PWT 8.0 – A User Guide

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Introduction

The introduction of a substantially revised version of the Penn World Table (PWT) is a useful moment to introduce or reintroduce this dataset to its users. The aim of this user guide is to provide a non-technical overview of PWT version 8.0: what are the new concepts, how is the dataset constructed, how can it be best used in research and what are some of the main limitations.[1]

The central element of PWT has always been real GDP per capita, a measure of relative living standards across countries at different points in time. This measure requires two main pieces of information, namely GDP per capita in national currency and purchasing power parities (PPPs) to correct for differences in prices across countries.[2] Many of the choices necessary for constructing PWT are related to estimating PPPs and we will use this guide to motivate these choices and discuss their consequences. GDP data are readily available from National Accounts (NA) statistics, and so require fewer choices. However, revisions of NA data by statistical offices are often substantial, with GDP increasing by half or even doubling in some cases. Such revisions are the

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[1] For a more technical discussion of the methodological innovations in PWT 8.0, see Feenstra, Inklaar and Timmer (2013). For discussions of earlier versions, see e.g. Summers and Heston (1991) and Kravis, Heston and Summers (1982).

[2] A country's PPP gives the number of local currency units (e.g. euro's) that are needed to buy a bundle of products worth one dollar in the US. Dividing the PPP by the nominal exchange rate (also in local currency units per dollar) then gives the "price level" of that country relative to the US. A price level of 0.5, for example, indicates that local prices converted to US dollars with the nominal exchange rate are ½ as high on average as in the United States, as might be the case for a developing country.

dominant reason for differences between subsequent versions of PWT that were emphasized by Johnson et al. (2013). We illustrate this using recent vintages of NA data.[3]

In version 8.0, we make three major changes to PWT, two of which are related to the calculation of PPPs. The first change is that we now also measure relative prices of exports and imports. This allows us to distinguish two measures of real GDP, one aimed at capturing relative living standards (as before) and one aimed at capturing relative productive capacity. Researchers can thus choose the measure that is most appropriate to the research setting. The second change is in how we estimate PPPs over time, by using more of the historical price survey material. This change has important implications for using PWT in research on cross-country economic growth. The third change is that we introduce measures of capital stock and (total factor) productivity, based on newly developed basic data discussed in Inklaar and Timmer (2013c). This broadens the type of research questions that can be answered directly using PWT, such as models relying on the distance to the technological frontier (e.g. Aghion and Howitt, 2006). Here we discuss these changes in broad terms and focus on the implications of our choices.

The limitations inherent in comparing living standards or productive capacity of economies across countries are a recurring theme in this guide. Whether due to the very nature of the exercise or the practical challenges encountered along the

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[3] GDP per capita data also requires data on the population of a country. Such data is typically less prone to large revisions.

way, it is not possible to be very precise in comparing countries at very different levels of economic development; see also Deaton and Heston (2010). Beyond that, changing basic national accounts data can and will lead to substantial differences in PWT versions over time. In response to the work of Johnson et al. (2013), we have changed the PWT methodology to reduce the likelihood of revisions over time, but a complete elimination of this concern is impossible because of changes to the underlying data. This implies that caution is in order when using the reported results and we discuss when to be cautious and provide practical suggestions on how to be cautious.

These recommendations will not apply to the same degree to every user and we will clarify this throughout. In general, users that are interested in specific numbers, such as the relative price level of Tanzania in 2000 or the real GDP per capita ranking of Vietnam in 1995, will need to be most careful as limitations to the basic data and specific methodological choices have their largest impact on such individual observations. These would typically be most relevant for the type of analysis done in country-level studies, such as OECD Economic Surveys. If instead an econometric analysis is performed on a dataset based on PPPs (e.g. Rodrik, 2008) or real GDP per capita levels (e.g. Ashraf and Galor, 2013), some of these considerations may be less important as the broad cross-country pattern of data is not severely affected by some of these choices. Finally, for those aiming to explain differences in cross-country economic growth, while accounting for differences in initial real GDP per capita levels, the recommendations for when to use real GDP per capita and when to use GDP at constant national prices will be most relevant.

GDP per capita – a numerical example

To illustrate the main concepts fromPWT8.0, Table 1 compares GDP per capita and productivity in China and the United States in 2005. The first row shows GDP per capita in national currency, so in renminbi (RMB) for China and US dollars (USD) for the US, and these data are directly from National Accounts. Since these values are in different currencies, a comparison between the Chinese and US values makes little sense. The second row converts the Chinese value in US dollars using the market exchange rate at the time of 8.2 RMB/USD. Comparing the Chinese and US values implies that China's GDP per capita level is only 4 percent of that in the US. However, the market exchange rate will not reflect relative prices of non-traded products, such as housing and many other services, while a PPP is designed to compare prices for all products in the economy. The third row shows real GDP^e per capita based on PWT8.0 and this makes a considerable difference, with China's relative income level at 12 rather than 4 percent of that in the US. As will be discussed in more detail below, real GDP^e per capita is a measure of comparative living standards as it covers prices for consumption and investment but not for exports or imports. As a result, the value for the United States is also affected (43212 vs. 42330). Row 4 shows real GDP^o per capita, which does reflect relative prices of exports and imports and is thereby a measure of comparative productive capacity. China has the same comparative living standards and productive capacity relative to the US, but this is not true in general, as we will demonstrate below.

Table 1, Comparing income and productivity in China and the United States for 2005

	China	United States	China/US
A: GDP per capita			
in national currency	14565	42330	
in US dollars, converted with exchange rate	1777	42330	4%
in US dollars, GDP^e	5342	43212	12%
in US dollars, GDP^o	5270	42330	12%
B: productivity			
GDP^o per worker (US$)	8967	87483	10%
Tangible capital stock per worker (US$)	29221	261588	11%
Human capital per worker (index)	2.46	3.57	69%
Total factor productivity (index)	0.34	1.00	34%

The second part of Table 1 looks at productivity of China relative to the US. The first row of panel B shows real GDP^o per worker, i.e. labor productivity, which is somewhat lower in China than the relative GDP^o per capita level as the Chinese employment-population ratio of 59 percent is higher than the 48 percent of the US. If the amount of tangible and human capital per worker were the same in the two countries, the relative total factor productivity level would be the same as the relative labor productivity level. However, China has considerably less tangible capital (11 percent) and human capital (69 percent) per worker. As a result, its relative total factor productivity level is higher than its relative labor productivity level.[4] Given this broad overview of the type of measures available in PWT8.0, we now turn to a more in-depth discussion on the choices we make.

[4] Note that both the amount of human capital per worker and total factor productivity have no natural units. The amount of human capital per worker is related the average years of schooling and the return to education, while total factor productivity is defined as the relative level of

PPPs for consumption and investment

Comparing GDP levels across countries requires correcting for price differences across countries. This challenge is analogous to measuring GDP growth over time: knowing the change in the quantity of products produced in an economy requires correcting (nominal) values for changes in prices. But while measuring price changes over time is a well-understood and (mostly) routine part of the work of statistical offices around the world, measuring price differences across countries is much more of a challenge. This is because spending patterns tend to be very different, especially when comparing rich and poor countries, see e.g. Deaton and Heston (2010). For instance, people in poor countries tend to spend much more of their income on food (Almås, 2012), so that food prices are much more important for living standards than in rich countries. An estimate of *relative* living standards needs to take both sets of spending patterns into account, which is an inherently imperfect endeavor.[5] A challenge of a more practical nature is how to compare, say, the cost of housing in a Nairobi slum to that in a Washington, DC suburb. Even if one can measure how much is spent on housing in the two places, determining how much of the difference in spending is due to price differences and how much due to the difference in the 'quantity' of

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output divided by the relative level of inputs. In both cases, there is no natural interpretation of the absolute values, only of the relative values.

[5] Deaton and Heston (2010) discuss this problem and provide an introduction to the broader index number literature. Note that these differences in spending patterns can be the result of differences in prices, but also of differences in preferences and that taking such differences into account is still challenging (Neary, 2004).

housing is even harder. As a result, the PPP comparing prices in Canada to the US will be much more precisely estimated than the PPP for Kenya relative to the US.

