

What is new in PWT 10.0?

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The release of the Penn World Table version 10.0 is the fifth release since the switch to the 'Next Generation of the Penn World Table', 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 10.0. PWT 10.0 does contain important new and revised data. This document provides an overview of the changes.

The changes fall in four broad categories, namely, I) the incorporation of new purchasing power parities (PPPs) data for most countries for the years 2011 to 2017; II) the incorporation of revised and extended National Accounts data, covering the period up to 2019; III) revisions to how we estimate employment data, in particular for low and middle-income countries; and IV) a modification to the methodology for estimating investment by asset.

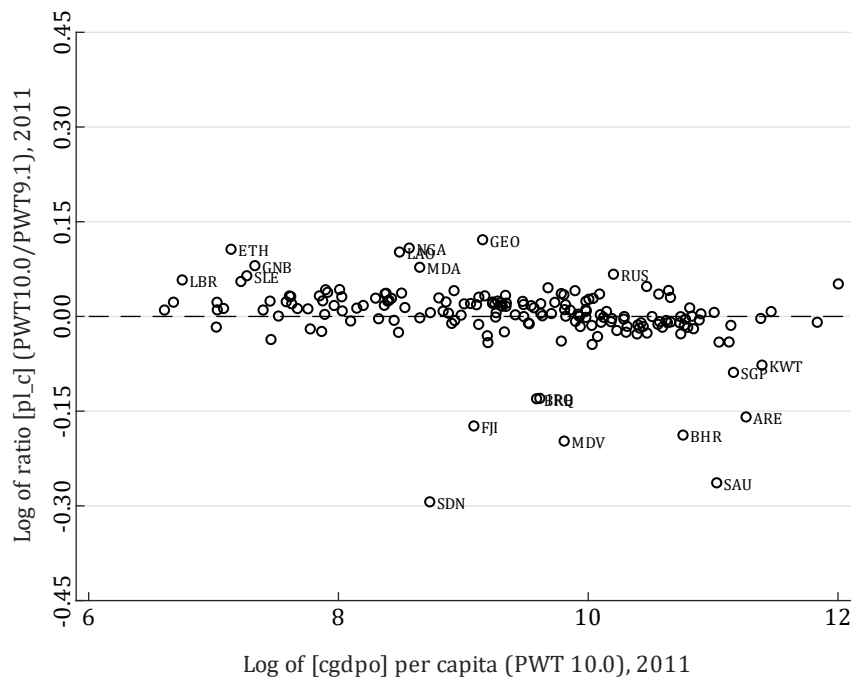
With the incorporation of the new 2017 ICP data in PWT 10.0, we also shift the reference year from 2011 to 2017. This means that all variables that were denoted in 2011 US dollars in PWT 9.0 and 9.1 are now denoted in 2017 US dollars.

I. New PPP data

The previous two releases of PWT already included the ICP benchmarks for 2011. With PWT 10.0, we add revised ICP benchmarks for 2011, new benchmarks for 2017 and interpolated ICP benchmarks for the intermediate years 2012-2016. Compared to the previous release, the price levels for the expenditure categories are revised substantially in PWT 10.0.

Figure 1 plots the ratio of the household consumption price level [pl_c] in PWT 10.0 relative to the price level in PWT 9.1 for the year 2011. The revisions to the price levels are primarily caused by updates to the purchasing power parities (PPPs) and expenditure shares at the basic heading level in the ICP. The World Bank documents the changes between the original and revised 2011 ICP benchmark extensively, directly comparing the old and new PPPs for aggregate consumption and total GDP for all countries (World Bank, 2020). For household consumption the ICP PPPs were revised substantially for the countries marked in the figure. For SDN, the revised PPP (World Bank 2020) is close to the original 2011 PPP (World Bank, 2014), but the reported market exchange rates differ, leading to a substantial revision to the relative price level.

