2011,2017,j}}{Def_{2011,2011,j}}$$

$$= \frac{CGDP_{2011,2017,j}}{CGDP_{2011,2011,j}} \times Def_{2011,2017,j}$$

$$= GR_{2011,2017,j} \times \frac{Def_{b,2017,j}}{Def_{b,2011,j}} = \text{growth rate in country } j \times \text{domestic price change in country } j \quad \text{(A1.1)}$$

where $CGDP_{s,t,j}$ represent GDP of country *j* in period *t* expressed in constant period *s* prices. Thus, $CGDP_{2011,2017,j}$ represents GDP in year 2017 expressed in constant 2011 prices.

Decomposition of change in GDP of a country expressed in a common currency unit using PPPs

Now let consider the case of international comparisons where GDP of each country is converted into the units of currency of reference country. Let $RGDP_{2011,j}$ and $RGDP_{2017,j}$ represent real GDP of country *j* in years 2011 and 2017 converted using PPPs from 2011 ICP and 2017 ICP with USA as the reference or base country. These figures cannot be compared directly as they are in prices of years 2011 and 2017 respectively. However, their ratio can be composed as below.

$$\frac{RGDP^{USA}_{2017,j}}{RGDP^{USA}_{2011,j}} = \frac{GDP_{2017,j}\big/PPP^{USA}_{2017,j}}{GDP_{2011,j}\big/PPP^{USA}_{2011,j}} = \frac{\dfrac{GDP_{2017,j}}{PPP^{USA}_{2017,j}}\Big/Def_{2011,2017,j}}{\dfrac{GDP_{2011,j}}{PPP^{USA}_{2011,j}}\Big/Def_{2011,2017,j}} \times \frac{Def_{2011,2017,j}}{Def_{2011,2011,j}}$$

$$= \frac{GDP_{2017,j}/Def_{2011,2017,j}}{GDP_{2011,j}/Def_{2011,2011,j}} \times \frac{Def_{2011,2017,j}}{Def_{2011,2011,j}} \times \frac{PPP^{USA}_{2011,j}}{PPP^{USA}_{2017,j}} = \frac{CGDP_{2011,2017,j}}{CGDP_{2011,2011,j}} \times Def_{2011,2017,j} \times \frac{PPP^{USA}_{2011,j}}{PPP^{USA}_{2017,j}}$$

$$= GR_{2011,2017,j} \times Def_{2011,2017,j} \times \frac{PPP^{USA}_{2011,j}}{PPP^{USA}_{2017,j}} = \text{country growth rate} \times \text{domestic price change} \times \text{effect of PPP change} \tag{A1.2}$$

Balk, Rambaldi and Rao (2020) (BRR) paper on global growth and inflation offers a decomposition of GDP of the world with a structure similar to that in (A.2).

Decomposition of change in world GDP expressed in the currency unit of the reference country using PPPs

The change in world real GDP, expressed in the currency units of USA using PPPs, is the ratio of sum of real GDP of all the countries in the world. As the current ICP covers 176 countries, this change is represented by the following ratio:

$$\frac{RGDP_{2017,W}}{RGDP_{2011,W}} = \frac{\sum_{j=1}^{176} GDP_{2017,j}\big/PPP^{USA}_{2017,j}}{\sum_{j=1}^{176} GDP_{2011,j}\big/PPP^{USA}_{2011,j}} \tag{A1.3}$$

BRR provide a decomposition of the ratio in (A.3) using the Sato-Vartia index number formula into global growth and global inflation components. Global inflation in turn has two components, one based on domestic inflation rates and the other on the effect of PPP change. Using the same notation in equation (A.2), the BRR (2020) decomposition of change in world real GDP is given by:

$$\frac{RGDP_{2017,W}}{RGDP_{2011,W}} = \prod_{j=1}^{176}\left[GR_{2011,2017,j}\right]^{w_j} \times \prod_{j=1}^{176}\left[Def_{2011,2017,j}\right]^{w_j} \times \prod_{j=1}^{176}\left[\frac{PPP^{USA}_{2011,j}}{PPP^{USA}_{2017,j}}\right]^{w_j} \tag{A1.4}$$

$$= \text{Global growth} \times \text{Average of domestic inflation rates} \times \text{PPP change effect}$$

$$= \text{Global growth} \times \text{Global inflation}$$

Each component in (A.4) is a weighted average of the corresponding country-specific changes. The weights in (A.4) are based on the Sato-Vartia index and are given by

$$w_j = \frac{L\left(s_{2011,j}, s_{2017,j}\right)}{\sum_{j=1}^{176} L\left(s_{2011,j}, s_{2017,j}\right)} \quad where\ s_{t,j} = \frac{RGDP_{t,j}}{RGDP_{W,j}};\ t = 2011, 2017$$

and

$L(a,b)$ is the logarithmic average of numbers *a* and *b* given by:

$$L(a,b) \equiv \frac{a-b}{\ln a - \ln b} \; if \;\; a \neq b; \; and \; L(a,a) \equiv a.$$

The components of Balk, Rambaldi and Rao (2020) decomposition are essentially weighted geometric averages of each of the three components in equation (A.2) where the weights are determined by shares of each of the countries in world real GDP in periods 2011 and 2017.

Appendix A2

Analysis of Price Levels and Price Structures using ICP Data

Our analysis thus far of results from the 2011 and 2017 rounds of the ICP explored the relationship between country level price levels and the real/nominal GDP per capita as well as the price levels for tradeable and non-tradeable groups of goods and services. This section explores the link between price level indexes and relative price structures at the country level as well as at the global level, an area that has not been unexplored in the past. Stability and evolution of relative price structures for selected countries and at the global level over a long period are explored using results from the 1975 ICP round reported in Kravis, Heston and Summers (1982), from now on KHS (1982), and results from the recently completed 2011 and 2017 cycles of the ICP.

A2.1 ICP Price Level Measures

2.1.1 Price Level Index (PLI) at the country level

Price level index for a given country is defined as the ratio of purchasing power parity of its currency and its exchange rate which are respectively denoted by $PPP \ \ and \ \ XR$. For any given country j its PLI is defined as:

$$PLI_j = \frac{PPP_j}{XR_j} \qquad j = 1,2,...,M \tag{A2.1}$$

As PPPs and exchange rates are determined relative to a base country currency, *PLI* in (1) depends on the base currency. If country 1 is used as the reference country, a more complete definition of PLI would be:

$$PLI_{1j} = \frac{PPP_{1j}}{XR_{1j}} \qquad j = 1,2,...,M \tag{A2.2}$$

It is useful to note here that PLI differ for different aggregates since PPP's for different aggregates differ. So a more complete notation would also indicate the aggregate for which PLI is defined. For the purpose of exposition in this section, unless and otherwise stated, PLIs are defined at the GDP level.

