What is new in PWT 9.0?

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The release of the Penn World Table version 9.0 represents the first substantial change to the 'Next Generation of the Penn World Table' of PWT versions 8.0 and 8.1, see Feenstra, Inklaar and Timmer (2015). If you are a first-time user of PWT, Section I of Feenstra et al. (2015) is still the recommended starting point, as the main structure of the database and definition of its variables are unchanged in PWT 9.0. That said, PWT 9.0 contains important new and revised data. This document provides an overview of the changes, with a more detailed discussion of particular topics in specific documents.

The changes fall in three broad categories, namely, i) the incorporation of new purchasing power parities (PPPs) data from the 2011 International Comparison Program (ICP) and other sources; ii) the incorporation of revised and extended National Accounts data, covering the period up to 2014; and iii) revised estimates of factor input data and labor cost shares.

I. ICP 2011 and other new PPP data

The latest round of PPPs included in PWT 8 was for the year 2005. With PWT 9.0, we add the PPPs from ICP 2011 to the set of PPP benchmarks and shift our reference year from 2005 to 2011. World Bank (2014) marked the release of the results of ICP 2011, with data on PPPs for consumption and investment for nearly 180 countries. Like ICP 2005, coverage was essentially global, though with 32 additional countries notably more extensive. Fifteen countries did not participate in any ICP round before 2011, so these were not covered in PWT8, but are included in PWT9. This increases the number of countries from 167 to 182 and the share of world population covered by PWT from 96.9 to 98.5 percent. [1]

[1] The list of new countries is: Algeria, Anguilla, Aruba, British Virgin Islands, Cayman Islands, Curaçao, Haiti, Montserrat, Myanmar, Nicaragua, Seychelles, Sint Maarten, State of Palestine, Turks and Caicos Islands and the United Arab Emirates. Some of these had previously been covered in PWT7 and earlier versions based on alternative price information that was not comparable in quality to ICP.

In addition, important methodological issues that were identified after the release of ICP 2005 (see World Bank, 2013), were solved for ICP 2011. These issues were primarily related to the price comparison across major regions of the world. In ICP, prices are first compared across countries within a region, such as Africa or Asia-Pacific. In that comparison, products that are particularly important for a region can be taken into account. Comparing prices across regions requires a common global product list and, as turned out, the ICP 2005 global product list included many products that were typical in the consumption baskets of high-income countries, but high-priced luxury items in low-income countries. Due to this bias, the ICP 2005 prices of regions with predominantly low-income countries were overestimated relative to high-income regions and the real GDP level of countries such as China were severely underestimated – as had also been separately established by Feenstra, Ma, Neary and Rao (2013).

Deaton and Aten (2016) and Inklaar and Rao (2016) demonstrate that this bias was present and important in ICP 2005. They also concluded that this source of bias was not present in ICP 2011. More generally, the ICP 2011 have been broadly accepted by the research community as the most sophisticated and reliable so far, without major methodological or practical flaws. Inklaar and Rao (2016) therefore constructed a set of relative prices for the year 2005, based on ICP 2005 data, but applying ICP 2011 methods and correcting for the bias in ICP 2005. In PWT 8.1, we already relied on these bias-adjusted relative prices. This means that the incorporation of ICP 2011 results does not lead to major shifts in income levels of lower-income relative to higher-income countries, though as shown below, individual country differences can be large.

The shift in reference year from 2005 to 2011 means that all variables that were denoted in 2005 US dollars in PWT 8.0 and 8.1 are now denoted in 2011 US dollars. For the period 1950 to 2005, this shift in reference year has no effect on real GDP, other than to increase all values by 12 percent – the increase in the US GDP deflator between 2005 and 2011.[2] For the years from 2006 onwards, however, PPPs are revised as consumption and investment PPPs are now based on interpolation between the 2005 and 2011 ICP benchmark results, while they were extrapolated from ICP 2005 in PWT8.

[2] Revisions to National Accounts will also lead to changes, see Section II.