Figure 1, Revisions to the household consumption price level in 2011, PWT 10.0 vs. 9.1



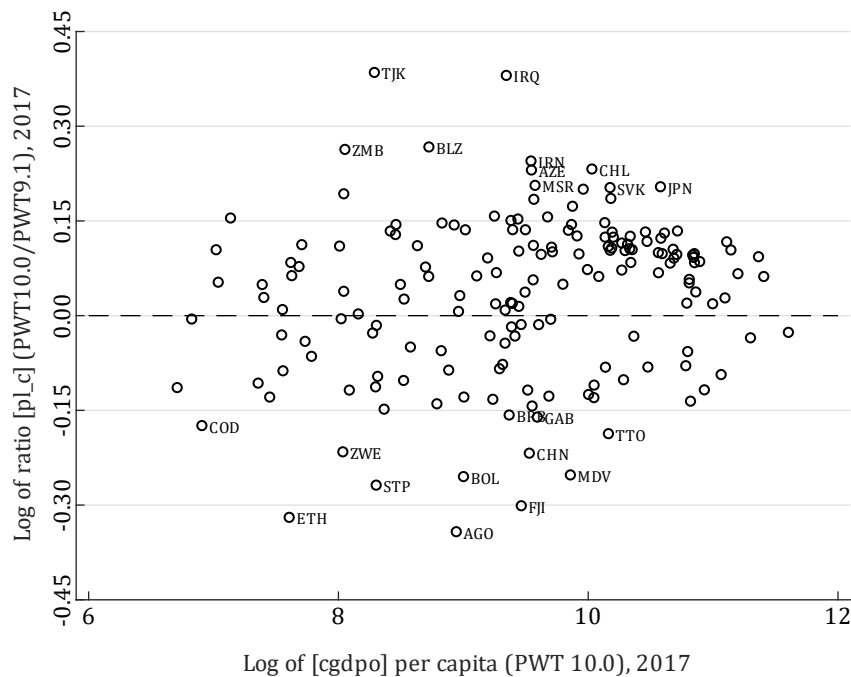
Note: [cgdp0] per capita is in 2017 US Dollars.

Figure 2 shows that the revision to the price levels between PWT 9.1 and 10.0 are more pronounced in 2017. For this year, we now rely on direct ICP benchmark for nearly all countries in our sample, instead of extrapolating the original 2011 ICP benchmark, as was the case for PWT 9.1.¹ The ICP data also replaces the 2014 OECD and 2011-2017 Eurostat benchmarks used in the previous release of PWT, leading to notable revisions for some countries.² 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 also remarked in Feenstra, Inklaar and Timmer (2015), this implies that caution is in order when relying on the estimate of relative prices and income for a particular country in a particular year.

¹ Note that there are no benchmarks in 2011 or 2017 for LBN, SYR, TKM and UZB. ARG and GUY are covered in 2017, but not in 2011.

² OECD 2014 benchmark countries are: ARM, AUS, AZE, BLR, CAN, CHL, ISR, JPN, KAZ, KGZ, KOR, MDA, MEX, NZL, RUS, TJK. Countries included in the 2011-2017 Eurostat benchmarks are: ALB, AUT, BEL, BGR, BIH, CHE, CYP, CZE, DEU, DNK, ESP, EST, FIN, FRA, GBR, GRC, HRV, HUN, IRL, ISL, ITA, LTU, LUX, LVA, MKD, MLT, MNE, NLD, NOR, POL, PRT, ROU, SRB, SVK, SVN, SWE, TUR.

Figure 2, Revisions to the household consumption price level in 2017, PWT 10.0 vs. 9.1