Notes/comments on PLI

1. PLI for the base or reference country is equal to 1. This follows from (A2.2) since by definition $PPP_{11} = 1 \ \ and \ \ XR_{11} = 1$.
2. An alternative interpretation of the price level index is that it is a ratio of the nominal GDP to real GDP. This can be seen from:

$$PLI_{1,j} = \frac{PPP_{1,j}}{XR_{1,j}} = \frac{GDP_j / XR_{1,j}}{GDP_j / PPP_{1,j}} = \frac{\text{nominal GDP}}{\text{real GDP}} \tag{A2.3}$$

   Combining this with (A2.1), for the base country the nominal and real GDP are the same.
3. Relative price levels between countries j and k is independent of the reference or base country used to measure PPPs and exchange rates. Using country 1 as the base, relative price level of country k relative to country j is given by:

$$RPLI_{1,jk} = \frac{PLI_{1,k}}{PLI_{1,j}} = \frac{PPP_{1,k}/XR_{1,k}}{PPP_{1,j}/XR_{1,j}} = \frac{PPP_{1,k}/PPP_{1,j}}{XR_{1,k}/XR_{1,j}} = \frac{PPP_{j,k}}{XR_{j,k}} = PLI_{j,k} \quad \text{(A2.4)}$$

When country 2 is used as the reference country, we have

$$RPLI_{2,jk} = \frac{PLI_{2,k}}{PLI_{2,j}} = \frac{PPP_{2,k}/XR_{2,k}}{PPP_{2,j}/XR_{2,j}} = \frac{PPP_{2,k}/PPP_{2,j}}{XR_{2,k}/XR_{2,j}} = \frac{PPP_{j,k}}{XR_{j,k}} = PLI_{j,k} \quad \text{(A2.5)}$$

This result follows from the fact that PPPs are transitive by construction and exchange rates are transitive in the absence of arbitrage. It can be seen that relative price level between countries *j* and *k* is the same whether the PPPs and exchange rates are measured relative to country 1 as the base or country 2 as the base.

2.1.2 Price Level Index (PLI) at the world level

As there no concept of purchasing power parities or exchange rates for the world as a whole, price level index at the world level is defined using equation (5). When PPPs and exchange rates for all countries are anchored on base country 1, PLI for the world with country 1 as the base country is defined as:

$$\text{PLI}_{1,\text{W}} = \frac{\text{Nominal GDP}_{1,W}}{\text{Real GDP}_{1,W}} = \frac{\sum_{j=1}^{M} NGDP_{1,j}}{\sum_{j=1}^{M} RGDP_{1,j}} = \frac{\sum_{j=1}^{M} GDP_j/XR_{1,j}}{\sum_{j=1}^{M} GDP_j/PPP_{1,j}} \quad \text{(A2.6)}$$

If country 2 is used as the base country, then the world level PLI with country 2 as base is given by:

$$\text{PLI}_{2,\text{W}} = \frac{\text{Nominal GDP}_{1,W}}{\text{Real GDP}_{1,W}} = \frac{\sum_{j=1}^{M} NGDP_{2,j}}{\sum_{j=1}^{M} RGDP_{2,j}} = \frac{\sum_{j=1}^{M} GDP_j/XR_{2,j}}{\sum_{j=1}^{M} GDP_j/PPP_{2,j}} \quad \text{(A2.7)}$$

Sheet 1 in ICP 1975_Price Levels illustration.xls (attached) shows the PLI for the world with USA as the base country as 0.5407 and as 1.38156 with India as the base country.

Notes/comments on PLI at the world level

1. The world level PLI is a weighted average of the PLI's of different countries where weights are the shares of each country in the real GDP of the world (sum of real GDPs of all the countries). Last term in Equation (6) can be expressed as follows:

$$\text{PLI}_{1,\text{W}} = \frac{\sum_{j=1}^{M} GDP_j/XR_{1,j}}{\sum_{j=1}^{M} GDP_j/PPP_{1,j}} = \frac{\sum_{j=1}^{M} \frac{GDP_j}{PPP_{1,j}} \times \frac{PPP_{1,j}}{XR_{1,j}}}{\sum_{j=1}^{M} GDP_j/PPP_{1,j}}$$

$$= \sum_{j=1}^{M} \frac{GDP_j/PPP_{1,j}}{\sum_{j=1}^{M} GDP_j/PPP_{1,j}} \times \frac{PPP_{1,j}}{XR_{1,j}} = \sum_{j=1}^{M} s_j \cdot \frac{PPP_{1,j}}{XR_{1,j}} = \sum_{j=1}^{M} s_j \cdot PLI_{1,j} \quad \text{(A2.8)}$$

2. It can be shown algebraically that PLI for the world with country 2 as the base country, $PLI_{2,W}$, in equation (A2.7) equals PLI for the world with country 1 as the base, $PLI_{1,W}$, in equation (6) times the ratio of PPP and XR of country 2 with country 1 as the base. That is, we have

$$PLI_{2,W} = PLI_{1,W} \cdot \frac{XR_{1,2}}{PPP_{1,2}} \tag{A2.9}$$

This result can be seen numerically from sheets 1 and 2 in ICP1975_Price Levels illustration.xls. Consider USA as country 1 and India as country 1. PLI for the world with countries 1 and 2 are:

$$PLI_{1,W} = 0.5407 \quad PLI_{2,W} = 1.38156$$

$$PPP_{1,2} = 3.38579; \; XR_{1,2} = 8.650$$

$$PLI_{2,W} = PLI_{1,W} \cdot \frac{XR_{1,2}}{PPP_{1,2}} = 0.5407 \times \frac{8.650}{3.38579} = 1.38156$$

2.1.3 Country Price Levels Normalized with World Price Level equal to 1

It is standard practice adopted in all ICP reports to publish price levels of countries expressed relative to world price level equal to 1. Let country 1 be the base country. Then the PLI for country *j* (equation A2.3) and the world PLI (equation A2.6), with country 1 as the base/reference, are given by:

$$PLI_{1,j} = \frac{PPP_{1,j}}{XR_{1,j}} \quad and \; \text{PLI}_{1,\text{W}} = \frac{\sum_{j=1}^{M} GDP_j / XR_{1,j}}{\sum_{j=1}^{M} GDP_j / PPP_{1,j}} \tag{A2.10}$$

and the PLI for country j relative to the world level, denoted by $RELW\_PLI_{1,j}$ is given by

$$RELW\_PLI_{1,j} = \frac{PLI_{1,j}}{PLI_{1,W}} \tag{A2.11}$$

By construction, relative price level at the world level is equal to 1. From the numerical example above, we have

$$PLI_{1,j} = \frac{3.38579}{8.650} = 0.3914; \quad PLI_{1,W} = 0.5407$$

$$RELW\_PLI_{1,j} = \frac{0.3914}{0.5407} = 0.7239$$

Therefore, the price level of country *j* relative to the world is 72.39%.