In 2005, the World Bank's International Comparisons Program (ICP) made the most recent benchmark comparison of consumption and investment prices based on a detailed cross-country price survey covering 146 countries around the world (see World Bank, 2008). More recently, a broad review of this comparison appeared (World Bank, 2013), which provides "health warnings" as well as suggestions for the next global comparison, of prices in 2011 across 200 countries. The 2005 comparison was a great improvement over the five earlier global comparisons. Most notably, it covered the largest number of countries ever as shown in Table 2, and the data collection, processing and PPP computation were also more rigorous. The table also illustrates that before 1996, European countries and OECD countries elsewhere made up the lion's share of countries. Country coverage in most other regions has steadily risen, with the exception of Latin America, where coverage has fluctuated over the years.

Table 2, ICP global benchmark comparisons and country participation, by region

ICP benchmark	1970	1975	1980	1985	1996*	2005
Europe & OECD	10	18	22	25	31	44
Asia	3	6	6	8	12	22
Latin America	1	4	16	7	21	10
Middle East & North Africa	1	2	3	4	12	15
Sub-Saharan Africa	1	3	13	19	19	44**
Former Soviet Union (CIS)					12	10
Total	16	33	60	63	107	145

Notes: Only includes countries currently included in PWT8.0, so omits Yugoslavia, which participated in 1975, 1980 and 1985. OECD refers to current membership.

* The 1996 benchmark was constructed for PWT6 based on the 1996 survey for OECD and EU countries and the 1993 survey for other regions in the world.

** This excludes Zimbabwe, which did participate in the 2005 benchmark, but is not included; see for more discussion the section 'Benchmark comparisons' below.

This discussion illustrates the main features and limitations of the PPP information used in PWT: data is available for relatively few benchmark years, for an incomplete set of countries, and data quality varies across countries and years. As the aim of PWT is to provide a broad and complete panel of real GDP estimates, the PPP source material requires further choices and estimation. The first set of choices is on how to use the basic benchmark material; the second on dealing with non-benchmark countries and years.

Benchmark comparisons

In each of the six global comparisons, prices are collected for many consumption and investment products. Together, these cover all of domestic absorption, i.e. GDP excluding the trade balance; comparing the trade balance, i.e. exports minus imports, across countries will be discussed in more detail in the next section. Price quotes would be collected on, for example, rice of different types and sold in different package sizes and the resulting relative prices are then averaged to arrive at a relative price of rice. Overall, a list of roughly 1000 products is priced in every country to cover all of consumption and investment. These prices are combined into 100 or more so-called basic headings for which information is available about the expenditure on these products.[6] We mostly take these basic

[6] The exception is the 1996 global comparison, for which only about 30 basic headings are available.

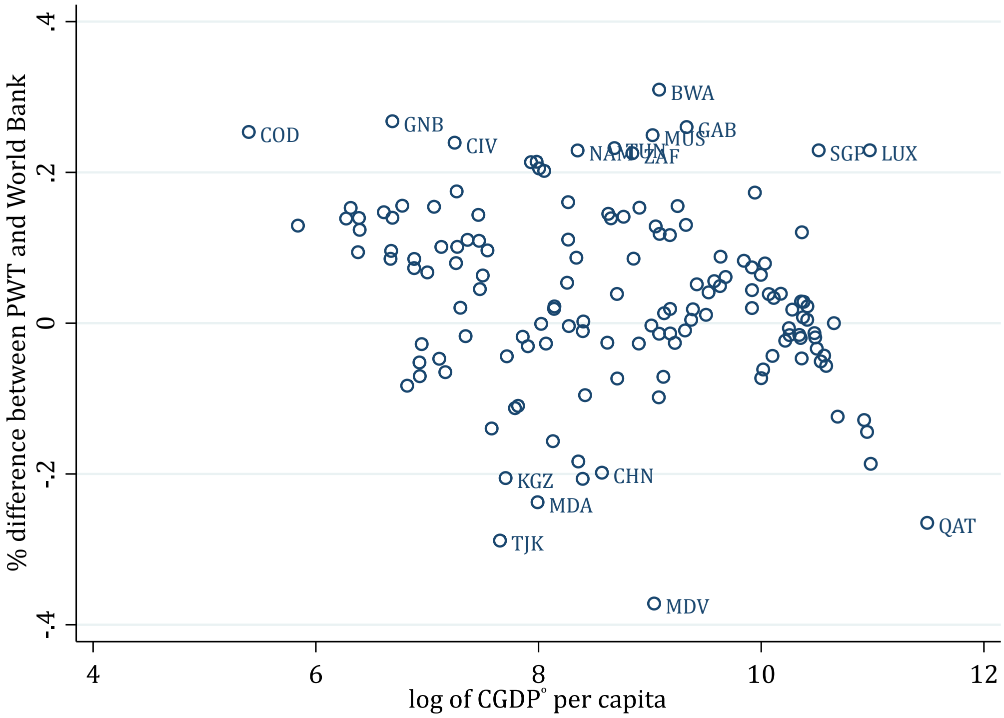
heading prices and expenditures as given, though for the 2005 benchmark, two adjustments were made. First, the relative consumption prices for China were deemed 20 percent too high by Deaton and Heston (2010), so all consumption basic headings were adjusted downwards by this proportion.[7] Second, for much of government consumption (health, education, collective services), no relative output prices are available, so instead relative input prices – mostly relative wages – are used. Since there are large productivity differences across countries, these relative input prices are a poor predictor of relative output prices.[8] The World Bank (2008) made an adjustment for some countries, but Heston (2013) discusses a method to make an adjustment for all countries and this method is applied in both PWT7.x and 8.0. The case of Zimbabwe also warrants discussion. Although prices were collected, the country was suffering through hyperinflation in this period. As a consequence, the ICP 2005 report (World Bank 2008) does report a PPP estimate, but not an exchange rate. Conversely, the World Bank's databank now omits a PPP estimate while showing an exchange rate. The PPP estimate we get using ICP 2005 data and the UN National Accounts' exchange rate also imply a relative price level that far exceeds what might be expected

[7] See also Feenstra, Ma, Neary and Rao (2013) for evidence that this adjustment is conservative.

[8] From the dual approach to productivity measurement, it follows that the relative price of output is equal to the relative price of inputs minus relative productivity.

based on the 1996 PPP.[9] For this reason, PWT8.0 omits PPP estimates for Zimbabwe in 2005.

Figure 1, Comparing 2005 GDP PPPs, PWT8.0 versus World Bank



Note: the PWT8.0 PPP refers to the GDPᵒ PPP, the World Bank GDP PPP is taken from World Bank (2008).

The next step is to compute a weighted average of basic heading PPPs to arrive at an overall GDP PPP. There are a large number of index number methods for doing so, and each of these corresponds to a different approach to weighting individual basic heading PPPs. A detailed comparison of these methods is beyond

[9] Using relative inflation rates to extrapolate 1996 PPPs to 2005 shows an estimated price level o 0.14 with USA=1, while the 2005 ICP data imply a price level of over 1.6. The 0.14 is also more in line with the expected price level for a country at Zimbabwe's level of development.

the scope of this paper,[10] but all aim to give larger weight to those products on which an economy spends relatively more. Here too, PWT version 8.0 follows somewhat different procedures than the World Bank, including different index number methods[11]; different treatment of regional data;[12] and a different PPP conversion of the trade balance;[13] see World Bank (2008) for details on their approach and Feenstra et al. (2013) for details on PWT. These factors, together with the changes to the basic headings for China and for government services, explain why PWT GDP PPPs in 2005 are different than the World Bank (2008) PPPs. Figure 1 plots these differences against the real GDP per capita level from PWT8.0. This shows how differences are often substantial and these occur at all levels of income. This will obviously be important for users interested in the income level of specific countries, though for users interested only in the broad cross-country pattern, the cross-country correlation of 0.97 between the two sets of PPPs should be reassuring.