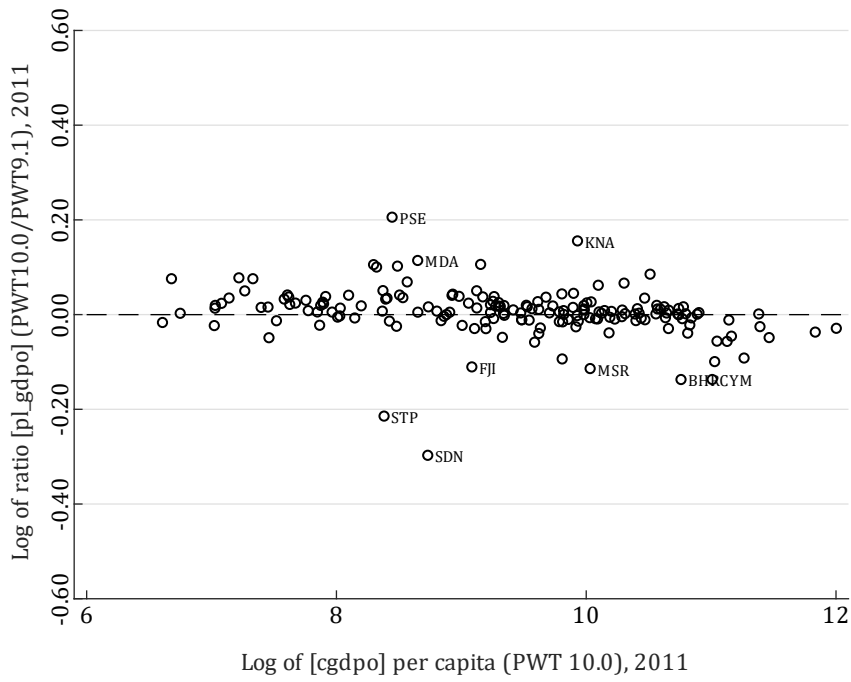


Notes: [cgdp0] per capita is in 2017 US Dollars. Omitted countries: LBR (-0.49), SDN (-1.18), VEN (3.05).

For the years between the 2011 and 2017 ICP benchmarks, we rely on interpolated PPPs estimated for the World Bank. These interpolations combine regional PPP benchmarks (such as for Eurostat countries and those in Western Asia) and utilize national price deflators and expenditure data at the basic heading level, yielding continuous and consistent relative price levels for the period 2011-2017 for nearly all countries in our sample. A detailed description of the methodology behind the construction of these interpolated PPPs is provided in Inklaar and Rao (2019, 2020). We prefer these estimates, interpolated at the detailed basic heading level, to our usual approach of interpolating/extrapolating benchmarks using price and expenditure data for aggregate expenditure categories (i.e., household-, government consumption, gross capital formation, export and import). We also favor the ICP interpolations over direct benchmarks from the OECD and Eurostat, as the price and expenditure information from the OECD and Eurostat benchmarks is incorporated in the interpolated ICP benchmark estimates.

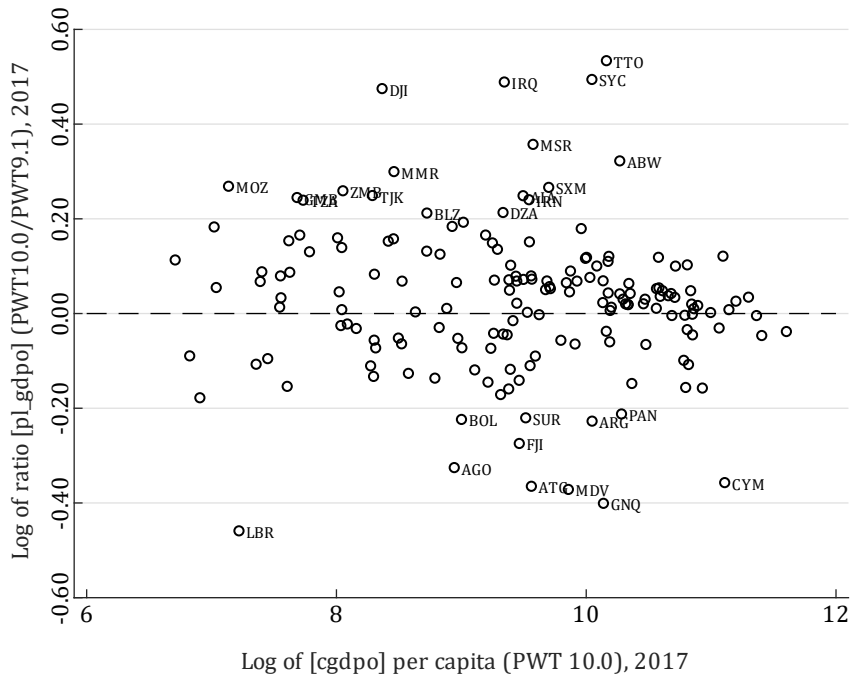
Figure 3 and 4 plot the ratio of the (output-based) Gross Domestic Product price level [pl_gdp0] in PWT 10.0 relative to the price level in PWT 9.1 for the years 2011 and 2017. The revisions discussed for household consumptions also apply at the more aggregate level. Corrections to the GDP expenditure composition, as discussed in section II below, result in additional adjustments for various countries. Revisions for 2011 are of the same order as for consumption, but the new PPP estimates for 2017 show larger differences for GDP than for consumption.