Result: Relative price levels of countries relative to the world, $\left\{ RELW\_PLI_{1,j} : j = 1,2,...,M \right\}$, are invariant or independent to the choice of the reference country. For example if countries 1 and 2 are used as base countries respectively, then

$$RELW\_PLI_{1,j} = RELW\_PLI_{2,j} \tag{A2.12}$$

This result follows from the definition of PLI's and equation 9 which shows the relationship between world PLI's using countries 1 and 2 as the reference countries. We have

$$PLI_{1,j} = \frac{PPP_{1,j}}{XR_{1,j}} \;\; ; \;\; PLI_{2,j} = \frac{PPP_{2,j}}{XR_{2,j}}$$

$$RELW\_PLI_{1,j} = \frac{PLI_{1,j}}{PLI_{1,W}} \; ; \; RELW\_PLI_{2,j} = \frac{PLI_{2,j}}{PLI_{2,W}} \;\; and$$

$$PLI_{2,W} = PLI_{1,W} \cdot \frac{XR_{1,2}}{PPP_{1,2}}$$

This result and equation (A2.11) are important as it implies that publication of price levels relative to world levels are invariant to the choice of the reference or base country.

An immediate corollary of this is that the relative price levels between two countries *j* and *k are independent of the choice of the reference country.*

A2.2 ICP and Price Structures

The ICP focus has generally been on PPPs, real expenditures and price levels – these are the key measures published in ICP reports. There is little discussion and few measures in the ICP that relate to price structures. Relative prices at the national and global level are important indicators of the relative importance and scarcity of goods and services and are useful for policy formulation at the national and international levels. In this section, we propose measures of relative prices constructed using the aggregates and PPPs from the ICP.

2.2.1 Geary-Khamis (GK) International prices and relative prices

The only measures that are likely to serve as measures of relative prices are the international prices resulting from the application of the GK method. The GK method was used in ICP until the 2005 ICP cycle when it was replaced by the GEKS method. The GK method, applied to data at the basic heading level, involves the solution of the following system of equations in international prices, $\{\Pi_i : i = 1,2,...,155\}$ and PPPs for the *M* countries.

$$\Pi_i = \frac{\sum_{j=1}^{M}\left(e_{ij} / PPP_j^{GK}\right)}{\sum_{j=1}^{M} q_{ij}} \qquad i = 1,2,...,155$$

$$\mathrm{PPP}_j^{GK} = \frac{\sum_{i=1}^{155} p_{ij} q_{ij}}{\sum_{i=1}^{155} \Pi_i q_{ij}} = \frac{\sum_{i=1}^{155} e_{ij}}{\sum_{i=1}^{155} \Pi_i q_{ij}} \qquad j = 1,2,...,M \tag{A2.13}$$

The GK method is applied for aggregation above the basic heading level. This means that expenditures and prices at the basic heading level are the inputs. While expenditures in local currency units are observed, prices at the basic heading level need to be computed using an aggregation method. So prices at the basic heading level are essentially PPPs at the basic heading level computed using the CPD method. Therefore, prices are given by:

$$p_{ij} = PPP_{ij} = \text{Purchasing power parity for i-th basic heading}$$

This means that the international prices in (13) are given by:

$$\Pi_i = \frac{\sum_{j=1}^{M}\left(e_{ij}/PPP_j^{GK}\right)}{\sum_{j=1}^{M} q_{ij}} = \frac{\sum_{j=1}^{M}\left(e_{ij}/PPP_j^{GK}\right)}{\sum_{j=1}^{M}\left(e_{ij}/PPP_{i,j}\right)} \tag{A2.14}$$

In order to solve the GK system, PPP of one of the countries (base/reference) is set to 1. Once the system in (A2.13) is solved the resulting international prices for all the 155 commodities (basic headings) provide an indication of the relative prices of goods and services.

Equation (A2.14) also provides an alternative interpretation of international prices:

$$\Pi_i = \frac{\sum_{j=1}^{M}\left(e_{ij}/PPP_j^{GK}\right)}{\sum_{j=1}^{M}\left(e_{ij}/PPP_{i,j}\right)} = \frac{\text{World real expenditure using GK PPPs for the GDP}}{\text{World real expenditure using PPPs at the basic heading level}} \tag{A2.15}$$

International prices defined in (A2.15) do not involve the use of exchange rates.

Comments: An important implication of (A2.15) is that international price level for GDP is equal to 1. Consequently, these international prices for the 155 basic headings can be considered as relative prices of these commodity groups expressed relative to GDP.

The report on the 1975 ICP (KHS, 1982) has international prices for all the 155 basic headings. The question is whether these international prices are suitable for establishing relative price levels. As these international prices are normalized world average prices, it would be useful to see if these are similar to world price levels defined in equation 8 based on PPPs from the GK method. The following equation provides such a link.

The world level price index for the *i-th* basic heading is given by:

$$PLI_{i,W}^{GK} = \frac{\sum_{j=1}^{M}\left(e_{ij}/XR_j\right)}{\sum_{j=1}^{M}\left(e_{ij}/PPP_j^{GK}\right)} = \frac{\sum_{j=1}^{M}\left(e_{ij}/XR_j\right)}{\sum_{j=1}^{M}\left(e_{ij}/PPP_{i,j}\right)} \times \frac{\sum_{j=1}^{M}\left(e_{ij}/PPP_{i,j}\right)}{\sum_{j=1}^{M}\left(e_{ij}/PPP_j^{GK}\right)} = PLI_{i,W} \times \frac{1}{\Pi_i} \tag{A2.16}$$

This equation means that the world PLI defined using the overall PPPs, $PPP_j^K : j = 1,2,...,M$, defined as the ratio of the world nominal expenditure to world real expenditure for the basic heading under consideration differs from the world PLI for the basic heading defined using equation (A2.8) by a factor which is the ratio of world real expenditure computed using basic heading specific PPPs and GK PPPs for the whole GDP.

However, when equation (16) at the GDP level, it implies that the world price level implied by GK method is the same as that used in (A2.8).

Main conclusion: The GK international prices provide a basis to study relative price structure at the global level.

GK international prices are unique if price of one of the basic headings is set to 1.

2.2.2 Relative prices using Price Level Index for specific countries with a selected Reference Country

For each basic heading or commodity group, price level index is defined as the ratio of PPP for the commodity group and the exchange rate. Thus, for country *j* the PLI using country 1 as the reference country is given by:

$$PLI_{i,1j} = \frac{PPP_{i,1j}}{XR_{1,j}} \quad i = 1,2,...,155 \tag{A2.17}$$

From (17) it is clear that the price level index is defined relative to the reference country. PLI for the reference country is equal to 1, by definition. However, PLI for country *k* with country as reference *j* is unique and it is the ratio of PLI's defined in (17) for countries *j* and *k*. This follows from:

$$\frac{PLI_{i,1k}}{PLI_{i,1j}} = \frac{PPP_{i,1k}/XR_{1k}}{PPP_{i,1j}/XR_{1j}} = \frac{PPP_{i,1k}/PPP_{i,1j}}{XR_{1k}/XR_{1j}} = \frac{PPP_{i,jk}}{XR_{jk}} = PLI_{i,jk} \tag{A2.18}$$

Equation (18) follows from the transitivity property of PPPs and the absence of arbitrage in exchange rates.

