What is new in PWT 10.01?

Reitze Gouma, Robert Inklaar, and Ryan Marapin

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The Penn World Table 10.01 constitutes a minor revision of the previous PWT 10.0 major release, the fifth release since 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 10.01.

This document provides information on the changes that were made for this minor revision compared to PWT 10.0. The change relates to the calculation of investment deflators and primarily affects the *na variables for capital and TFP, i.e., those primarily designed to capture growth over time. In Section I we detail the change, in Section II we discuss the impact on the most-affected variables.

I. Changes in the estimation of the asset price deflators

In the current version of the dataset changes have been made to the estimation of the investment price deflators. As discussed in Inklaar et al. (2019), cross-country differences in asset price inflation (or deflation) for Information and Communication Technology (ICT) assets can be affected by the degree to which country statistical agencies adjust for quality change. Starting with version 8.0 we have therefore implemented a *harmonisation* procedure which uses for all countries the US ICT asset price changes, adjusted for differences in the change in the aggregate deflator for gross fixed capital formation (GFCF). However, a change in the implementation of this method in PWT 10.0 (as well as in PWT 9.1) had consequences for the price deflators of non-ICT assets due to a *normalisation* we impose.

Since price deflators by asset are not available from the UN National Accounts Main Aggregates Database (UNMAD), we rely on a variety of national and international sources (OECD, Eurostat) and combine different vintages of National Accounts data. To ensure that the resulting series of deflators are consistent with the aggregate deflator for GFCF from the UNMAD, we normalise the asset-level deflators so that the (Törnqvist) aggregate deflator change is equal to the aggregate GFCF deflator from the UNMAD.

In PWT versions 8.0, 8.1, 9.0 and, again, in 10.01 we first normalise and then impose the harmonised ICT deflators. In PWT versions 9.1 and 10.0, we first harmonise and then normalise. Since the harmonised ICT deflators typically grow more slowly than the national ICT deflators, harmonising before normalising leads to faster growth of the non-ICT deflators.

To clarify why this is the case, assume (for expositional simplicity) that we distinguish only two assets, an ICT asset I and a non-ICT asset N and that the share of the ICT asset in investment, s^I, is constant over time.[1] Then the aggregate investment deflator change can be computed as:

[1] In reality, we have data on three ICT assets and six non-ICT assets and the investment shares of each of these nine assets vary over time. This time variation is accounted for in aggregation by using a two-period average investment share, i.e., a Törnqvist index rather than the constant share in equation (1).

$$\Delta \log P_i = s_i^I \Delta \log P_i^I + \left(1 - s_i^I\right) \Delta \log P_i^N \quad (1)$$

Here P_i^I is the investment price deflator for ICT assets in country i, P_i is the aggregate investment price index and Δ is the difference operator (omitting time subscripts for simplicity). In the normalisation operation, we compare the aggregate price change from equation (1) to the aggregate price change observed in the National Accounts, $\Delta \log P_i^{NA}$, and adjust the asset price changes by that difference:

$$\Delta \log \widetilde{P}_i^x = \Delta \log P_i^x + \Delta log\, P_i^{NA} - \Delta \log P_i, x \in I, N \quad (2)$$

The harmonisation operation replaces the observed price change of ICT assets from national statistics by the price change for those assets in the United States, adjusted for differences in aggregate price changes:

$$\Delta log\, \hat{P}_i^I = \Delta log\, P_{US}^I + \Delta log\, P_i^{NA} - \Delta log\, P_{US}^{NA} \quad (3)$$

The order of operations used in PWT 9.1 and 10.0 is first harmonisation, then normalisation, so first adjusting ICT deflator changes using equation (3) and then applying equation (2) to ensure that the aggregate price change matches that observed in the national statistics.

Yet the reason for the harmonisation is that we believe that for many countries, the aggregate price change is misleading because inadequate quality-adjustment leads national statistics to show a too rapid rise in ICT prices. By forcing the aggregate price change to match that in national statistics *after harmonisation*, the slower growth rate of the (harmonised) ICT deflators lead to higher growth rates of non-ICT deflators. For that reason, we return to the order of operations used in PWT 8.0, 8.1 and 9.0 and first normalise (equation (2)) and then harmonise (equation (3)). This implies that the aggregate investment change in PWT 10.01 will typically be slower than that shown in the National Accounts.