Figure 3, Revisions to the GDP⁰ price level in 2011, PWT 10.0 vs. 9.1



Note: [cgdp] per capita is in 2017 US Dollars.

Figure 4, Revisions to the GDP⁰ price level in 2017, PWT 10.0 vs. 9.1

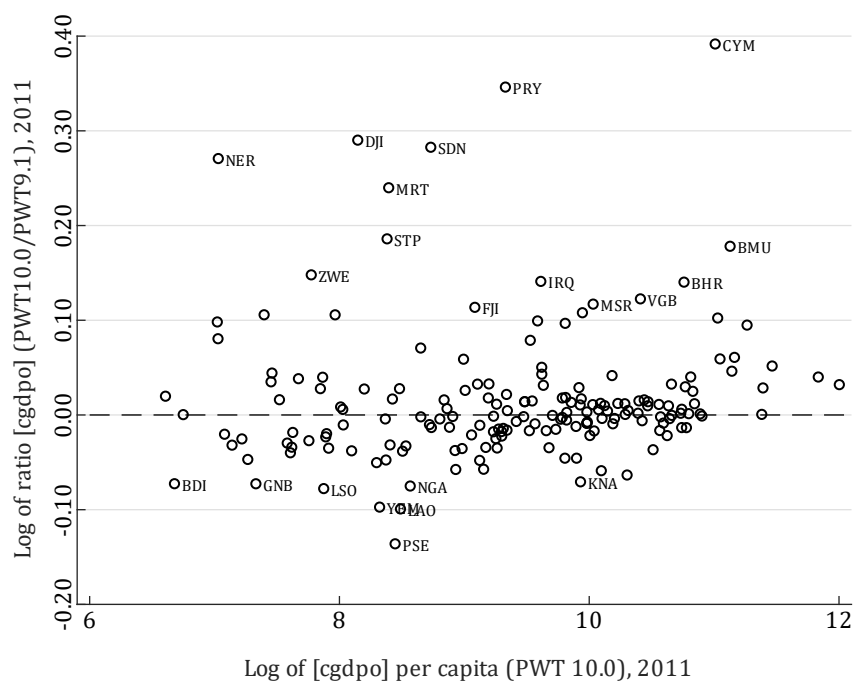


Notes: [cgdp] per capita is in 2017 US Dollars. Omitted countries: KGZ* (0.67), SDN (-1.00), TCA* (-2.19), VEN* (3.03); '*' countries are marked as outliers [i_outlier].

II. GDP data from the National Accounts

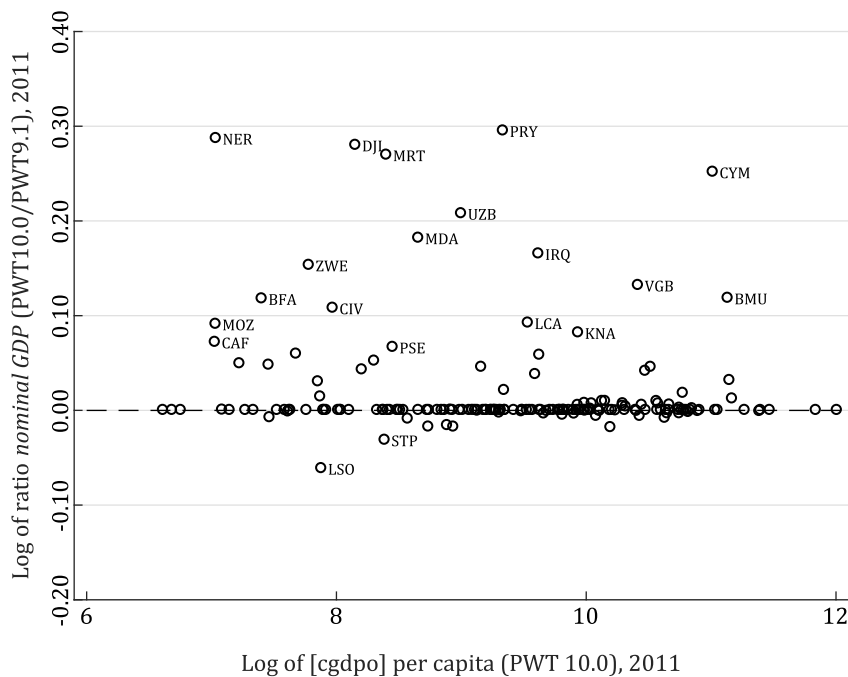
Revisions in PWT are due to the incorporation of new PPP data, which mainly affects price levels, as well as new National Accounts (NA) data of countries which mainly affects nominal GDP levels and real growth rates. In PWT 10.0 we observe a number of comprehensive revisions in the NA data that lead to considerable changes to the levels of GDP at current PPPs as well (see figure 5). As was the case for the previous release of PWT, revisions are commonly observed for African nations, but also for countries in Latin America, the Caribbean and the Middle East. As shown in figure 6 for our benchmark year 2011, nominal GDP was adjusted upwards by no less than 30 percent for Paraguay (PRY), 29 percent for Niger (NER), and 28 percent for Djibouti (DJI). As discussed in the note accompanying PWT 9.0, these comprehensive revisions are both welcome and alarming, since they reflect the great effort made by national bureaus of statistics, but also underscore the uncertainty regarding the true size of these economies.