The price level index at the GDP level is defined following (17) as:

$$PLI_{\mathrm{GDP},1j} = \frac{PPP_{\mathrm{GDP},1j}}{XR_{1,j}} \tag{A2.19}$$

The relative price structure for country *j* across all the commodities can then be defined as:

$$RPLI_{i,1j} = \frac{PLI_{i,1j}}{PLI_{GDP,1j}} = \frac{PPP_{1,1j}}{PPP_{GDP,1j}} \quad for \quad i = 1,2,...,155 \tag{A2.20}$$

For example, from KHS (1982) Table 6.3, for India PPP for Food Beverages and Tobacco (FBT) was 3.78 rupees per dollar whereas PPP for GDP was 2.59 rupees per dollar. This means that relative price level of FBT for India was 3.78/2.59 = 1.46 indicating that FBT prices are 46% higher relative to overall GDP when compared to prices in the United States.

Note: It is important to note that the relative prices here are not invariant to the choice of the reference country. The relative price structure between FBT and GDP is *also* relative to the relative prices in the United States. For example, if we choose Sri Lanka as the reference country, we have PPP for India for FBT and GDP respectively 3.78/5.27 = 0.717 and 2.59/2.93 = 0.884 and the relative price of FBT to GDP when Sri Lanka is used as the reference country is 0.717/0.884 = 0.812. This means FBT is cheaper in India than the GDP basket relatively to that observed in Sri Lanka.

However, these relative prices are useful for comparing relative price levels across countries. For example the ratio of RPLI for India and Sri Lanka is given by:

$$\frac{RPLI_{FBT,USA\,India}}{RPLI_{FBT,USA\,Sri\,Lanka}} = \frac{3.78/2.59}{5.27/2.93} = \frac{1.46}{1.7986} = 0.812 = RPLI_{FBT,Sri\,Lanka\,India} \quad \text{(A2.21)}$$

This measure of relative price level applies when any other country is used as reference country.

Result: The relative prices of commodity groups between two countries *j* and *k* is independent of or invariant to the choice of the reference country used.

2.2.3 Relative price levels using Price Level Index with World Level equal to 1

In the previous section, relative price level indexes are defined using PLI's measured with respect to a reference country. As in the example in equation (A2.21), though the relative PLI for a particular commodity is independent of the reference country it is desirable to have a relative PLI which is free from this problem. A possible solution is to use price level index for each country for each country expressed relative to the world.

For any given commodity *i*, the relative PLI with respective to world is given in equation (A2.11) which is:

$$RELW\_PLI_{i,1,j} = \frac{PLI_{i,1,j}}{PLI_{i,1,W}}$$

Though this measure makes use of country 1 as the base relative to world PLI, it is invariant to the choice of the reference country.

Now the RPLI defined for commodity *i* using world price level, relative to GDP price level is given by:

$$RPLI_{i,W,j} = \frac{RELW\_PLI_{i,1,j}}{RELW\_PLI_{\text{GDP},1,j}} = \frac{PLI_{i,1,j}/PLI_{i,1,W}}{PLI_{\text{GDP},1,j}/PLI_{\text{GDP},1,W}} \quad (22)$$

The relative price level of commodity group *i* measured using the world price level as the base given in (A2.22) is independent of the base country used in measuring PPPs and exchange rates.

The measure in (A2.22) is our preferred measure of relative price levels at the country level based on the current ICP published results.

A2.3 Global Relative Price Structure using ICP results

The starting point for measuring the global price structure is to compute world price level for each of the commodities as well as for GDP. World price level defined in equations (A2.6) and (A2.7) needs a country to be identified as the base country. Using country 1 as the base country, the world price levels for different commodities, $\{j = 1,2,...,155\}$ and GDP are defined as:

$$\text{PLI}_{i,1,W} = \frac{\text{Nominal Exp}_{i,1,W}}{\text{Nominal Exp}_{i,1,W}} = \frac{\sum_{j=1}^{M} \text{Nominal } Exp_{i,1,j}}{\sum_{j=1}^{M} \text{Real Exp}_{i,1,j}} = \frac{\sum_{j=1}^{M} \text{Exp}_{i,j}/XR_{1,j}}{\sum_{j=1}^{M} Exp_{i,1,j}/PPP_{1,j}} \quad j = 1,2,...,155 \quad \text{(A2.23)}$$

and

$$\text{PLI}_{\text{GDP,1,W}} = \frac{\text{Nominal GDP}_{1,W}}{\text{Real GDP}_{1,W}} = \frac{\sum_{j=1}^{M} NGDP_{1,j}}{\sum_{j=1}^{M} RGDP_{1,j}} = \frac{\sum_{j=1}^{M} GDP_j / XR_{1,j}}{\sum_{j=1}^{M} GDP_j / PPP_{1,j}} \tag{A2.24}$$

The relative price level of commodity *i* is then defined as the ratio of expressions in (A2.23) and (A2.24).

$$RPLI_{i,W} = \frac{PLI_{i,1,W}}{PLI_{GDP,1,W}} \tag{A2.25}$$

The relative price level of commodity *i* defined in (A2.25) is independent of the reference country which is designated as country 1 in equations (A2.23) to (25).

The relative price vector measured using (A2.25) is our preferred measure at the global level.

World relative prices keeping expenditure shares constant

The world level PLI for commodity $i, i = 1,2,...,155$, and at the GDP level used in the numerator and denominator of (A2.25) are essentially weighted averages of the country specific price levels where the weights are the country shares in real expenditures of the respective commodities. This means that even when PPPs for two commodities are exactly the same, the world price level may differ if the real expenditure share weights are different. So differences in world price levels for two commodities can be attributed to price differences reflected in PPPs and differences in weights.

From equation (A2.8) we have PLI for a commodity *i* can be written as:

$$\text{PLI}_{\text{GDP,1,W}} = \frac{\sum_{j=1}^{M} GDP_j / XR_{1,j}}{\sum_{j=1}^{M} GDP_j / PPP_{GDP,1,j}} = \sum_{j=1}^{M} s_{GDP,j} \cdot \frac{PPP_{GDP,1,j}}{XR_{1,j}} = \sum_{j=1}^{M} s_{GDP,j} \cdot PLI_{GDP,1,j}$$

$$\text{PLI}_{\text{i,1,W}} = \frac{\sum_{j=1}^{M} \exp_{i,j} / XR_{1,j}}{\sum_{j=1}^{M} \exp_{i,j} / PPP_{GDP,1,j}} = \sum_{j=1}^{M} s_{\text{i},j} \cdot \frac{PPP_{\text{i,1},j}}{XR_{1,j}} = \sum_{j=1}^{M} s_{\text{i},j} \cdot PLI_{i,1,j} \quad j = 1,2,...,155 \tag{A2.26}$$

where $s_{GDP,j} = \frac{RGDP_j}{\sum_{j=1}^{M} RGDP_j}$; *and* $s_{i,j} = \frac{RExp_{i,j}}{\sum_{j=1}^{M} RExp_{i,j}}$ *for* $i = 1,2,...,155,$ are the shares of country *j* in world real GDP and world real expenditure on commodity *i*.