There are three sets of countries for which PPPs and real GDP change in a different fashion:

1. Nineteen countries from Central America and the Caribbean did not participate in ICP 2005, but did participate in ICP 2011 and at least one earlier ICP round. In PWT8, the PPPs and real GDP numbers for these countries were extrapolated from that earlier ICP round (1996 in many cases) to 2011, the latest year in PWT 8. In PWT9 the PPPs for that period are interpolated using data from their earlier ICP benchmark and the new 2011 round.[3]
2. For countries in the European Union (EU) and/or OECD, PWT relies not only on the ICP benchmark data, but also includes their more frequent PPP benchmark comparisons; i.e. annual data for EU countries and triennial data for non-EU OECD countries. In PWT 8, EU PPP data until 2010 was used; for non-EU OECD countries the most recent PPP data were for 2008. In PWT 9.0, for EU countries we incorporate PPP data up to 2014., For non-EU OECD countries the 2011 ICP PPPs are the most recent available.
3. Turkmenistan and Uzbekistan have only participated in ICP 1996, so their PPP data continues to be extrapolated.

In addition to the new consumption and investment PPPs from ICP 2011, we also extend the PPP information for exports and imports. As in PWT 8, these trade PPPs are based on the framework introduced by Feenstra and Romalis (2014), but while trade PPPs were previously available for the period from 1984 to 2007, the trade PPP data in PWT 9.0 extend through 2014.

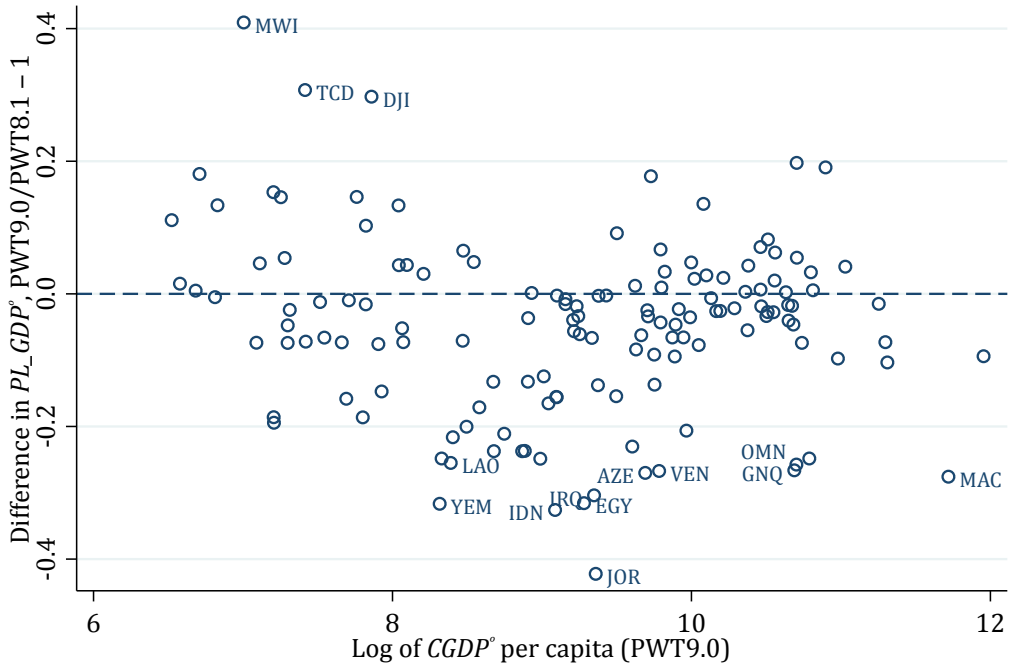
To illustrate the impact of these changes, Figure 1 plots the ratio of the GDP^o price level in PWT 9.0 relative to the price level in PWT 8.1 for the year 2011 for the 142 countries that participated in ICP 2005 and in ICP 2011. In PWT 8.1, the price levels for these countries were based on extrapolations from 2005 based on relative inflation, while in PWT 9.0, we use the ICP 2011 PPPs in combination with newly estimated trade PPPs. As the figure shows, the differences can be substantial, with price levels (relative to the US)

[3] The list of countries not in ICP 2005 but in ICP 2011 and in an earlier ICP round is: Antigua and Barbuda, Bahamas, Barbados, Belize, Bermuda, Costa Rica, Dominica, Dominican Republic, El Salvador, Grenada, Guatemala, Honduras, Jamaica, Panama, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname and Trinidad and Tobago. Zimbabwe did participate in ICP 2005, but the results were not incorporated in PWT 8 due to the distorting impact of hyperinflation on prices and exchange rates.

lower by, on average, 6 percent and 16 countries for which the difference is larger than 25 percent (up or down).