Figure 5, Revisions to GDP⁰ at current PPPs in 2011, PWT 10.0 vs. 9.1



Note: [cgdp0] per capita is in 2017 US Dollars.

Figure 6, Revisions to GDP at current national price in 2011, PWT 10.0 vs. 9.1



Note: [cgdpo] per capita is in 2017 US Dollars.

Data on economic growth is also subject to changing methods and revisions in the National Accounts. As was evident for PWT 9.1, the average growth farther back in time shows notably smaller revisions than the growth rates for years closer to 2019.

III. Employment

For PWT 10.0 we made substantial changes to the source data for employment. In addition, we modified the linking procedure used to combine the employment estimate from different sources. By incorporating more up-to-date information and critically assessing the comparability of the available sources, these adjustments have helped to improve our estimates of total employment for a few dozen, mostly African, South/South-East Asian and Latin American countries. As is common for every release of PWT, routine revisions to the employment data in the original sources also alter the estimates for some countries, particularly for more recent years.

For previous releases of PWT we relied on three main sources: (1) The Conference Board's (TCB) Total Economy Database, (2) the International Labour Office's (ILO) official and modelled employment data, and (3) the World Bank's employment and labor force statistics reported in the World Development Indicators (WDI). Our method for deriving total employment is to estimate employment-to-population ratios from different sources and applying these to the population numbers from the UN National Accounts Main Aggregates Database (UN-AMA).

Data from TCB is based on estimates taken directly from the national statistics, but also employment data sourced indirectly from the GGDC's own 10 sector database (SD10) and productivity statistics from the Asian Productivity Organization. The SD10 has since been updated by researchers from UNU-Merit in the Expanded Africa Sector Database (EASD; Mensah et al., 2018) and for the period 1990-2018 has been superseded by an upcoming release of the GGDC's Economic Transformation Database (ETD; de Vries *et al.*, 2021).

In PWT 10.0, we now source employment data, for countries where TCB relied on secondary data, directly on employment data from the ETD combined with data from the SD10 and EASD. The ETD takes particular care to cover both formal and informal labor, providing more encompassing estimates of total employment for the developing- and middle-income countries covered by this database. Note that we only use the ETD estimates that are based directly on benchmark data, i.e., population censuses, labor force surveys and household surveys. The reason for this constraint is that the ETD uses PWT data to extrapolate/interpolate between benchmark years. Using these interpolated figures would thus create an undesirable feedback loop between PWT and the ETD. The 'Labor detail' file made available in the 'Additional data and programs' section on the PWT 10.0 webpage provides full details on the sources for employment data for each country and year.

Whenever ETD or TCB data is unavailable we turn to the ILO instead. For previous releases of PWT, we treated the ILO's official benchmark estimates as equivalent to the modelled time series. For years where both benchmark and modelled data was available an average was used. In addition, all benchmark estimates were treated equivalently, regardless whether they were based on population censuses, labor force or other surveys. Unfortunately, the official and modelled estimates do not always correspond, causing breaks in the employment series during census years. The levels for the official sources also vary considerably, potentially reflecting differences in methods and coverage for each respective survey. The ILO also notes that the modelled estimates "are subject to high uncertainty and should not be used for country comparisons or rankings", precluding us from solely relying on these modelled timeseries.