It can be shown that the difference in PLI for commodity *i* and for GDP can be decomposed into price differences and differences in weights. We have:

$$PLI_{i,1,W} - PLI_{GDP,1,W} = \sum_{j=1}^{M} \left(\frac{s_{i,j} + s_{GDP,j}}{2} \right) \left(PLI_{i,1,\text{j}} - PLI_{\text{GDP,1,j}} \right) + \sum_{j=1}^{M} \left(\frac{PLI_{i,1,\text{j}} + PLI_{\text{GDP,1,j}}}{2} \right) \left(s_{i,j} - s_{GDP,j} \right) \tag{A2.27}$$

In equation (A2.27), the first component on the right hand side is a measure of price level differences for commodity group *i* and GDP as a whole.

In view of this we implement a slightly simpler approach where we define world PLI for commodity group *i* and for GDP using simply GDP level expenditure shares for both. For each commodity group *i*, we make use of the following modified measure of world price level.

$$\text{PLI*}_{\text{i,1,W}} = \frac{\sum_{j=1}^{M} \exp_{i,j} / XR_{1,j}}{\sum_{j=1}^{M} \exp_{i,j} / PPP_{GDP,1,j}} = \sum_{j=1}^{M} s_{\text{GDP},j} \cdot \frac{PPP_{\text{i,1,}j}}{XR_{1,j}} = \sum_{j=1}^{M} s_{\text{GDP},j} \cdot PLI_{i,1,j} \quad j = 1,2,...,155 \quad \text{(A2.28)}$$

and the world level relative price levels for different commodities, relative to that of GDP, is given by

$$RPLI_{i,W} = \frac{PLI^{*}{}_{i,1,W}}{PLI_{GDP,1,W}} \quad \text{(A2.29)}$$

where the numerator in (A2.29) is defined and computed using (A2.28).

Our preferred measure of world price structure is the ratio in (A2.29) applied to commodity groups $i = 1,2,...,155$.

Appendix A3

Use of International Average Prices for the analysis of Price Structures in ICP

In Appendix 2, we have seen how ICP results may be used in the analysis of price levels across countries. The last section of Appendix 2 proposed a way of making use of ICP results to compare price levels of different national aggregates relative that of GDP.

The main focus of ICP is on real expenditures and price levels in the participating countries. The ICP reports thus far have little discussion of relative price structures at the global or regional level. One of our aims in the paper is to study relative price structures at the global level and examine whether there have been major shifts in relative prices evident in the recently completed 2011 and 2017 ICP rounds of the ICP compared to those observed in the 1975 ICP round

Relative prices are fundamental to any economic analysis – these are basic to any general equilibrium type of analyses. The purpose here is not to make statements like "rice" is "cheaper" than bread but to establish a relative price. This means that how many units of "bread" (a composite commodity) have the same price as one unit of "rice". This concept is easier to explain and understand when we have commodities like 1 kg of potatoes or 1 litre of milk etc. But the concept is the same for composite commodities.

International Average Prices

In order to study relative price structures, we construct *international average prices* for various basic headings and for higher level aggregates by treating these as composite commodities. We describe the process using the basic headings. The ICP framework identifies 155 basic headings which are groupings of commodities which are similar in their attributes. For example different varieties of "rice" constitute the *rice* basic heading.

Let $\left\{p_{ij}, e_{ij} : i = 1,2,...,155;\ j = 1,2,...,\mathrm{M}\right\}$ represent prices and expenditures for *i-th* basic heading in *j-th* country. Prices at the basic headings are essentially PPPs computed using prices on items included in the basic heading and the CPD method (see Rao, 2013a and 2013b for details) and hence

$$p_{ij} = PPP_{ij} \tag{A3.1}$$

where PPPs are all expressed relative to the currency of a reference country (in our case USA). Then quantities are defined, following KHS (1982) as well as the standard ICP framework, as

$$q_{ij} = \frac{e_{ij}}{p_{ij}} = \frac{e_{ij}}{PPP_{ij}} \quad i = 1,2,...,155;\ \mathrm{j} = 1,2,...,\mathrm{M} \tag{A3.2}$$

Further let PPPs from ICP at the aggregate level (GDP level) be represented by $PPP_{GDP,j}$; $j = 1,2,...,M$. These PPPs reflect relative purchasing powers of currencies in terms of their command over goods and services. Once these PPPs are given, international average prices for different commodities (basic headings) are computed using the following formula. International price for *i-th* commodity (or basic heading) is defined as:

$$\Pi_i = \frac{\sum_{j=1}^{M}\left(e_{ij}/PPP_{GDP,j}\right)}{\sum_{j=1}^{M} q_{ij}} \qquad i = 1,2,....,M \tag{A3.3}$$

The numerator in (A3.3) represents the total world expenditure on *i-th commodity or basic heading*. As expenditures in different countries expressed in respective local currency units cannot be added to compute world expenditure, the country-specific expenditures are converted into a common currency using PPPs at the GDP level[13]. The denominator is the total quantity of *i-th commodity* and the ratio in (A3.3) gives an international average price.

Is the notion of international average price completely new? A similar concept of international average price was introduced by Geary (1953) as a part of what is now known widely as the Geary-Khamis (GK) system for international comparisons. The GK system, shown in equation (A2.13) is given by the following system of inter-related equations:

$$\Pi_i = \frac{\sum_{j=1}^{M}\left(e_{ij}/PPP_j^{GK}\right)}{\sum_{j=1}^{M} q_{ij}} \qquad i = 1,2,...,155$$

$$\text{PPP}_j^{GK} = \frac{\sum_{i=1}^{155} p_{ij}q_{ij}}{\sum_{i=1}^{155}\Pi_i q_{ij}} = \frac{\sum_{i=1}^{155} e_{ij}}{\sum_{i=1}^{155}\Pi_i q_{ij}} \qquad j = 1,2,...,M \tag{A3.4}$$

The first set of equations in the GK system define international average prices very similarly to what we have in (A3.3) with the difference that PPPs used in defining GK international prices are defined by the second set of equations.

The main feature of our definition of international prices is that (A3.3) can be defined using any set of conversion factors whereas in the case of GK system only PPPs that are solutions of the system in (A3.4) can be used in computing international average prices.