As discussed above, there are no (remaining) systematic differences in the underlying measurement methodology of ICP 2005 and ICP 2011 and the price levels are also not systematically different – i.e. the differences are not related to income level. Yet individual country differences are large. This has long been a feature of consecutive ICP benchmark rounds and, as the current results demonstrate, even better-funded and more closely harmonized ICP rounds suffer from this.

Figure 1, Difference in the 2011 GDP^o price level, PWT 9.0 vs. 8.1, for countries in ICP 2005 and ICP 2011

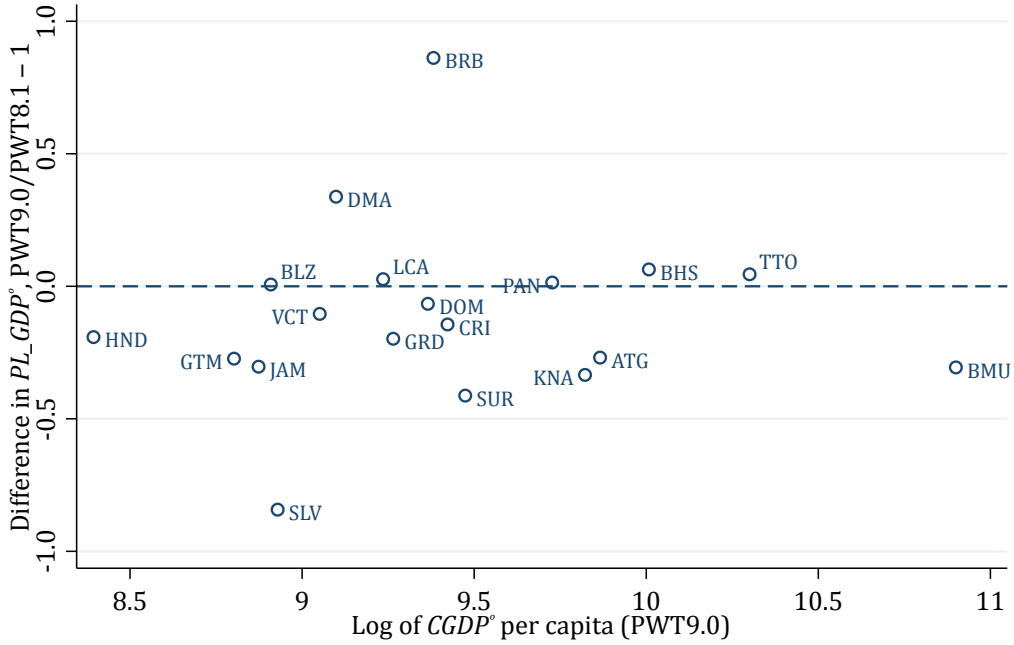


Note: $CGDP^o$ per capita from PWT9.0 is in 2011 US dollars. PL_GDP^o from PWT8.1 was inflated by a factor 1.123 to account for US inflation. Included are the 142 countries that were in ICP 2005 and ICP 2011.

Figure 2 shows that the differences are notably larger for the set of countries that were part of ICP 2011 and an earlier ICP round but did not participate in ICP 2005. For instance, the price level for Barbados (BRB) is 80 percent higher in PWT9.0 than in PWT8.1, while the price level for El Salvador (SLV) is 80 percent lower. The PPP for Zimbabwe is 920 percent higher and not shown in the figure. These newer figures should be considered an improvement over the previous estimates. This is, in part, because we would expect more recent price comparisons to more accurately reflect the relative price level of a country compared with extrapolations from (much) earlier comparisons, but also because the ICP

2011 round relied on more extensive data collection and improved methodologies, especially compared to the ICP rounds before ICP 2005. This is also illustrated by the fact that in PWT8, the observations for El Salvador in recent decades had been flagged as outliers due to implausibly high relative price levels.

Figure 2, Difference in the 2011 GDP^o price level, PWT 9.0 vs. 8.1, for countries in ICP 2011 but not in ICP 2005



Note: *CGDP*° per capita from PWT9.0 is in 2011 US dollars. *PL_GDP*° from PWT8.1 was inflated by a factor 1.123 to account for US inflation. Included are the 19 countries that were not in ICP 2005 but were in ICP 2011 and in PWT8.1; Zimbabwe, with a difference of 9.2, is omitted.