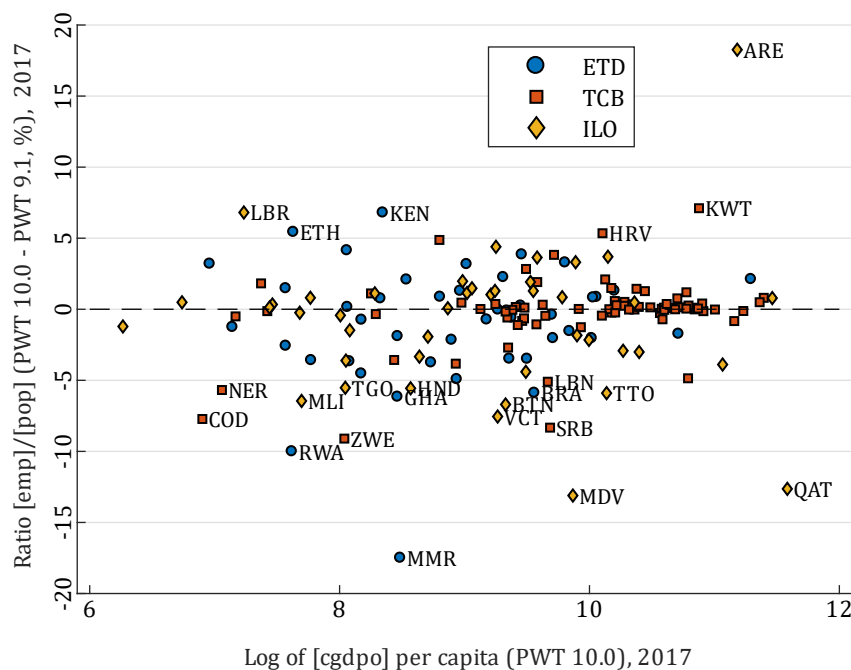
In PWT 10.0 we rely on the ILO's official data to estimate levels of employment for benchmark years. Recall that we always express total employment from any of our main sources as a ratio of population, which is taken from the UN-AMA. These ratios are interpolated linearly between benchmark years and extrapolated using the ILO's modelled data. For the benchmark years, we distinguish between estimates based on (1) population censuses, (2) labor force surveys, and (3) household surveys – in that order of preference. If benchmark estimates are available from more than one of these sources, we interpolate/extrapolate levels from the first preferred source using trends from the remaining sources, for overlapping periods. This prevents trends breaks in the employment ratio resulting from a switch in the type of employment survey for different

benchmark years. Given the high variance in some of the ILO's official estimates – most notably the labor force- and household surveys – we manually compare the employment ratios with estimates from the WDI, the ILO's modelled estimates and TCB, dropping obvious outliers.

For years where ETD, TCB or ILO data is unavailable we use the WDI employment and labor force statistics to extrapolate the employment ratios. In addition, in rare instances, TCB data is used to extrapolate series based on the ETD. Again the 'labor detail' file outlines for each country/year combination whether employment levels are based on 'official' estimates from the ETD, TCB or ILO and which years were 'interpolated' using data from the EASD, SD10, ILO, WDI, or TCB.

Figure 7 below shows the revisions to the employment to population ratios for the year 2017, subtracting the ratio in PWT 9.1 from PWT 10.0. A distinction is made between the three primary sources, ETD, TCB and ILO. The most substantial revisions originate from the different treatment and linking of ILO benchmark data. In nearly all cases the ETD replaces TCB data. For six countries the absolute difference in the employment to population ratio between these two sources was greater than 5 percentage points.

Figure 7, Revisions to the employment/population ratio for 2017, PWT 10.0 minus 9.1



Note: [cgdpo] per capita is in 2017 US Dollars.