Recognizing this important difference and also the similarity between our definition of international prices and that of GK international prices, we have decided to label these as pseudo-GK prices. Given this distinction we note that:

- these international prices can be readily computed once we have expenditure and price (PPP) data at the basic heading level along with GDP level PPPs; and
- These are like GK prices and can be used for the analysis of price structures BUT cannot be used for the analysis of expenditure structures for countries at constant prices since international prices in (A3.3) are based on pre-determined PPPs at the GDP level and not from a feedback mechanism.

Interpretation of Pseudo GK International Prices

We can substitute the expression for q_{ij} in (A3.2) in the expression for international prices:

[13] We note here is that it is quite possible to make use of market exchange rates to convert these expenditures. Given the volatility associated with exchange rates and the fact that they do not reflect purchasing power of currencies, we make use of GDP or economy level PPPs.

$$\Pi_i = \frac{\sum_{j=1}^{M}\left(e_{ij}/PPP_{GDP,j}\right)}{\sum_{j=1}^{M}\left(e_{ij}/PPP_{i,j}\right)} \quad i=1,2,....,155 \tag{A3.5}$$

The numerator of the expression in (A3.5) is the total world real expenditure on *i-th* commodity obtained by converting expenditures using PPP at the GDP level. The denominator is the total real expenditure on *i-th* commodity derived using PPPs specific for the basic heading. The numerator and denominator differ in the PPP's used for converting prices.

Important properties of the pseudo-international prices:

1. The pseudo-international prices ensure that world real expenditure on *i-th* commodity is the same whether it is obtained by summing deflated country level expenditures using GDP level PPPs or by simply evaluating the total world consumption, $\sum_{j=1}^{M} q_{ij}$ at the international prices. This follows from (A3.3).That is:

$$\sum_{i=1}^{155}\left(\Pi_i \cdot \sum_{j=1}^{M} q_{ij}\right) = \sum_{i=1}^{N}\sum_{j=1}^{M}\left(e_{ij}/PPP_{GDP,j}\right) \tag{A3.6}$$

2. From equation (A3.6), it is clear that these international prices can be used to study the expenditure structure at international prices. Share of *i-th* commodity in world real GDP (consumption) is simply:

$$S_i = \frac{\Pi_i \cdot \sum_{j=1}^{M} q_{ij}}{\sum_{i=1}^{155}\left(\Pi_i \cdot \sum_{j=1}^{M} q_{ij}\right)} \quad i=1,2,...,155$$

3. Then what is the difference between pseudo GK and the GK international prices. In the case of the pseudo-GK prices there is no feedback mechanism shown in (A3.4). This means that PPPs used in computing international average prices in the GK system has to satisfy the second part of (A3.4). In comparison, our international average prices can be defined using any set of PPPs at the GDP level. Therefore, at the country level the real expenditure obtained at PPPs from the GDP level and quantities evaluated at international prices would be different.

$$\sum_{i=1}^{155}\left(\Pi_i \cdot q_{ij}\right) \neq \sum_{i=1}^{155}\left(e_{ij}/PPP_{GDP,j}\right) = \sum_{i=1}^{155} e_{ij} \Big/ PPP_{GDP,j} \quad j=1,2,...,M \tag{A3.7}$$

   If GK prices are used, equality holds in equation (A3.7).

4. At the GDP level, international price is equal to 1. This can be seen from the definition in (A3.5) and the denominator also uses GDP level PPPs . This means that the international prices are all relative to the price of GDP basket.
5. The pseudo-international price level is quite similar to the world price level defined as the ratio of world nominal expenditure to world real expenditure used in the ICP and also our empirical work. The world price level for a commodity was defined as:

$$WPLI_i = \frac{\sum_{j=1}^{M}\left(e_{ij}/XR_j\right)}{\sum_{j=1}^{M}\left(e_{ij}/PPP_{i,j}\right)} \quad i=1,2,....,155 \tag{A3.8}$$

So, the international average price of commodity i is similar to WPLI we discussed in equation (A2.24) Appendix 2 except that XR is replaced by PPP for GDP.

Appendix Table: International Average Prices, 2011 and 2017; GK International Prices, 1975 - at the detailed basic heading level

Item - ICP 2011, 2017	International Average Prices, 2011	International Average Prices, 2017	GK International Prices , 1975	Name of item in 1975
	(1)	(2)	(3)	(4)
Rice	0.8936	1.2771	1.09	Rice
Other cereals, flour and other cereal products	2.2106	2.4906	1.05	Meal, other cereals
Bread	1.072	1.3696	0.72	Bread
Other bakery products	1.1159	1.3354	1.27	Biscuits, cakes etc
Pasta products and couscous	1.7855	1.4069	1.17	Macaroni, sphagetti
Beef and veal	1.4987	1.3117	0.93	Fresh beef and veal
Pork	1.3738	1.2981	1.59	Fresh pork
Lamb, mutton and goat	1.1533	0.9852	1.06	Fresh lamb, mutton
Poultry	1.6805	1.3016	1.59	Fresh poultry
Other meats and meat preparations	1.5826	1.641	1.52	other fresh meat
Fresh, chilled or frozen fish and seafood	0.8396	1.0856	1.45	Fresh and frozen fish
Preserved or processed fish and seafood	1.2504	1.5533	1.13	canned fish
Fresh milk	1.6354	2.0365	1.13	Fresh milk
Preserved milk and other milk products	1.5872	1.5239	1.17	Milk products
Cheese and curd	1.3939	1.6653		
Eggs and egg-based products	1.9677	1.6469	1.57	Egg, egg products
Butter and margarine	1.4063	2.118	1.68	Butter
Other edible oils and fats	2.2492	2.0987	1.28	Margarine, edible oil
Fresh or chilled fruit	1.2441	1.2861	1.12	Other fresh fruits
Frozen, preserved or processed fruit and fruit-based products	1.8508	2.0589	1.23	Other fresh fruits
Fresh or chilled vegetables, other than potatoes and other tuber vegetables	0.9298	0.9987	0.71	Fresh vegetgables
Fresh or chilled potatoes and other tuber vegetables	1.1084	0.9203	1.14	Tubers including potatoes
Frozen, preserved or processed vegetables and vegetable-based products	1.6044	1.6872	1.29	Vegetables other than fresh
Sugar	1.5673	2.0125	1.02	Sugar
Jams, marmalades and honey	1.7161	1.917	1.03	Jam, syrup, joney
Confectionery, chocolate and ice cream	1.1484	1.4545	1.1	Chocolate, ice cream
Food products n.e.c.	1.3486	1.5642	1.17	Salt, spices and sauces
Coffee, tea and cocoa	1.5187	1.7813	1.96	Coffee; Tea - 1.11 and Cocoa - 1.05
Mineral waters, soft drinks, fruit and vegetable juices	1.2616	1.2957	1.35	non-alcoholic beverages
Spirits	1.4665	1.4365	1.61	Spirits
Wine	0.9266	1.2521	1.06	Wine, cider
Beer	1.0775	1.2708	1.16	Beer
Tobacco	0.7383	0.9272	1.1	Cigarettes
Narcotics	0.7641	1.1102	2.31	Cigars, tobacco, snuff
Clothing materials, other articles of clothing and clothing accessories	0.9419	1.1231	1.97	Clothing materials
Garments	1.1826	1.2837	1.1	Men's clotjhing; Women's clothing - 1.29; Boys and girls clothing - 1.32; men's and boys' underwear - 1.48; women's and girls' underwear - 1.13; Haberdashery, millinery - 0.97; clothing rental and repair
Cleaning, repair and hire of clothing	0.9724	0.7716	0.57	Clothing rental and repair
Shoes and other footwear	0.8686	0.7953	0.93	Men's footwear ; Women's footwear - 1.14; Children's footwear - 0.86
Repair and hire of footwear	1.3659	1.8191	0.85	Footwear repairs
Actual rentals for housing	0.8727	0.6508	0.85	Rents
Imputed rentals for housing	1.1629	1.46		
Maintenance and repair of the dwelling	1.208	1.242	1.11	Indoor repai and upkeep
Water supply	0.9855	1.0759		
Miscellaneous services relating to the dwelling	1.2401	1.1972		
Electricity	1.1344	1.1442	1.14	Electricity
Gas	0.7922	0.84	1.4	Gas
Other fuels	1.0882	1.1215	0.81	Other fuels
Furniture and furnishings	0.3922	0.2215	0.69	Furniture and fixtures
Carpets and other floor coverings	0.8112	0.8689	1.17	Floor coverings
Repair of furniture, furnishings and floor coverings	1.2644	1.3111		
Household textiles	0.8042	0.7576	1.26	Househokd textiles, etc