These figures illustrate that a PPP estimate for a specific given country in a specific year is subject to a sizeable level of uncertainty, especially if the estimate is not based on a recent ICP benchmark but extrapolated over longer periods. As we also remarked in our 'User Guide to PWT8' (Feenstra, Inklaar and Timmer, 2013), this implies that caution is in order when relying on the point estimate of relative income for a particular country in a particular year and that 'true' income levels may be 10–20 percent higher or lower.[4]

The broader cross-country pattern of prices is much less affected by this uncertainty. This is most easily demonstrated using the Balassa-Samuelson/Penn-effect relationship between the log price level and log income level – measured as exchange-rate-converted GDP per capita. Estimating this relationship for the 142 countries from Figure 1 for the

[4] See also Rao and Hajarghast (2016), who estimate standard errors of relative prices, which imply a similar confidence interval.

log price level from PWT 9.0 yields a nearly identical coefficient as when using the log price level from PWT 8.1, namely 0.22.

II. GDP data from the National Accounts

Revisions in the PWT are due to incorporation of new PPP data from the ICP, which mainly affects price levels, as well as new National Accounts (NA) data of countries which mainly affects nominal GDP levels and real growth rates. While typically receiving less attention in the discussions, this source of revisions can be as least as important than PPP revisions for making real GDP comparisons across countries. National Accounts data in PWT8 covered the period up to 2011 and were from the version of the United Nations National Accounts Main Aggregates Database compiled in 2012. Since then, nearly all countries have revised their National Accounts data, in part because more complete source material has become available for the most recent years, but many countries have also made comprehensive revisions. A growing number of countries has shifted from the accounting rules of the 1993 edition of the System of National Accounts (SNA) to the 2008 edition, which requires capitalization of research and development (R&D) expenditure (amongst many other changes).

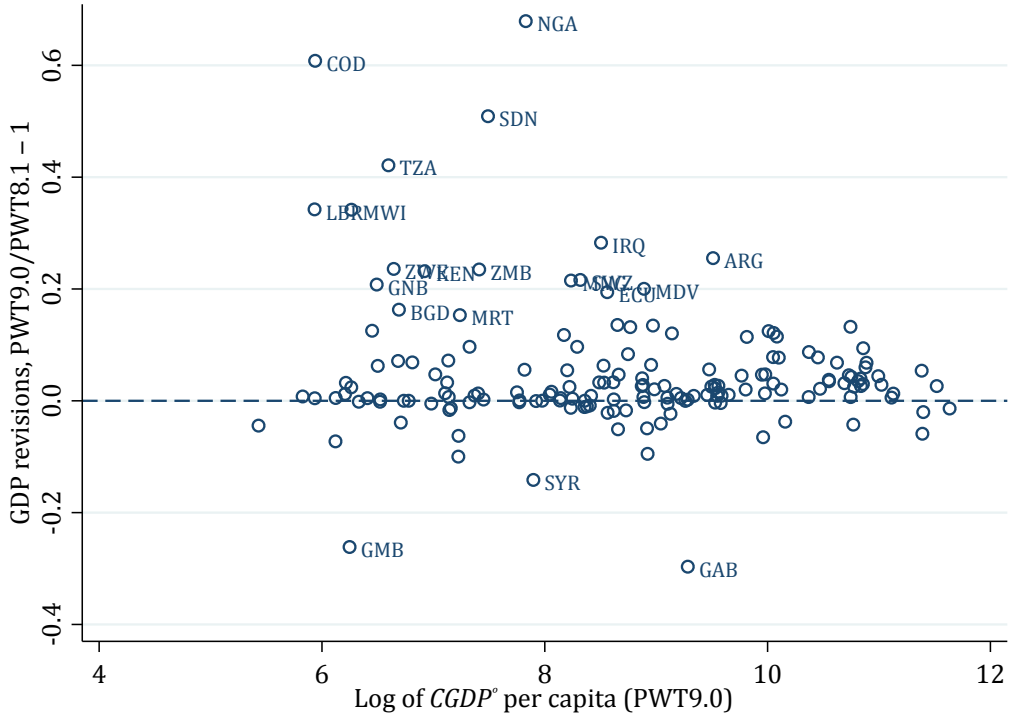
By itself, these new accounting rules have a fairly modest effect, increasing GDP by around 2–3 percent in advanced economies (Eurostat, 2014). A change in the accounting system can also be an occasion for other changes, such as shifts to new sources or a re-benchmarking.[5] For example, the transition to SNA2008 in the EU led to GDP revisions due to 'statistical improvements' of 1.4 percent for the EU-28 as a whole, but larger for individual countries: e.g. amounting to 2.6 percent of GDP in the UK and 5.9 percent in the Netherlands (Eurostat 2014).