II. Impact of the adjustment

The degree to which this adjustment affects the results for a particular country, depends on the degree to which statistical agencies already adjust for quality change in ICT assets and the weight of ICT assets in investment. For countries that already employ quality-adjusted ICT deflators, the changes in the estimation methodology will have little effect. Countries that do not adjust for quality changes in ICT assets, will show a markedly lower growth in the aggregate investment deflator compared to the previous PWT version and to the reported GFCF deflator from the National Accounts. Since the investment price deflators are a component in the derivation of many variables in the Penn World Table, changing the estimation methodology also changes these variables. Table 1 presents the variables in the main output file that are affected.

The most substantive changes are in the *na variables, i.e., the variables designed for capturing growth over time. The c* variables, designed for capturing comparative levels across countries, are primarily determined by the purchasing power parities (PPPs), which are unchanged. For country-

year observations where PPPs are not directly available, we use the asset deflators in estimation, so changes in these variables can primarily be traced to this.[2]

Table 1: Affected variables in the main output file

Acronym	Description
cn	Capital stock at current PPPs (in mil. 2017US$)
ck	Capital services levels at current PPPs (USA=1)
ctfp	TFP level at current PPPs (USA=1)
cwtfp	Welfare-relevant TFP levels at current PPPs (USA=1)
rnna	Capital stock at constant 2017 national prices (in mil. 2017US$)
rkna	Capital services at constant 2017 national prices (2017=1)
rtfpna	TFP at constant national prices (2017=1)
rwtfpna	Welfare-relevant TFP at constant national prices (2017=1)
irr	Real internal rate of return
delta	Average depreciation rate of the capital stock
pl_n	Price level of the capital stock, price level of USA in 2017=1
pl_k	Price level of the capital services, price level of USA=1

For that reason, we focus on the *na variables in the remainder of this note. We first illustrate the impact of the change on overall investment prices, then trace that to the impact on capital stocks (rnna), capital services (rkna) and total factor productivity (rtfpna).

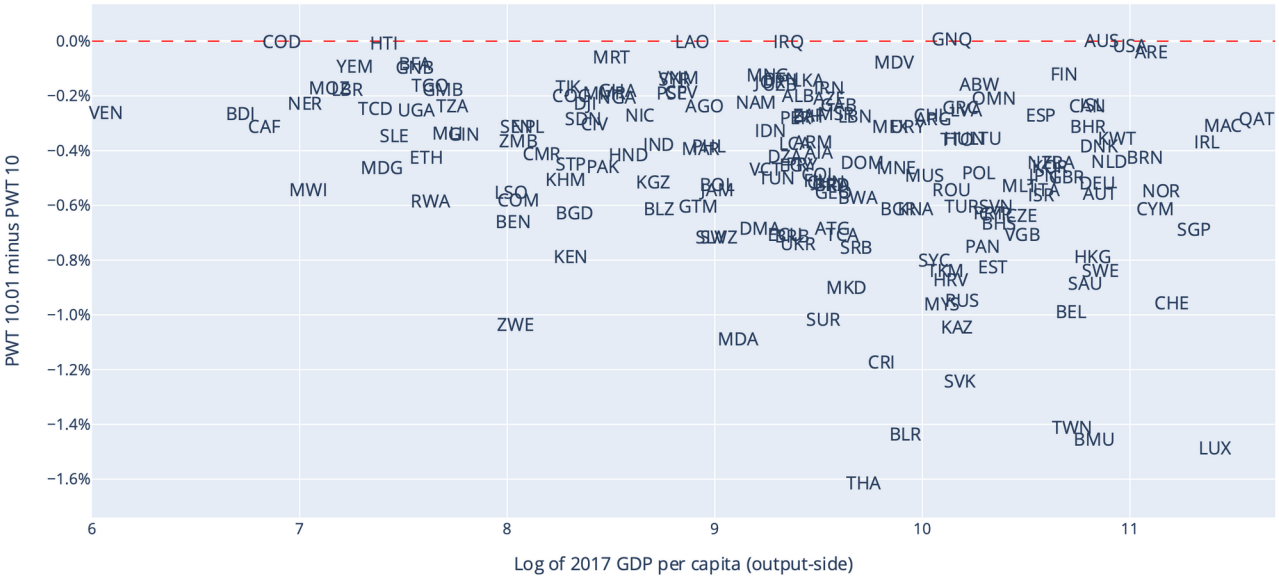
Impact on aggregate investment prices

Figure 1 shows the effects of the adjustment in the estimation methodology for the 1970-2010 average annual growth in the aggregate investment deflator, for the 180 countries available in PWT. We chose this long period to emphasise the change in broader growth patterns. Aggregate asset deflator growth rates have been calculated by aggregating the growth of the individual price deflators for 9 detailed assets[3], using Törnqvist weights of nominal investment, i.e., modifying the investment shares in equation (1) to be two-period average shares. We plot the difference in the average annual growth of the price deflator between PWT 10.01 and PWT 10.0 against the log of 2017 level of $CGDP^o$ per capita.