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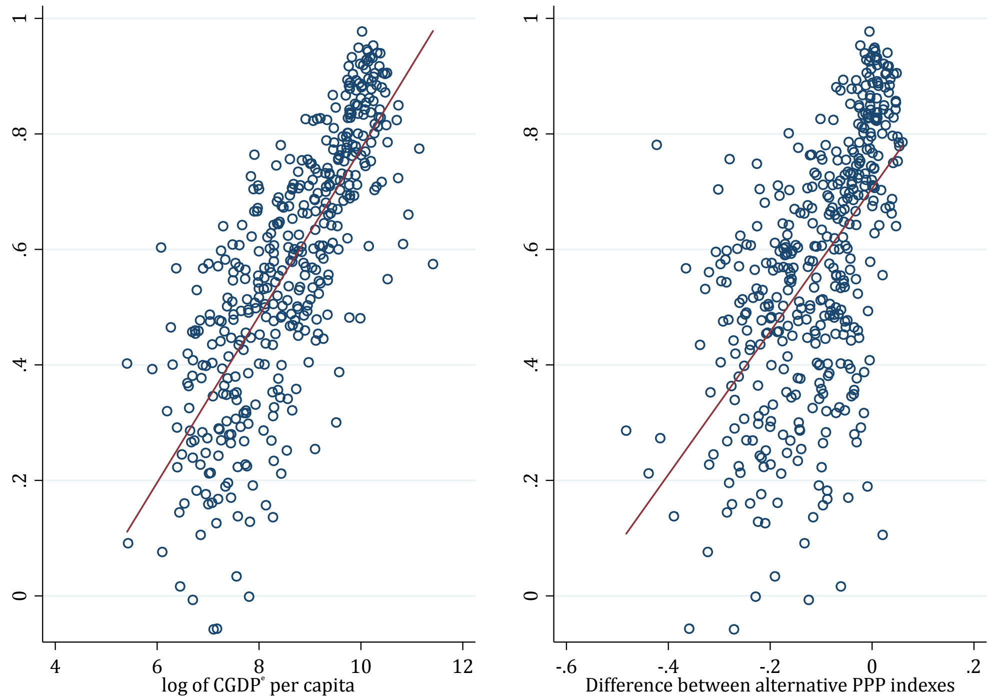
[10] For those interested, see e.g. Diewert (2013) or Balk (2008).

[11] The World Bank (2008) uses the GEKS procedure in most regions and the IDB procedure in Africa, while PWT uses the GEKS procedure to go from the basic heading level to consumption and investment and the GK procedure to combine these to total GDP.

[12] The World Bank's methods maintains fixed parities within regions, also when computing PPPs across regions, while in PWT this is only the case for EU/OECD countries, whose benchmark PPP data come directly from Eurostat and OECD.

[13] The World Bank uses the exchange rate to convert the trade balance, while PWT measures specific PPPs for exports and imports; see the next section for details.

Figure 2, Correlation between expenditure shares of each country and the US across benchmark comparisons compared with income levels and PPP precision



Note: difference between alternative PPP indexes is the percent difference between a GDP PPP computed using the GEKS index number and the Geary-Khamis (GK) index number.

As discussed above, some of the differences seen in Figure 1 are due to differences in index number methods. The choice of index number method will matter more when comparing two countries with very different spending patterns. Since the literature has advanced many plausible alternative methods and has proven that none of these will be perfectly suited to the job (Van Veelen, 2002), there will be a margin of uncertainty in every cross-country comparison of prices and real income. Furthermore, that uncertainty will be larger when comparing countries for which spending patterns differ more.

Since information on those spending patterns is available, we compute the correlation between each country's expenditure shares and those in the US.[14] The left-hand panel of Figure 2 plots these correlations against the log of GDP per capita for each of the six global comparisons. As expected, expenditure shares in rich countries are more similar to those in the US than shares in poor countries. If the aim is to compare each country's income level to that in the US, then this correlation measure suggests that richer countries' income levels can be more precisely estimated than poorer countries' income levels. The right-hand panel plots these correlations against the percent difference in GDP PPPs across two popular index number methods, the GEKS and the Geary-Khamis (GK) methods.[15] This shows that for countries with more highly correlated expenditure patterns, the choice of PPP method matters less than for countries with much lower correlations. To illustrate: if the correlation is 0.7 or higher, the average absolute difference between the two PPPs is only 4.5 percent; if it is lower than 0.7, the difference is almost 15 percent. More in general, the fact that the difference in PPPs according to two widely-used method can be as large as 50 percent illustrates that due care is needed when comparing living standards between rich and poor countries.

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[14] The correlation of expenditure shares is chosen as it is an intuitive measure that is related to the computation of PPPs. For a more rigorous discussion on similarity measures, see Diewert (2002).

[15] See e.g. Diewert (2013) or Balk (2008) for more details on these methods. The GK method has traditionally been used in PWT, while the GEKS method has gained ground in the statistical community. PWT8.0 uses a combination of these methods, see below for details.

In PWT8.0, we provide the correlation between expenditure shares in each country and the US for all benchmark observations. In addition, we provide a separate file with all the bilateral correlations, as those will be more useful when comparing, say, China and India, rather than India and the US. While the correlations are not a structural measure of the reliability of PPP estimates, they can be used as a warning signal that whenever the correlation is low, the real GDP (per capita) level should not be interpreted with too much precision.[16] Furthermore, we provide the software so that alternative PWT datasets can be constructed using different PPP methods, so that for any set of empirical results the sensitivity to this choice can be assessed.

The discussion so far has focused on PPP data from the global ICP comparisons. In addition to these, Eurostat and the OECD also collect and estimate PPP data, see Eurostat/OECD (2012). These comparisons are done more frequently than the ICP comparisons, annually since 1995 for countries covered by Eurostat (current and potential future EU members) and once every three years since 1996 for (other) OECD countries. Assuming that a benchmark PPP observation leads to a more reliable estimate of real GDP than a non-benchmark observation

[16] One alternative approach would be to estimate PPPs in country-product-dummy (CPD) regression as in Rao (2005) and use the standard errors of the coefficients as a reliability measure. However, such a measure ignores the variation in expenditure shares and only accounts for the variation in relative prices across products. That variation is unrelated to GDP per capita or the correlation of expenditure shares measure.

–on which more below– it is important to incorporate such additional benchmark data, so that is what we do in PWT8.0.[17]

Non-benchmark countries

Combining PPP data from the six global ICP comparisons and the OECD/Eurostat comparisons only provides data for a modest number of countries and years, 436 observations from ICP and 438 from OECD/Eurostat. Furthermore, only 167 countries have at some point participated in an ICP comparison. Compare this to the 209 countries or areas for which the UN National Accounts (NA) compiles GDP data and there is a clear shortfall. This shortfall is even larger when comparing the number of country-year observations: from UN NA and historical NA data, we have a dataset of 10063 observations spanning the period from 1950 to 2011. This means that PPP benchmark data are directly available for only 8.6 percent of all country-year observations. Furthermore, many of these benchmark observations are for a limited number of countries. Table 3 shows that 49 countries only participated in a single benchmark comparisons, while only 37 (European and OECD) countries participated in more than 6 benchmarks. How then to deal with the 42 countries that have never participated in an ICP comparison and how to deal with the many years for which there are no benchmark PPP observations for the other 167 countries?

[17] The Asian Development Bank also constructed updated PPPs for 2009, the results of which may be included in a future update of PWT.

Table 3, Number of benchmarks per country

Benchmarks	Countries	Observations
1	49	49
2	30	60
3	20	60
4	15	60
5	7	35
6	9	54
>6	37	555

There are broadly three approaches to dealing with the 42 'non-benchmark' countries. The first approach, taken by the World Bank (2008), is to *impute* PPP-converted GDP per capita, by showing for other countries how the ratio of this variable to gross national income per capita converted using *nominal* exchange rates[18] varies systematically with the secondary school gross enrollment rate. This approach exploits the common finding that the exchange-rate-converted GDP per capita level underestimates the PPP-converted GDP per capita level for poorer countries, the so-called Penn effect (Samuelson, 1994; Inklaar and Timmer, 2013a). But while this relationship is found in every PPP benchmark comparison, it is not a structural relationship, as indicated by the changing coefficients over time in World Bank (2008, p. 164).[19] Furthermore, the observations for countries with estimated PPPs would subsequently be less useful in testing some cross-country relationships. This is most obviously the

[18] Or, to be precise, the World Bank's Atlas method, which smoothens out large exchange rate fluctuations.