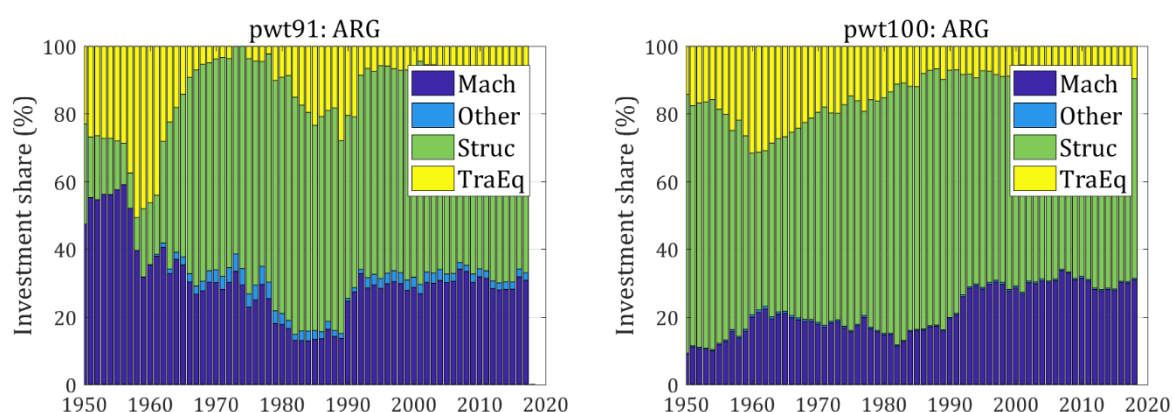
IV. Nominal investment

For all releases of PWT since 8.0, asset-specific investment data is based on National Accounts statistics, derived from the Conference Board's (TCB) Total Economy Database, and estimates using the Commodity-flow method (CFM). For PWT 10.0 we adjust the linking procedure between both sources. Initially we only linked at the final 9-asset level, meaning we only used investment shares from TCB at the most detailed, nine asset level. For this release we also incorporate TCB investment data if it is only available for higher-level assets; 'Total construction' for example. We define a tree-like structure of assets where the nine lowest-level assets (children) are assigned to several higher-level assets (parents, grandparents, etc.). Investment shares are expressed relative to the direct parent and TCB data is extrapolated using CFM data or fixed shares for years where data is missing for that child or any of its siblings. This means that even though the share of 'Residential structures' and 'Other construction' relative to 'Total construction' may be based on fixed shares for a given year, the share of 'Total construction' in Gross Fixed Capital Formation' can still be based directly on TCB data for that year. This ensures that broad trends reported in the National Accounts' investment series are also incorporated in this release of PWT.

Figure 8 below illustrates the impact of these revision on the investment shares for Argentina between PWT 9.1 and 10.0. In PWT 9.1, we only used TCB nominal investment data from 1993 onwards. Prior to 1993, the shares were extrapolated at the 9-asset level using estimates from the CFM. Even though information on investment in 'Total construction' (*Struc*) was available from TCB, the trend in the left-hand figure is based solely on (volatile) CFM data.

In PWT 10.0, we use all available primary information. The trend in 'Total construction' from 1950-2018 is based on TCB investment data. Prior to 1993 we do rely on CFM data to break this aggregate further down into two assets: 'Residential structures' and 'Other construction'. Argentina represents a more severe revision, but the new investment data has a marked impact on our estimates of capital stock and services for about 30 countries where TCB offers only a partial timeseries of nominal investment.

Figure 8, Example of revision to nominal investment, Argentina 1950-2019



Note: nominal investment shares at the 4-asset level, PWT 9.1 (left) versus PWT 10.0 (right).

V. Other changes

- **Update to PWT 10.0:** On February 18, 2021 we updated PWT 10.0 and replaced the exchange rate [xr] for Sudan for the years 1970 to 2019 with estimates from the World Bank's World Development Indicators. The 'official exchange rate' reported in the UN National Accounts for the years after 2008 deviate from the 'equivalent exchange rate', which was primarily used for trading purposes. Note that this predominantly affects the Sudanese level of real GDP at current PPPs, and variables depending on these estimates (i.e. [ctfp]).
- **Update to PWT 10.0:** On January 28, 2021 we updated PWT 10.0 and replaced the ICP benchmarks for the years 1996 and 2005 with benchmarks from Eurostat and the OECD whenever available. This resolved spikes in price levels for several European countries (notably GBR) and revised growth rates of price levels between 1985 and 1996 for several OECD countries.
- **Update to PWT 10.0:** On January 26, 2021 we updated PWT 10.0 due to an error in the current value of GDP [v_gdp] for our alternative time-series of China. Note that the variables relying on current GDP (e.g. [cgdpo], [rgdpo], etc.) as well as the reported price levels, were also affected by this revision for CHN.
- **New TFP estimates:** New employment and investment data has allowed us to extend TFP estimates for several countries: BWA, IDN, MUS, NAM, UZB, ZMB.
- **New output/expenditure estimates:** A new 2017 PPP benchmark for GUY allowed us to include this country in PWT 10.0.
- **Update human capital [hc]:** update from Barro and Lee v. 2.0 to 2.2. Revisions for CHN and DOM.