But while these changes are certainly noteworthy, they are small compared to revisions in several African countries. In recent years, statistical systems for measuring GDP in countries like Nigeria and Ghana have been overhauled and revamped with major consequences for levels and growth rates of GDP. In Ghana, the level of GDP was revised upwards by 60 percent in 2010 (Jerven, 2013), while in Nigeria the GDP level was

[5] In National Accounts practice, it is common for many aggregates to be extrapolated from a benchmark year using, for instance, more timely but less comprehensive source material.

increased by 89 percent.[6] These revisions are welcome, since they provide a more comprehensive view of these economies, but also alarming, as they suggest substantial uncertainty about the true size of African economies. Such concerns about the reliability of National Accounts estimates are not new. Previous research has aimed to provide an alternative perspective based on detailed Demographic and Health Surveys (Young, 2012) and on nighttime light intensity (Henderson, Storeygard and Weil, 2012). On a more positive note, a report by the African Development Bank (2013) shows that the size of the revisions in Ghana and Nigeria have been exceptions rather than the rule for African countries updating their accounting methodologies.

Figure 3, Revisions to the level GDP in local currency units for the year 2011



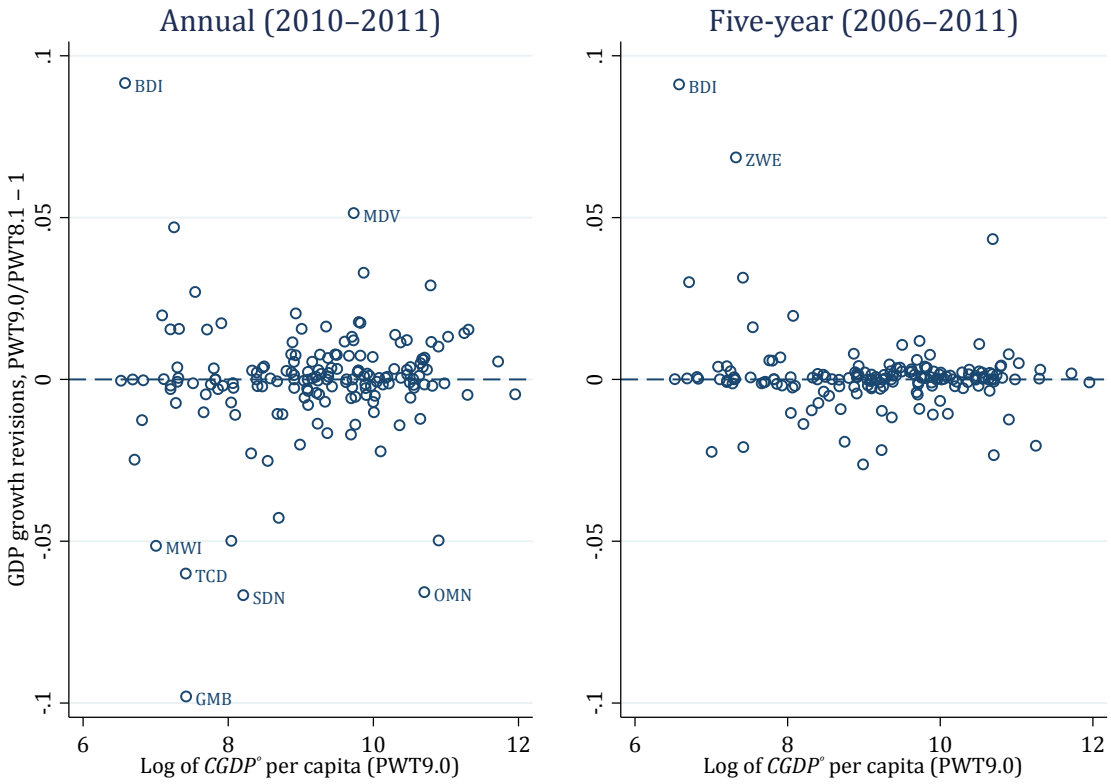
More generally, they argue that African countries are making greater efforts to produce timely and reliable National Accounts statistics. Yet other evidence in the report suggests there could be future surprises comparable to Ghana or Nigeria: of the 44 countries surveyed, 27 relied on a National Accounts benchmark that was 10 or even 20 years out of date. Given that the once-a-decade re-benchmarking in some European countries

[6] http://www.economist.com/news/finance-and-economics/21600734-revised-figures-show-nigeria-africas-largest-economy-step-change.

already lead to sizeable revisions, it would not be surprising if there were very large revisions in some African countries in the future.