[19] The most common explanation for the Penn effect is the Balassa-Samuelson hypothesis, according to which prices in the non-traded sector rise more quickly than in the traded sector due to lower productivity growth.

case for testing the Penn effect (which was assumed when imputing the PPPs for missing countries), but could be a broader problem as well.

The second approach, taken in earlier versions of PWT, is to use 'post-adjustment' indices. These are indices used by, for instance, the UN or the US State Department to determine the cost of living when expats are posted in a foreign (capital) city. This approach does not suffer from the problem of the first approach, namely that the estimated PPPs would already reflect some of the cross-country patterns one may wish to test. However, it is unclear to which degree these indices reflect the same information as PPPs, or even the same information as each other. The three sets of post-adjustment indices used in PWT6.1 show very extensive differences for numerous countries. For example, according to the UN index, prices in Myanmar are 15 percent lower than in the US, while the index from Employment Conditions Abroad indicates that prices are almost 50 percent higher. The same range of estimates can also be found for rich countries, such as the UK. So while there may be a statistical relationship between PPPs and post-adjustment indices, it is hard to determine how far such a relationship can be trusted.

Both of these approaches have two further (mostly practical) drawbacks. First of all, to deal with non-benchmark years we use relative prices for components of GDP, rather than GDP as a whole – see below for details. Even if these two approaches would be useful for estimating economy-wide price levels, estimation for the GDP components would be required to fully incorporate these non-benchmark countries into PWT. The second, and related, drawback is a loss of transparency. Because one or more additional estimations would be needed for some countries but not for others, we believe it would make PWT harder to interpret.

We have therefore opted for a third approach, namely to omit these countries. This is not ideal, as it means a less rich dataset. However, less than 3 percent of the world population live in non-benchmark countries. Of these, Myanmar, Algeria, Afghanistan and North Korea already account for two-thirds of the non-benchmark population. Omitting non-benchmark would thus not lead to a distorted view of global economic performance. Furthermore, with the even greater country coverage of ICP 2011, the category of non-benchmark countries is set to shrink even further. PWT8.0 will thus only include the 167 countries that participated in a global ICP price comparison at some point in the past.

Non-benchmark years

That still leaves the majority of country-year observations that are not covered by PPP benchmarks. Estimating PPPs for non-benchmark years will typically rely on data on national price changes. If a PPP is the price of goods in country A relative to those in country B, then the change in this PPP may be well approximated by the change in prices in country A relative to the change in prices in country B. This will hold by definition when comparing prices of individual products, but comparing the relative price of a *bundle* of goods is more complicated.

This problem arises, again, because spending patterns differ across countries and over time, but also because prices for different product change at different rates over time and across countries. Statisticians compiling the consumer price index (CPI) only have to take into account price changes and the national spending pattern. But when compiling a PPP, all sets of budget shares have to be taken into account, for instance by using the average share to weight the price difference for each product.[20] As shown by Deaton (2012), this is likely to lead to systematic differences between national inflation rates and the change in PPPs, with the PPPs of poorer countries increasing at a faster rate than indicated by the inflation differential between poorer and richer countries.[21] More in general, as long as spending patterns and product inflation rates differ across countries, there will be systematic differences between changes in economy-wide PPPs and differences in overall inflation.

We draw two lessons from this observation. First, that it is preferable to use information from benchmark PPPs whenever possible. Although PPP benchmarks are by no means perfect observations of relative prices, there is less indication that they are systematically biased than PPPs that are extrapolated from another benchmark using relative inflation rates.[22] Put differently: PPPs benchmarks were the best estimates of comparative price levels at the time, so it seems sensible to use the original source material. An alternative estimate would only be preferable if it is of demonstrably higher quality than the original. In benchmark years, PPPs can be used directly, while for years in between benchmarks, the trend can be interpolated. This approach is a departure from earlier versions of PWT, which constructed a set of PPPs for a *single* benchmark

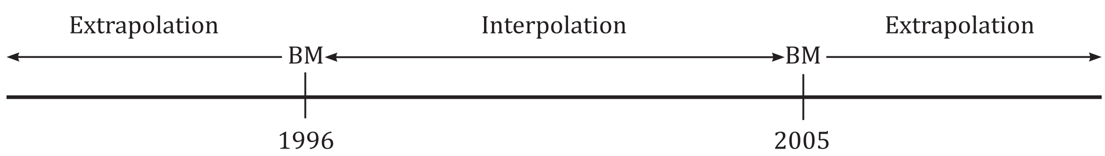
[20] In a two-country case, this gives a Törnqvist PPP.

[21] See also McCarthy (2013) for an extensive discussion of this topic.

[22] See also Inklaar and Timmer (2013b).

year and extrapolated these using relative inflation rates to the full set of years.[23] As we show in Feenstra et al. (2013), this new approach using all possible PPP benchmark information overturns the finding of Bergin, Glick and Taylor (2006) that the Penn effect disappeared when going back further in time. Feenstra et al. (2013) shows that this finding is an artifact of the extrapolation methodology used in earlier versions of PWT, and without that extrapolation, the Penn effect is preserved.

Figure 3, Schematic illustration of a hypothetical PPP computation



Note: BM stands for 'benchmark'. This hypothetical country participated only in the 1996 and 2005 benchmarks.

Figure 3 summarizes the approach to PPP computation that we use in PWT8.0. Say that a hypothetical country participated in the 1996 and 2005 ICP benchmarks, so those benchmark data are used. In between these two benchmarks, PPPs are interpolated using the national accounts price movements for each country relative to the US, thereby ensuring that for those intervening years the estimated PPPs are consistent with the benchmarks on either side.

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[23] Again for sensitivity analysis, the programs and data we provide would allow one to construct a PWT dataset based on only the 2005 ICP benchmark, which is methodologically comparable to PWT7.0 and PWT7.1, or relying on any of the other benchmarks.

Before 1996 and after 2005, there are no benchmarks for this particular country, so PPPs are extrapolated using relative inflation rates.

The second lesson is that any PPP extrapolation should be done at a detailed level, so not for GDP as a whole, but for different components of GDP. A guiding principle should be that if expenditure shares and relative price trends differ considerably across countries and over time, the relative change of an aggregate price index will not adequately capture the change in PPPs. This is in accordance with earlier PWT practice, whereby PPPs for household consumption, investment and government consumption are separately extrapolated using price trends for each of these components from the National Accounts. In each year, the PPPs for the three components are then weighted using expenditure shares for all countries to arrive at a GDP PPP.

The results of Feenstra et al. (2013) on the Penn effect indicate, though, that even this extrapolation below the GDP level can lead to qualitatively different patterns in the data than benchmark or interpolated observations. This suggests that an even more detailed breakdown of GDP would be preferable, but this is not readily feasible given available National Accounts data. We therefore indicate for each observation whether it is based on a PPP benchmark, interpolated between PPP benchmarks or extrapolated using relative inflation. This way, the robustness of any findings to, for instance, including real GDP observations based on extrapolated PPPs, can be established. In addition, we compared the extrapolated PPPs to benchmark and interpolated PPPs and to predicted PPPs based on Penn effect regressions. This led us a) to replace some market exchange rates by estimated rates whenever price levels spiked due to misaligned exchange rates and b) to label some observations as outliers whenever price levels would be systematically outside a range we consider plausible based on observed benchmark and interpolated price levels and predicted price levels from Penn effect regressions. These choices are motived and discussed in detail in the documentation on the PWT website.