- **Revision capital services [rkna]:** fixed an issue in PWT 9.1, where the implied capital compensation ($[k] / [ucc]$) did not always equal $(1-[labsh]) * [gdp]$. This fix solves several breaks in [rkna], most notably for CZE, LVA, ROU and RUS.
- **Revision price level capital stocks [pl_n]:** fixed an issue in PWT 9.1, where the price level for capital stocks was always equal to the price level for GDP [pl_gdpo] for the USA. The price level for the USA is now estimated using asset-specific PPPs weighted by nominal capital stocks. It is set to 1 for the USA in the base year 2017.
- **Outliers price levels.** We have identified a number of new outliers in the price levels for GDP and Domestic Absorption (DA). We used the criteria discussed at length in the document "Outliers in PWT8.0", available on the PWT website. In short, price levels for [cgdpo] and [cda] are marked an outlier if the price level is extrapolated from the first or last available benchmark *and* the observed level exceeds the bounds of a predicted level, based on an OLS regression of the log of GDP per capita and the log price level of GDP and DA respectively. New outliers were identified for one or more years for ABW, ALB, ARM, ATG, BGR, BLR, CYM, IRQ, OMN, SDN, SXM, TGO, TJK, VEN. Some of the outliers identified in PWT 9.0 and 9.1 were no longer identified as such. Consult the [i_outlier] variable for further details.

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Appendix

In Inklaar *et al.* (2019), we decomposed a country's GDP per capita level relative to the United States into the contribution from differences in factor inputs and differences in productivity levels. Here we relied on the intensive form production function suggested by Hsieh and Klenow (2010). The tables below respectively reproduce the results for 2011 based on PWT 9.1 (table A1), for 2011 based on PWT 10.0 (table A2) and for 2017 based on PWT 10.0 (table A3). Although the new PWT 10.0 data suggests that labor input can account for more of the cross-country variation in income levels than previously thought, the difference is slight. Productivity differences remain the dominant sources of income differences, also for 2017.

Table A1: Original development accounting results for 2011, PWT 9.1

	Capital input, β^K	Labor input, β^L	Total factor productivity, β^A
$N_{m,t}$, original initial stocks	0.044 (0.0330)	0.277*** (0.0241)	0.679*** (0.0445)
$N_{m,t}$, new initial stocks	0.050 (0.0340)	0.277*** (0.0241)	0.673*** (0.0457)
$K_{m,t}$, new initial stocks	0.075** (0.0311)	0.277*** (0.0241)	0.648*** (0.0376)

Notes: The table show the beta coefficients for regression of capita input, labor input and productivity on GDP per capita, see Inklaar *et al.* (2019) equations (4a–c), where instead of a single α , we use each country's share of capital income in GDP, α_m . $N_{m,t}$ is computed as in equation (9), $K_{m,t}$ as in equation (8). Data are for 117 countries. Standard errors between parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

Table A2: New development accounting results for 2011, PWT 10.0

	Capital input, β^K	Labor input, β^L	Total factor productivity, β^A
$N_{m,t}$, new initial stocks	0.030 (0.0363)	0.283*** (0.0243)	0.687*** (0.0466)
$K_{m,t}$, new initial stocks	0.068** (0.0328)	0.283*** (0.0243)	0.649*** (0.0395)

Notes: see table A1.

Table A3: New development accounting results for 2017, PWT 10.0

	Capital input, β^K	Labor input, β^L	Total factor productivity, β^A
$N_{m,t}$, new initial stocks	0.074** (0.0366)	0.278*** (0.0239)	0.648*** (0.0489)
$K_{m,t}$, new initial stocks	0.095*** (0.0350)	0.278*** (0.0239)	0.626*** (0.0452)

Notes: see table A1.