To illustrate recent revisions to PWT source data, Figure 3 shows the change in the level of GDP in local currency units for the year 2011 between the National Accounts data that were used for PWT8 and the data used for PWT9. Nigeria's (NGA) revision is the largest but there are large upward (and also some downward) adjustments in other countries, such as Gabon (GAB), Liberia (LBR) and Bangladesh (BGD).

Figure 4, Revisions to growth of GDP, annual and five-year



Data on economic growth is also subject to changing methods and revisions. A prominent example is the revision of the methods for estimating India's economic growth in January 2015, which implied much faster growth than had previously been reported: the 2013-2014 GDP growth rate was revised upwards from 4.7 to 6.9 percent.[7] These revisions continue to exercise policy makers and analysts, raising questions about the 'true' Indian

[7] See http://in.reuters.com/article/india-gdp-idINKBN0L319Z20150130.

rate of growth.[8] The issue of National Accounts revisions and their impact on research was also raised more generally by Johnson, Larson, Papageorgiou and Subramanian (2013), who show that cross-country growth regression studies relying on annual growth rates of GDP can be severely affected by moving from one vintage of National Accounts data to the next. Figure 4 illustrates this point, showing revisions to the annual growth of the volume of GDP (in local currency units) between 2010 and 2011 and the revision to the average annual growth rate between 2006 and 2011. The average growth over the five-year period shows notably smaller revisions than the annual growth rate, confirming the Johnson et al. (2013) finding.

III. Capital, labor and TFP

In addition to revisions in PPPs and GDP, PWT9 also includes improvements in the source material and data compilation for the labor and capital input data. A discussion of these changes is given below for each topic. The basic method used to measure capital and labor has not been changed, for a full exposition , see Feenstra, Inklaar and Timmer (2015), specifically (online) Appendix C. In conjunction with these new estimates, we also provide new detailed source material, to be more useful and more transparent.

Specifically, we now provide a detailed labor file, that details the sources and methods for the data on employment, years of schooling and the labor share, as well as the various alternative labor share measures that can be used to assess the sensitivity of our choices. We also provide a detailed capital file, that provides a breakdown of investment, capital stocks and depreciation by four assets – structures, machinery, transport equipment and other assets, which include software and other intellectual property products.

- **Investment data.** One of the main innovations in PWT 8 was the reintroduction of capital stocks series based on estimates of investment by asset. Those estimates were based on National Accounts data, detailed expenditure data from ICP benchmarks, and estimates based on output in the construction industry and supply (production + imports – exports) of machinery and equipment, the so-called Commodity Flow Method (CFM).

[8] See e.g. http://www.economist.com/news/finance-and-economics/21696546-few-economists-wholeheartedly-believe-indias-stellar-growth-rate-elephant

In PWT 9.0, this basic approach is unchanged, but its implementation has greatly improved. First, we include substantially more investment data, directly taken from national accounts sources, reducing our reliance on the indirect CFM estimates. Second, we incorporate data compiled under the new System of National Accounts, which includes investment in R&D. This improved dataset is the result of a collaboration with The Conference Board and will underlie not just PWT 9.0, but also upcoming versions of the The Conference Board's Total Economy Database.[9] A joint paper providing a more detailed discussion of the construction and features of these data is planned for release in June 2016.

- **Labor share.** In PWT8 we introduced the variable *LABSH* that gives estimates of the share of labor income in nominal GDP. It is relatively straightforward to determine the share of labor income of *employees* in GDP, as this information is a regular part of the National Accounts of countries. Estimating the labor income of self-employed workers is more challenging. If a country reports the total income of self-employed, known as mixed income, there is a clear upper bound to overall labor income, leading to a reasonable estimate. When such information is not available, PWT8 assumed self-employed earn the same average wage as employees or alternatively that self-employed labor income equaled value added in agriculture, depending on which method leads to a lower labor share.[10] This approach was motivated to minimize the risk of overestimation, which is high when using the former. However, this conservative procedure could lead to underestimation of labor shares.