Implications

The choice to use the historical PPP survey data has implications for the use of PWT in research. Until now, there has always been a clear connection between growth of GDP at constant national prices and the change in real GDP over time. Starting from a single benchmark year, PPPs in earlier years were estimated using national price trends. Since those price trends are the same as those underlying growth of GDP at constant national prices, the only differences in growth rates were due to differences in the weights of consumption, investment and government expenditures, used to aggregate these components with the trade balance to total GDP.[24] However, the use of multiple PPP benchmarks in constructing real GDP in PWT8.0 means that changes in real GDP will now show *less resemblance* to growth of GDP at constant national prices. This is confirmed in Table 1, which shows the correlation between annual GDP growth directly from the National Accounts and the change in real GDP from PWT7.1 and from PWT8.0. Column (1) shows that both real GDP measures are strongly correlated with GDP growth from the National Accounts, but that this correlation is clearly

[24] For growth of GDP at constant national prices, the weights would be expenditure valued at national prices, while for real GDP the weights would be expenditure valued at reference prices (i.e. in PPP-converted values).

higher in PWT7.1 than in PWT8.0. Moreover, when splitting the sample between observations based on benchmark or interpolated PPPs and extrapolated PPPs, the difference becomes starker. For PWT7.1, there is little change in the correlation, which is as expected since real GDP is computed by extrapolating backwards or forwards from the benchmark year in the same way for all observations. For PWT8.0, there is a difference between PPPs (and thus real GDP) based on benchmark and interpolated observations and PPPs based on extrapolated observations. This is reflected in the sharp drop in correlation, to 0.58 in column (2). Comparing five-year or ten-year growth rates rather than annual growth rates leads to higher correlations, but clear differences remain between GDP growth and the change in real GDP from PWT8.0.

Table 4, The correlation between annual GDP growth and the annual change in real GDP, PWT7.1 versus PWT8.0

	All observations	Benchmark & interpolated	Extrapolated
PWT7.1	0.89	0.85	0.89
PWT8.0	0.70	0.52	0.76
Number of observations	7776	2664	5112

Note: The change in real GDP from PWT7.1 is measured as the growth of variable rgdpch plus population growth. GDP growth is computed from variable rgdpna in PWT8.0 and change in real GDP from PWT8.0 is computed from variable rgdpe. Benchmark & interpolated refers to those observations that in PWT8.0 are based on benchmark PPPs or PPP interpolated between benchmarks (variable i_cig).

The new method of estimating PPPs has arguably led to a measure of real GDP that is more reliable than before since older benchmark information is no longer discarded. This has substantially changed PWT data, as benchmark and interpolated observations now cover one-third of all observations in PWT. As a consequence, though, real GDP has become less suitable to measure changes over time in a single country. Real GDP has always been less than ideal for this purpose, as it is estimated using information on spending patterns across all countries. Since a country's spending pattern is the result of its own preferences and relative prices, other countries' spending patterns are irrelevant when measuring the economic performance of a single economy over time. So if an analysis aims to explain cross-country differences in GDP *growth rates*, we would strongly recommend using data on the growth of GDP at constant national prices, directly based on a country's National Accounts. To facilitate such research, we have included a measure of real GDP in PWT8.0 whose growth rate equals the National Accounts measure of real GDP growth (i.e. at constant national prices), and whose level in the benchmark year 2005 equals real GDP on the output side, as discussed next.

International trade PPPs

As a second major change, PWT8.0 introduces a new measure of real GDP to the dataset. The traditional measure is based only on prices of consumption and investment, i.e. domestic final expenditure (also known as domestic absorption), while the new measure also accounts for differences in the prices of exports and imports. Put differently, the new measure of real GDP accounts for differences in the terms of trade. A real GDP measure that ignores terms of trade differences is certainly relevant, as it can be seen as a measure of real income: for consumers it does not matter if income is high because export prices are relatively favorable or because productivity is high. But for comparing the productive capacity of economies, we do want to make such a distinction and account for favorable (or unfavorable) terms of trade in comparing GDP across countries.[25] PWT8.0 therefore includes two distinct real GDP measures, one from the expenditure side, GDP^e, and one from the output side, GDP^o. This is in addition to the real GDP measure, $RGDP^{NA}$, discussed just above, which equals GDP^o in 2005 but whose growth rate is taken from the National Accounts of each country.

Computing GDP^o requires developing new information on the relative price of exports and of imports as these prices are not part of the World Bank's ICP program. Instead, the World Bank makes the simplifying assumption that the law of one price holds for traded products so that the exchange rate can be used to express the trade balance in real terms. Yet there is much evidence that is at odds with this assumption. The review by Burstein and Gopinath (2013) concludes that even in the long-run, exchange rate movements do not fully 'pass through' to export and import prices and that imperfect competition and pricing-to-market seem to play an important role in explaining these patterns.

Yet quantifying these price differences has been a challenging undertaking. The only readily available data from which price differences of exports and imports can be inferred is data on the value and quantity of traded products. Dividing the value by the quantity gives a unit value, but this is only an average price of a potentially very heterogeneous bundle of products.[26] Recent research by Hallak

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[25] This argument is made more formally in Feenstra et al. (2009).

[26] For example, one product in the 6-digit Harmonized System list is 'Color television receivers' and that is the most detailed level available in a wide cross-country setting. On Amazon.com, television prices vary between $100 and $50 000.

and Schott (2011) and Feenstra and Romalis (2012) has estimated how much of the observed differences in unit values is due to differences in product quality and how much is due to actual price differences. After netting out the portion of unit-value differences across countries that are due to quality, the remainder is the "quality-adjusted price" component. These remainders are aggregated up to obtain the export and import PPP for each country and year. Because the law of one price is closer to holding for traded goods than for non-traded goods, these export and import PPPs are closer to the nominal exchange rates of countries.

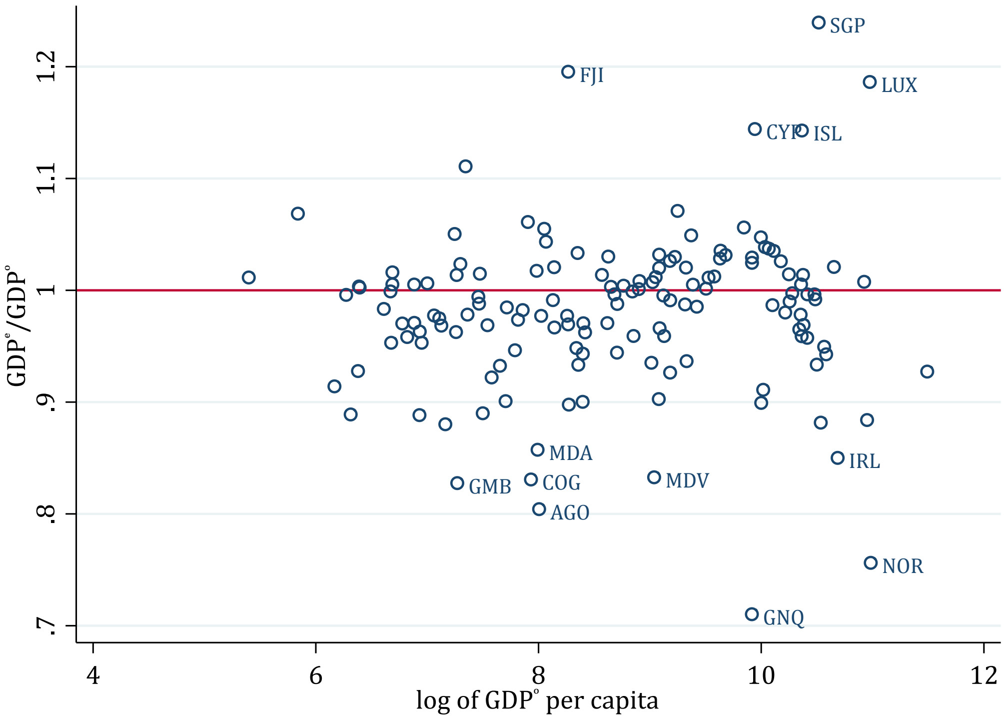
The resulting trade PPPs can then be used alongside the domestic PPPs from the ICP. By dividing the trade PPPs by the nominal exchange rate, we obtain the "price levels" of exports and imports for each country. A country will have favorable terms of trade if it receives a relatively high price for its exports (compared with prices received by other countries exporting the same product) and pays a relatively low price for its imports (again, compared with prices paid by other countries importing the same product). This will tend to make real GDPe higher than real GDPo. The impact on real GDP will not only depend on the terms of trade, however, but also on the domestic prices obtained by dividing the domestic PPPs by the nominal exchange rate.[27] If domestic prices are lower than trade prices, as would be typical for a developing countries, and the country has a real balance of trade surplus, then real GDPe will tend to be higher than real GDPo. So in addition to the terms of trade, the comparison of trade prices to domestic prices also determine the gap between real GDP^e and real GDP^o, which has a straightforward interpretation: countries with a real GDP^e level that

[27] See footnote 2.

exceeds their real GDP^o level can consume in excess of their economy's productive capacity and vice versa.