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Item - ICP 2011, 2017	International Average Prices, 2011	International Average Prices, 2017	GK International Prices , 1975	Name of item in 1975
Major household appliances whether electric or not	1.2293	1.3741	1.44	Refigerators and freezers; Washing appliances - 1.49; cooking appliances - 1.24; heating appliances - 1.33; cleaning appliances - 1.5; other household appliances - 2.01
Small electric household appliances	0.3849	0.3886		
Repair of household appliances	0.9452	1.2719		
Glassware, tableware and household utensils	0.7835	0.8029	1.11	Household utensils
Major tools and equipment	1.2065	1.1773		
Small tools and miscellaneous accessories	1.6545	1.0481		
Non-durable household goods	1.0402	1.4571	1.23	Non-durable household goods
Domestic services	1.0825	1.0028	0.29	Domestic services
Household services	0.9404	0.887	0.96	Household services
Pharmaceutical products	1.1617	1.3244	0.93	Drugs, medical preparations
Other medical products	1.066	1.1381	1.32	Medical supplies
Therapeutic appliances and equipment	1.0855	1.3768	0.83	Therapeutic equipment
Medical services	0.8666	0.8384	0.54	Physicians' services
Dental services	0.9289	0.9777	0.54	Dentists' services
Paramedical services	0.9752	1.1138	0.57	Nurses' services
Hospital services	1.1703	0.8386	0.42	hospitals
Motor cars	1.2929	1.3966	1.43	Personal automobiles
Motor cycles	1.3623	1.6577	1.18	Other personal transport
Bicycles	1.6438	1.4314		
Animal drawn vehicles	0.6315	1.2151		
Fuels and lubricants for personal transport equipment	1.1095	1.4003	1.64	Gasoline, oil, grease
Maintenance and repair of personal transport equipment	0.496	0.4384	0.65	Automobile repairs
Other services in respect of personal transport equipment	1.1339	1.0691		
Passenger transport by railway	0.9248	1.0982	0.26	Rail transport
Passenger transport by road	0.6264	0.7406	0.28	Bus transport
Passenger transport by air	1.2006	1.3665	0.86	Air transport
Passenger transport by sea and inland waterway	1.0826	1.1093		
Combined passenger transport	0.9829	1.5055		
Other purchased transport services	1.3223	1.5424	0.46	Local transport
Postal services	0.8609	0.8555	0.95	Postal services
Telephone and telefax equipment	1.2122	1.1942		
Telephone and telefax services	1.0921	1.0523	0.89	Telepho,e gtelegraph
Audio-visual, photographic and information processing equipment	1.1281	1.056	1.26	Radio, televisions, phonographs
Recording media	1.0998	1.0508		
Repair of audio-visual, photographic and information processing equipment	1.1299	1.0577		
Major durables for outdoor and indoor recreation	1.135	1.291	1.23	Durable recreational equipment
Maintenance and repair of other major durables for recreation and culture	1.7681	1.7919		
Other recreational items and equipment	0.519	0.5345		
Garden and pets	0.7481	0.8926		
Veterinary and other services for pets	1.0622	0.8582		
Recreational and sporting services	0.5088	0.5829		
Cultural services	0.9791	0.7924		
Games of chance	0.7516	0.7884		
Newspapers, books and stationery	1.2221	1.5056	0.93	Books, papers, magazines
Package holidays	0.8967	0.9968		
Education	0.902	1.1311		
Catering services	0.9808	1.2265	0.96	Catering services
Accommodation services	0.3591	0.4104	0.55	Hotels and lodgings
Hairdressing salons and personal grooming establishments	0.5554	0.5029	0.56	Barber and beauty shops
Appliances, articles and products for personal care	1.4692	0.4591	1.15	Other personal care goods; Toilet articles - 1.17
Prostitution	0.7398	0.5069		
Jewellery, clocks and watches	1.3297	0.8018		
Other personal effects	0.856	0.892		
Social protection	0.6857	0.3765		
Insurance	0.4724	0.5898		
Financial Intermediation Services Indirectly Measured (FISIM)	1.0836	1.0484		
Other financial services n.e.c.	0.941	0.9825		
Other services n.e.c.	0.8173	1.4043		
Net purchases abroad	1.245	1.0493	1.28	Expensiture of Residents abroad