  In PWT 9.0, we attempt to identify such cases, by considering two criteria: (1) does the chosen method (same average wage or value added in agriculture) lead to a labor share of less than 40 percent, on average? And (2) is the share of GDP going to fixed assets larger than 50 percent, on average? The first criterion is motivated by the observation that, whenever mixed income data is available, the labor share is only rarely smaller than 40 percent (i.e. in less than 10 percent of cases). The second criterion relies on an estimate of the income flowing to owners of fixed assets. To that

[9] See https://www.conference-board.org/data/economydatabase/. While the Total Economy Database also estimates total factor productivity growth, only PWT provides estimates of comparative capital input levels.

[10] In addition, some countries report an employee compensation share of more than 70 percent. Since such high shares occur very rarely if mixed income data is available, this suggests the employee compensation shares already includes an estimate of self-employed labour income.

end, we subtract the World Bank's estimate of natural resource rents from GDP. Take Saudi Arabia: its estimated labor share (based on mixed income data) is 25 percent of GDP, natural resource rents account for 40 percent of GDP, leaving 35 percent for owners of fixed assets, such as buildings and machinery. Whenever data on mixed income is available, the share of income going to owners of fixed capital is only rarely larger than 50 percent. For both criteria, we consider the average across the full period to identify countries where the labor share is clearly underestimated. In those countries, we use the larger, rather than the smaller, of the two alternative methods.[11]

While we view this is a worthwhile refinement, the labor share estimates remain uncertain, especially in countries where no information is available on mixed income. For this reason, we provide additional detailed data underlying our compilations, namely the various labor share alternatives and information on which method is used for which specific observations.

- **Average hours worked and TFP**. PWT8 and PWT9 report the average hours worked by persons engaged (variable *AVH*), sourced from The Conference Board's *Total Economy Database*. These data cover 65 countries and since this is less than the 111 countries for which TFP could be computed based on labor and capital estimates, the data on average hours worked were not taken into account when computing TFP levels (*CTFP*) or growth (*RTFPNA*) in PWT8.

  In PWT9, we changed the computation method to take into account the available data on average hours worked for countries and years for which these are available, by imputing missing values. For countries without any information, average hour worked is set equal to average hours worked in the US. This ensures that *CTFP* is not affected by this choice, though a consequence is that TFP growth is higher, on average, since US average hours worked have declined at an average annual rate of 0.2 percent since 1950. This approach is clearly no substitute for careful measurement (or econometric modeling) of average hours worked, as, for example, increases in income levels tend to lead to decreases in average hours worked. The current approach

[11] There are two exceptions, Sudan and Sierra Leone. In Sudan, this approach leads to a labour share that is exceptionally high in 1996-1998, so we set the labour share at 0.9 in those years. In Sierra Leone, new vintage National Accounts data lead to very high estimates of the labour share after 2001, so we use the *employee* compensation share for those years.

should thus be seen more as a 'weak prior' rather than a true correction for hours worked. For countries with data for part of their time series, we assumed no change in average hours worked before the first observation. This ensure *CTFP* reflects higher or lower average hours worked, while avoiding stringent assumptions about the evolution over time.

Note that PWT9 continues to show data on average hours worked only for countries and years for which the *Total Economy Database* also reports data, as the imputed figures are removed after computing *CTFP* and *RTFPNA*. See the PWT program package (specifically gen_pwt.do) for the precise implementation of the imputation.

- **Human capital**. In PWT8, a human capital index was estimated using data on the average years of schooling from Barro and Lee (2013) and rates of return on education from Psacharopoulos (1994). As we describe in more detail in our document 'Human capital in PWT9.0', the Barro and Lee (2013) data for a range of countries is hard to square with several alternative sources. In PWT9, we therefore draw in part upon the data from Barro and Lee (2013) and in part on data by Cohen and Leker (2014), which updated the work of Cohen and Soto (2007). The precise implementation of this combination of sources is also discussed in the 'Human capital in PWT9.0' document on the PWT website. This change in source material has a relatively small effect on cross-country comparisons, but more notable effects on growth rates for several countries.

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