We caution that the gap between real GDP^e and real GDP^o is not a measure of the gains from trade for countries, or at least, not the gains from trade as compared to autarky (i.e. no trade). We have not built anything into the calculations in PWT8.0 that would allow the gains as compared to autarky to be estimated. Rather, this gap reflect the ability of countries to trade as prices that *better than the average world prices* (i.e. higher for exports or lower for imports). By construction, then, the sum over countries of real GDP^e and real GDP^o should be close to zero, as occurs in the dataset for all years.

Figure 4, Real GDP^e and GDP^o per capita in 2005



Note: only the 145 countries included from the 2005 ICP benchmark are included.

For individual countries, the gap between GDP^e and GDP^o can be considerable. The median absolute difference is 3.2 percent and in 5 percent of the countries, the difference is even larger than 20 percent. Figure 4 shows the difference between GDP^e and GDP^o per capita in 2005 set against log of GDP^o per capita in 2005. The larger differences are typically observed in smaller, open economies. So the choice between GDP^e and GDP^o clearly matters.

For many analyses, it is now possible to use the conceptually appropriate real GDP measure. For instance, for analyzing productivity differences across countries (e.g. Hall and Jones, 1999; Caselli, 2005), real GDP^o would be the appropriate measure, while for comparing cross-country wellbeing (e.g. Jones and Klenow 2011), real GDP^e would be better suited. In comparisons of cross-country wellbeing, the effect from favorable or unfavorable terms of trade can and should now also be taken into account.

Moreover, to emphasize the breadth of new information, we provide not only provides PPPs for total exports and imports, but also distinguished by "broad economic categories" (BEC). This breakdown by BEC means that a distinction is made of the prices paid for, for example, imports of capital goods versus imports of industrial materials. This could, for instance, shed new light on the role of imported technology, as highlighted in Caselli and Wilson (2004), by accounting for price differences of imported capital goods.

Implications

The newly developed international trade prices increase the number of GDP concepts that are included in PWT8.0. In addition, we distinguish between the traditional real GDP measures and current-price measures. Table 5 summarizes the resulting five measures. The first, $RGDP^{NA}$ is primarily suited for measuring economic growth of a particular country over time. Its level in 2005 is the same as $RGDP^{o}$ and $CGDP^{o}$, but its growth rate is equal to that in the National Accounts. The next two, $CGDP^{e}$ and $CGDP^{o}$, give the best estimate of the level of GDP in a country relative to another at a single point in time, where $CGDP^{e}$ is a measure of comparative living standards and $CGDP^{o}$ is a measure of comparative productive capacity. To make the magnitudes comparable over time, we account for US inflation, but changes in CGDP levels should not be seen as measure of economic growth. Finally, there are two real GDP measures, $RGDP^{e}$ and $RGDP^{o}$. These aim to comparable across countries and over time, see Feenstra et al. (2013) for details. These measures are primarily useful to compare trends in comparative living standards ($RGDP^{e}$) or in productive capacity ($RGDP^{o}$). This can give insight on such questions as how rich is China compared with the US in 1950. In 2005, $RGDP^{o}$ equals $CGDP^{o}$ and $RGDP^{e}$ equals $CGDP^{e}$.

Table 5, GDP concepts in PWT8.0 and their use

Series	*Best use*	*Example*
$RGDP^{NA}$	Studies only requiring (output-based) growth rates over time and comparing *growth rates* across countries	Dependent variable in (cross-country) growth regressions
$CGDP^{e}$	Expenditure-based, to compare relative living standards across countries at a single point in time	Initial level in growth regressions requiring relative living standards
$CGDP^{o}$	Output-based, to compare relative productive capacity across countries at a single point in time	Initial level in growth regressions requiring productive capacity or productivity
$RGDP^{e}$	Expenditure-based, to compare relative living standards across	Living standards of China today compared to the US at some point

	countries and over time	in the past
RGDP^o	Output-based, to compare relative productive capacity across countries and over time	Productive capacity of China today compared to the US at some point in the past

Expenditure shares and price levels

While data on real GDP per capita is most often used in research, the data on price levels and shares by GDP expenditure category are frequently used as well. Think of studies looking at the effect on growth of openness (e.g. Alcalá and Ciccone, 2004), the comparison of investment rates and prices (Hsieh and Klenow, 2007) or the analysis of a real consumption measure rather than a real GDP measure (Jones and Klenow, 2011).

For such purposes, PWT8.0 includes expenditure share variables and relative prices of those expenditure categories. These relative prices are the constituent parts of the overall GDP price level, but the variation across countries is quite different. This is illustrated in Table 6, which shows the relationship between relative price levels for GDP and each of the expenditure categories and the level of CGDP^o per capita. Each cell in the table is based on a separate regression, where the price level of that expenditure category is explained by the (log of) CGDP^o per capita. The bottom row of the table shows that if CGDP^o per capita, the relative price level of GDP^o increases significantly, which is known as the Penn effect (Samuelson, 1994). The table shows that relative prices of consumption increase most rapidly with income levels, relative prices of exports and imports increase only very modestly and investment prices show no systematic relationship with income. These findings are in line with those of Hsieh and

Klenow (2007), who find that investment goods are relatively expensive in poorer countries because of the low price of consumption in those countries.

Table 6, Price levels and CGDP^o per capita levels

	pl(x)
Household consumption	0.128***
Government consumption	0.217***
Investment	0.0207
Exports	0.0166***
Imports	0.0230***
GDP	0.136***

Notes: each cell in the table is the coefficient on the log of CGDP^o per capita from a regression explaining the relative price level of an expenditure category, denoted pl(x). *** denotes a coefficient significantly different from zero at the 1% level based on robust standard errors, clustered by country. Each regression includes only the 2706 benchmark and interpolated observations in PWT8.0 and includes year dummies.

This provides a useful link to the real expenditure shares in PWT8.0, which are shares in real CGDP^o. The starting point of Hsieh and Klenow (2007) is the observation that the real investment share is lower in poor countries than in rich countries. This could be because poor countries devote less of their nominal GDP (i.e. at national prices) to investment than rich countries, or it could be because the price of investment is relatively high in poor countries. To see this more precisely, we express the real share of expenditure category *x* as:

(1) $$csh(x) = \frac{sh(x)}{pl(x)/pl(gdp)},$$

where *csh* is the real share, *sh* is the nominal share (i.e. at national prices), *pl(x)* is the relative price level of expenditure category *x* and *pl(gdp)* is the relative price level of GDP. Hsieh and Klenow (2007) show that real investment shares in poor countries are low purely because the investment prices are high, not because nominal investment shares are low.

The findings in Table 6 also relate to Alcalá and Ciccone (2004), who argue that openness, i.e. exports plus imports over GDP, should be measured in real terms rather than in nominal terms (i.e. at national prices). They find that poorer countries are less open in real terms than in nominal terms and this is also the case in PWT8.0.[28] This can be explained using the results in Table 6, namely that the relative price of $CGDP^o$ increases at a much faster rate with income than the relative price of exports or imports. So in poor countries, prices of exports and imports are relatively high, reducing the real share relative to the nominal share.

Table 6 shows that prices of government consumption increase at the fastest rate with income. This can be explained by the Balassa-Samuelson hypothesis, whereby the non-traded sector shows little or no productivity improvement as countries grow richer and therefore faster increases in prices. Government consumption consists of spending on government administration, education and health, activities which are typically among the least exposed to international trade. However, these are also the activities where prices are hardest to measure. As discussed above, the relative prices for these categories of expenditures are approximated by productivity-adjusted relative wages and it is unknown to what extent these are an accurate reflection of 'true' prices.

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[28] Note that Alcalá and Ciccone (2004) define their measure or 'real openness' as nominal exports plus imports over real GDP. With PWT8.0, real openness can now be measured as real exports plus imports over real GDP due to the introduction of export and import PPPs.