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Item - ICP 2011, 2017	International Average Prices, 2011	International Average Prices, 2017	GK International Prices , 1975	Name of item in 1975
Housing	0.9123	0.9388		
Health	0.8697	0.8136		
Recreation and culture	0.481	0.3241		
Education	0.4874	0.7957		
Social protection and other services	0.4684	0.9971		
Housing	0.5532	0.9869		
Pharmaceutical products	1.1061	1.0812	0.93	Drugs, medical prepartions
Other medical products	0.5118	0.5648	1.32	Medical supplies
Therapeutic appliances and equipment	0.6548	0.5975	0.83	Therapeutic equipment
Out-patient medical services	0.5241	-5.2525		
Out-patient dental services	0.753	0.8197		
Out-patient paramedical services	0.786	0.8138		
Hospital services	0.5906	0.6924		
Compensation of employees	1.105	1.0672	0.81	White collar; unskilled blue collar - 0.43; skilled blue collar - 0.61; professional - 0.83
Intermediate consumption	0.8996	0.6322		
Gross operating surplus	1.0366	1.005		
Net taxes on production	0.8527	0.7915		
Receipts from sales	0.8745	0.9408		
Recreation and culture	1.7899	2.317		
Education benefits and reimbursements	1.5545	1.6441		
Compensation of employees	1.4244	1.7486		
Intermediate consumption	1.5779	1.6473		
Gross operating surplus	1.8843	1.8016		
Net taxes on production	1.6271	1.7234		
Receipt from sales	0.6065	0.5999		
Social protection	0.629	0.5796		
Compensation of employees	0.9629	0.6832	0.81	White collar; unskilled blue collar - 0.43; skilled blue collar - 0.61; professional - 0.83
Intermediate consumption	1.2533	1.2655	1.21	Commodities of government
Gross operating surplus	1.4837	1.5439		
Net taxes on production	2.0279	2.4264		
Receipts from sales	1.7254	1.1078		
Fabricated metal products, except machinery and equipment	0.7159	0.7918		
Electrical and optical equipment	1.5047	1.4198	1.3	Electrical transmission equipment
General purpose machinery	1.517	0.8263	1.29	General industrial machinery
Special purpose machinery	0.6347	1.1507	1.31	Special Industrial machinery
Road transport equipment	0.446	0.9513	1.53	Trucks, buses, trailers
Other transport equipment	1.5205	1.9819	1.87	Other transport equipment
Residential buildings	0.5336	0.5302	1.09	one and two-family dwellings; multi-family dwellings - 1.07
Non-residential buildings	1.6198	1.92	1.49	Industrial buildings; commercial buildings - 1.15; office buildings - 1.12;
Civil engineering works	0.9845	0.8229	0.86	Roads, streets, highways
Other products	0.8709	0.8616		
Change in inventories	1.1808	1.201	1.21	Increase in stocks
Acquisitions less disposals of valuables	0.9917	0.9548		
Balance of exports and imports	0.6315	0.6467	1.28	Exports minus imports

Notes:
Columns G and H show international prices for basic headings in 2011 and 2017 ICP
Figures in Column I are from Appendix Table 6.3 in KHS (1982) pp. 212-215
Column K shows GK international prices for related item categories

Appendix A4: List of Countries in Price Level Index Analysis and Similarity of Price Structures

iso3	country		iso3	country		iso3	country
ALB	Albania		GAB	Gabon		PAK	Pakistan
DZA	Algeria		GMB	Gambia, The		PAN	Panama
AGO	Angola		GEO	Georgia		PRY	Paraguay
AIA	Anguila		DEU	Germany		PER	Peru
ATG	Antigua and Barbuda		GHA	Ghana		PHL	Philippines
ARM	Armenia		GRC	Greece		POL	Poland
ABW	Aruba		GRD	Grenada		PRT	Portugal
AUS	Australia		GIN	Guinea		QAT	Qatar
AUT	Austria		GNB	Guinea-Bissau		ROU	Romania
AZE	Azerbaijan		HTI	Haiti		RUS	Russian Federation
BHS	Bahamas, The		HND	Honduras		RWA	Rwanda
BHR	Bahrain		HKG	Hong Kong SAR, China		STP	Sao Tome and Principe
BGD	Bangladesh		HUN	Hungary		SAU	Saudi Arabia
BRB	Barbados		ISL	Iceland		SEN	Senegal
BLR	Belarus		IND	India		SRB	Serbia
BEL	Belgium		IDN	Indonesia		SYC	Seychelles
BLZ	Belize		IRN	Iran, Islamic Rep.		SLE	Sierra Leone
BEN	Benin		IRQ	Iraq		SGP	Singapore
BMU	Bermuda		IRL	Ireland		SXM	Sint Maarten
BTN	Bhutan		ISR	Israel		SVK	Slovak Republic
BOL	Bolivia		ITA	Italy		SVN	Slovenia
BIH	Bosnia and Herzegovina		JAM	Jamaica		ZAF	South Africa
BWA	Botswana		JPN	Japan		ESP	Spain
BRA	Brazil		JOR	Jordan		LKA	Sri Lanka
VGB	Virgin Islands, British		KAZ	Kazakhstan		KNA	St. Kitts and Nevis
BRN	Brunei Darussalam		KEN	Kenya		LCA	St. Lucia
BGR	Bulgaria		KOR	Korea, Rep.		VCT	St. Vincent and the Grenadines
BFA	Burkina Faso		KWT	Kuwait		SDN	Sudan (AFR)
BDI	Burundi		KGZ	Kyrgyz Republic		SUR	Suriname
CPV	Cabo Verde		LAO	Lao PDR		SWE	Sweden
KHM	Cambodia		LVA	Latvia		CHE	Switzerland
CMR	Cameroon		LSO	Lesotho		TWN	Taiwan
CAN	Canada		LBR	Liberia		TJK	Tajikistan
CYM	Cayman Islands		LTU	Lithuania		TZA	Tanzania
CAF	Central African Republic		LUX	Luxembourg		THA	Thailand
TCD	Chad		MDG	Madagascar		TGO	Togo
CHL	Chile		MWI	Malawi		TTO	Trinidad and Tobago
CHN	China		MYS	Malaysia		TUN	Tunisia
COL	Colombia		MDV	Maldives		TUR	Turkey
COM	Comoros		MLI	Mali		TCA	Turks and Caicos Islands
COD	Congo, Dem. Rep.		MLT	Malta		UGA	Uganda
COG	Congo, Rep.		MRT	Mauritania		UKR	Ukraine
CRI	Costa Rica		MUS	Mauritius		ARE	United Arab Emirates
CIV	Cote d'Ivoire		MEX	Mexico		GBR	United Kingdom
HRV	Croatia		MDA	Moldova		USA	United States
CUW	Curarao		MNG	Mongolia		URY	Uruguay
CYP	Cyprus		MNE	Montenegro		VNM	Vietnam
CZE	Czech Republic		MSR	Montserrat		PSE	West Bank and Gaza
DNK	Denmark		MAR	Morocco		ZMB	Zambia
DJI	Djibouti		MOZ	Mozambique		ZWE	Zimbabwe
DMA	Dominica		MMR	Myanmar			
DOM	Dominican Republic		NAM	Namibia			
ECU	Ecuador		NPL	Nepal			
EGZ	Egypt, Arab Rep.		NLD	Netherlands			
SLV	El Salvador		NZL	New Zealand			
GNQ	Equatorial Guinea		NIC	Nicaragua			
EST	Estonia		NER	Niger			
SWZ	Eswatini		NGA	Nigeria			
ETH	Ethiopia		MKD	North Macedonia			
FJI	Fiji		NOR	Norway			
FIN	Finland		OMN	Oman			
FRA	France						