Finally, it is useful to point out that PWT8.0 also includes a residual real expenditure share, so the shares of consumption, investment, exports and imports do not add up to one. As explained in the *National Accounts in PWT8.0* document, this residual category can include net exports of services since the export and import PPPs only refer to merchandise trade. This explains why, for example, Panama has a large positive residual expenditure: the Panama Canal revenues count as exports of transport services. This category also includes any statistical discrepancy. For example, GDP in India is measured from the income side and the statistical discrepancy is the difference between GDP and the sum of expenditures.

Capital and productivity

The construction of the data on capital and productivity in PWT8.0 are discussed in detail in Inklaar and Timmer (2013c), but it is helpful to highlight some of the main features and limitations. In the past, PWT data has often been used to construct measures of total factor productivity (TFP), such as by Hall and Jones (1999) and Caselli (2005). These would typically use GDP per worker as the measure of labor productivity and correct for differences in tangible capital per worker and human capital per worker, as in Table 1. PWT8.0 improves upon those earlier approaches in two important ways:

1. Rather than assuming a single depreciation rate that is constant across countries and over time, we allow this to be different. By distinguishing investment in up to six types of assets, including at least machinery, transport equipment and buildings, our depreciation rate will vary across countries and over time.

2. Rather than assuming a single share of labor compensation in GDP to weight the importance of human versus physical capital, we have constructed new measures from basic National Accounts data.

These improvements, and in particular the use of a country-specific and year-specific labor share, help to reduce the role of TFP differences in explaining cross-country income differences, as we show in Feenstra et al. (2013). Similar to the distinction between different GDP measures in Table 5, PWT8.0 includes a TFP measure that allows for comparisons across countries at a point in time (variable CTFP) and a measure that allows comparisons within countries across the years ($RTFP^{NA}$). Despite the improvements over earlier work, there are still shortcomings in the TFP measures in PWT8.0 due to a lack of data:

1. *Capital services.* Jorgenson and Griliches (1967) argued that not every dollar's worth of capital generates the same return. Shorter-lived assets, such as computers would be expected to earn a greater productive return than long-lived assets, such as buildings. Practical difficulties in determining a required rate of return across countries and over time have stopped us from implementing such an approach. This is likely to underestimate capital input mostly in the richer economies where investment in information and communication technologies is highest.[29]
2. *Land, inventories, subsoil assets and intangibles.* Our current set of assets only covers the so-called fixed reproducible assets recognized in the System of

[29] The Total Economy Database of The Conference Board does provide TFP growth measures based on growth in capital services rather than growth in the capital stock as in PWT.

National Accounts. Differences in the availability of land, inventories, subsoil assets (e.g. World Bank, 2006) or intangible assets (e.g. Corrado, Hulten and Sichel, 2009) are not taken into account. This will understate capital input in oil-producing and other resource-intensive countries; in countries with large arable land areas; and in richer economies that increasingly rely on investment in intangible assets.

3. *Hours worked.* Data on the number of persons engaged could be constructed for 164 out of 167 countries in PWT, but data on average annual hours worked is only available for 52 countries (from the Total Economy Database of The Conference Board). Hours worked vary between 1380 and 2800 hours per year, with richer countries working relatively fewer hours. Labor input of the poorer countries is thus underestimated by using the number of workers.
4. *Human capital.* To account for differences in human capital, we use data on the average years of schooling from Barro and Lee (2010) and use rates of return for completing different sets of years of education (Psacharopoulos, 1994). This ignores any variation in these returns over time or across countries. Likewise, it ignores differences in the cognitive skills that students obtain, which may be more important than the simply the number of years in school (Hanushek and Woessman, 2012). Ignoring cognitive skills likely underestimates labor input in richer countries as richer countries have higher cognitive skills given the average years of schooling. However, data do not allow a cognitive skills measure to be implemented for a broad enough sample that also includes variation over time.

Despite these shortcomings, we believe the current data on relative TFP levels and on TFP growth in PWT8.0 represent a useful improvement over earlier work and the list of shortcomings is an open invitation to realize further improvements.

National Accounts

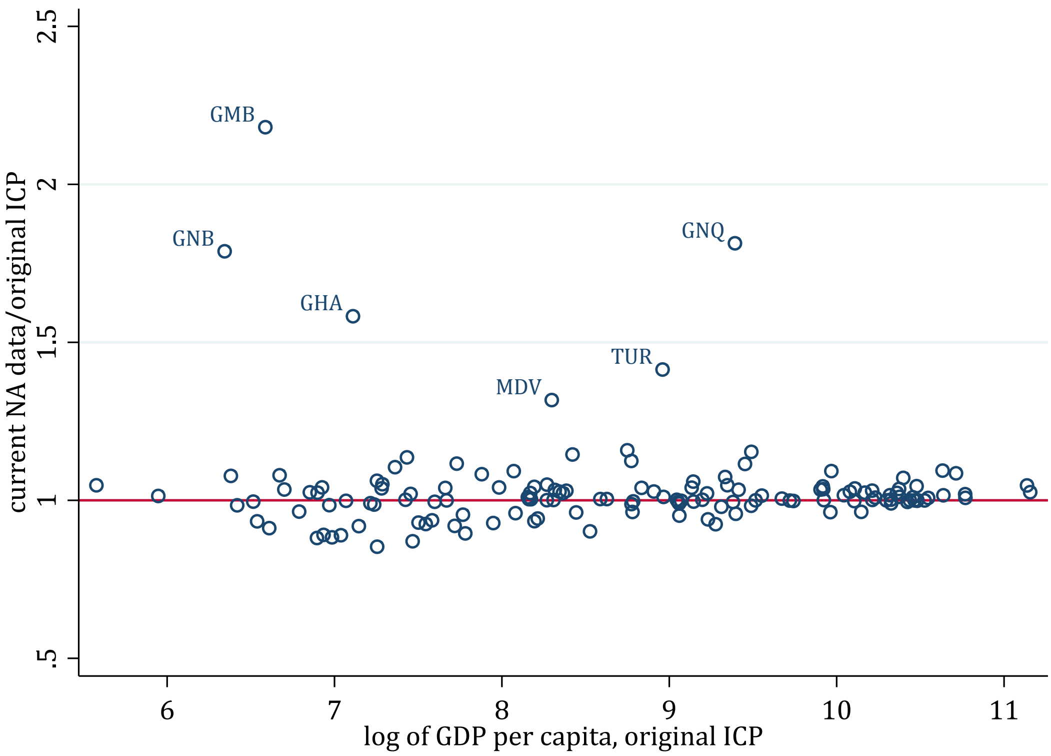
Besides the PPP benchmark data, the other main data input of PWT is National Accounts (NA) data. These data are used, first, to estimate PPPs where benchmark or interpolated data is not available using national price indices.[30] Second, PWT relies on NA for data on GDP at national prices, which is converted to real GDP using the GDP^e and GDP^o PPPs. Comparative GDP figures are thus subject to change if the underlying NA data are revised. In advanced economies, such revisions are typically quantitatively small. For example, the 2009 Comprehensive Revision by the US Bureau of Economic Analysis revised US GDP in 2008 upwards by 1.2 percent (Seskin and Smith, 2009), neither a negligible nor a substantial change. Changes of similar magnitude are likely to be seen in more countries, for instance as the accounting rules of the System of National Accounts (SNA) 1993 are replaced by those of SNA 2008.

In contrast, Ghana revised its GDP upwards by 60 percent in 2010 (Jerven, 2013). Although such a large revision is not typical, it is also not as unusual as may be hoped. Figure 5 compares GDP per capita in 2005 as published originally in

[30] For interpolation between benchmarks, we also use national accounts price indexes to determine the precise year-to-year pattern instead of doing a linear interpolation. This is a second-order impact of these data.

World Bank (2008) with GDP per capita using the most recent NA data. It shows that Gambia's GDP per capita has more than doubled after revisions in recent years and even Turkey's GDP per capita has increased by over 40 percent. In contrast, the median absolute revision is a more modest 3.4 percent. As in Figure 4, the broad cross-country pattern is not materially affected. The correlation between the two sets of GDP per capita numbers in Figure 5 is 0.996, though that is scant comfort if your main interest is the level of living standards in Ghana.

Figure 5, GDP per capita in 2005: NA revisions since 2008



Note: 'original ICP' denotes the GDP per capita level as reported in World Bank (2008), 'current NA data' computes the GDP per capita level based on the World Bank (2008) PPPs and current National Accounts data, the December 2012 release of the UN NA Main Aggregates Database.

These revisions do not just affect the level of real GDP, but also the growth rates. Johnson et al. (2013) document how different versions of PWT can show notably different growth patterns. Especially the results of studies that rely on annual GDP growth rates were found to be sensitive to the PWT version that was used. In part this will be due to the earlier PPP estimation methodology that relied on PPPs for a given benchmark year and replaced those after a new benchmark.[31] But while this source of variation across PWT version will be much reduced by our newly adopted methodology, NA revisions are another source of variation. Table 7 illustrates this for two UN NA 'vintages', the first with data up to 2009 (released December 2010) and the second with data up to 2011 (released December 2012). The table compares two sets of growth rates, one for 2009 and one for 1995; 2009 is the latest year that can be compared, while 1995 is chosen as an earlier year for which revisions are (presumably) no longer as substantial. For both years, we compare the annual growth rate, the five-year average annual growth rate and the ten-year average annual growth rate, following the findings by Johnson et al. (2013) that average growth over these longer time spans is more stable across PWT versions. The table shows the 5th and 95th percentile of the revision to growth rates across the two vintages as well as the correlation between the growth rates in the two vintages.

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[31] Earlier versions of PWT up to v6 constructed real GDP using a weighted average of the national accounts growth rates of the *components* of GDP, i.e. C, I and G. That approach was criticized by Johnson *et al* (2013) because the weights would change with the ICP benchmark in different versions of PWT. To address this criticism, PWT7 used the national accounts growth rate of *total* GDP instead of the components,, as we also do in PWT8.0 when constructing the growth rate of $RGDP^{NA}$.

Table 7, Revisions to UN NA GDP growth, 2009 vs. 2011 vintage

	2009			1995		
	Annual	5-year	10-year	Annual	5-year	10-year
Median growth	0.2	4.1	4.1	4.1	2.3	3.2
Revisions						
5th percentile	-1.6	-1.1	-0.6	-0.8	-0.2	-0.4
95th percentile	3.2	1.3	0.7	0.1	0.2	0.2
Correlation	0.93	0.96	0.98	0.97	0.99	0.99

Notes: Revisions compare GDP growth across the 2009 and 2011 UN NA vintage for each of the 167 countries in PWT8.0. The annual growth rate refers to growth from 2008 to 2009 in the left-hand panel and 1994-1995 in the right-hand panel. The five-year growth rate refers to 2004-2009 and 1990-1995; and the ten-year growth rate refers to 1999-2009 and 1985-1995.

The results in Table 7 confirm the Johnson et al. (2013) finding that long-run growth rates are less affected by NA revisions than annual growth rates as the 90-percent range of revisions shrinks considerable, from 4.8 to 1.3 percentage points for growth rates up to 2009 and from 0.9 to 0.6 percentages for growth rates up to 1995. This also confirms that more recent data are more likely to change due to NA revisions. This is unsurprising, as the most up-to-date GDP growth numbers tend to be based on incomplete source data. The cross-country correlations at the bottom of the table indicate that rapidly-growing countries in one vintage also tend to grow fast in the other vintage, but a correlation of 0.93 for annual growth in 2009 indicates notable variation.

To help assess the sensitivity of any research results to the NA vintage used, we provide the 2009 and 2010 NA data vintages.[32] In addition, we include the statistical capacity indicator of the World Bank in PWT8.0. This indicator is constructed since 1999 for developing economies and it is based on the quality

[32] Old vintages are not made available by the UN.

of the statistical methodology, frequency with which source data is collected and the timeliness with which data is provided. Not all of these aspects refer (directly) to NA data, but this indicator can be useful to assess the reliability of a country's data.[33]

China

China also deserves some attention in regards to its NA. As discussed above, the 2005 ICP results underestimated China's GDP level, which we adjust for in PWT8.0 as in PWT7.0 and 7.1. In addition, there have long been doubts about the accuracy of China's growth figures. In the academic literature, the debate has been between those arguing that the official statistics get it broadly right (Holz, 2006) and others arguing that official statistics systematically overstate growth (Maddison 2006; Maddison and Wu, 2008). We find the 'overstatement' argument convincing and use alternative NA data based on data from Wu (2011). Table 8 shows average annual GDP growth for each decade since 1952, comparing the official NA data to the adjusted GDP data we use in PWT8.0. It show that the degree to which growth is overstated varies considerably over time, but is present in every period. As a result, the GDP level in 1952 is more than twice as high according to the adjusted growth figures than according to the official growth figures. Since China participated in an ICP comparison for the first time only in 2005, there is no readily available independent information for a possible cross-check of this result. While we present data based on the adjusted

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[33] The work by Jerven (2013), Devarajan (2013) and Young (2012) are useful in this regard as well.

2005 PPP and adjusted growth rates in PWT8.0, we also provide the data to construct an alternative dataset using official PPPs and growth rates for China.

Table 8, Average annual GDP growth in China 1952-2010, adjusted versus official

	Official	Adjusted	Difference
1952-1960	6.2	5.4	0.8
1960-1970	3.3	2.8	0.5
1970-1980	6.2	4.6	1.6
1980-1990	9.3	6.2	3.0
1990-2000	10.4	7.1	3.3
2000-2010	10.5	9.2	1.3

Note: adjusted GDP growth is provided by Harry Wu, based on Wu (2011); official data is from the UN NA (December 2012 version). The adjusted growth series are used in PWT8.0.

Concluding remarks

In this guide, we have explained and motivated the choices we made in constructing PWT8.0 and discussed the implications of these choices for researchers using PWT. To summarize, we recommend the following:

1. Use GDP^e and GDP^o series only as a measure of the relative level across countries. For comparing GDP growth, use the series of GDP at constant national prices from the National Accounts data, $RGDP^{NA}$.
2. Use GDP^e when interested in comparative well-being; use GDP^o when interested in an economy's productive capacity.
3. Beware that observations in PWT that are directly based on PPP benchmark data or interpolations between PPP benchmarks are more reliable than observations based on extrapolations from benchmarks and can show differences in patterns such as the Penn effect.

4. Beware that there is a greater margin of uncertainty when comparing countries with very different spending patterns.
5. Beware that revisions to National Accounts data can have a substantial impact on the level of GDP and on GDP growth rates and that such revisions are typically the dominant reason for changing data between PWT versions.

Not all recommendations will be equally relevant to all types of users. For instance, recommendation 4 would mostly be relevant when comparing a single country's GDP^e or GDP^o per capita or PPP to other countries. Furthermore, we provide the basic data and programs so that alternative PWT datasets can be constructed, for instance based on a different index number method or on official rather than adjusted Chinese data.

This guide was explicitly aimed at a non-technical audience, the Feenstra et al. (2013) paper discusses the more technical aspects and the main new insights from PWT8.0, while Inklaar and Timmer (2013c) discuss the new capital and TFP data in more detail. This guide could also not discuss some of the more detailed aspects of PWT. To cover those aspects, there is additional documentation available on:

- The technical details on how the different data sources are combined and how PWT is constructed in Stata, including the underlying programs [Technical guide to PWT8.0],
- The differences in methodology, results and variable naming between PWT7.1 and PWT8.0 [Comparing PWT8.0 with 7.1],
- How data on capital and TFP have been constructed [Capital, labor and TFP in PWT8.0],

- The sources of NA data, variable definitions and accounting rules [National Accounts in PWT8.0],
- The choice for a particular exchange rate series [Exchange rates in PWT8.0],
- The identification of outliers [Outliers in PWT8.0].

While the appeal of a dataset with information on economic performance for most countries in the world over the past 60+ years is obvious, it is of little use if used without due regard of the choices and limitations that underlie it. We hope that this guide has given a better understanding of the PWT8.0 dataset, so that it is used to its greatest potential.

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