[2] The relative shares of assets in capital stocks and services can also change due to this change in calculation of deflators, but that will typically be a smaller factor.

[3] ICT-assets: Telecommunications Equipment (CT), Computer Hardware (IT), Computer Software (SOFT); Non-ICT assets: Residential Structures (RStruc), Other Construction (OCon), Transport Equipment (TraEq), Other Machinery and Equipment (OMach), Cultivated Assets (CULT), Other Intellectual Property Products (OIPP).

Figure 1: 1970-2010 average annual growth of the aggregate investment price deflator (Ip), PWT 10.01 - PWT 10



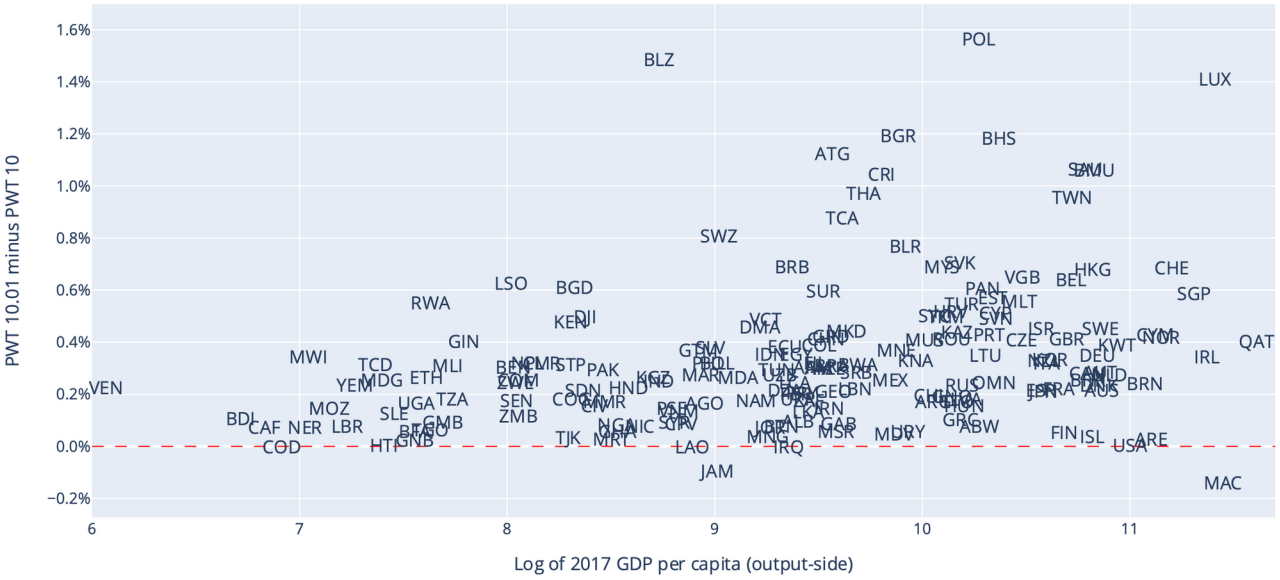
Note: Figure shows on the vertical axis the average annual growth rate of aggregate investment prices over the period 1970–2010 in PWT 10.01 minus that in PWT 10.01. The log of CGDP^o per capita in 2017 is on the horizontal axis.

In Figure 1 we see that in PWT 10.01 aggregate investment prices grow more slowly than in 10.0, with the average change –0.46 percent (see Table 1, below). This is in line with the expectations formulated above since the harmonised ICT deflators are now incorporated after the normalisation and these harmonised deflators grow more slowly than the national ICT deflators. This figure is thus a comparison between the growth of aggregate investment prices as officially reported in the national accounts (PWT 10), and the growth of aggregate investment prices after harmonising ICT deflators (PWT 10.01). There is considerable heterogeneity across countries in the degree to which the average annual investment price deflator has changed. Generally speaking, countries that are close to zero are those in which statistical agencies already adjust for quality change in ICT assets or where ICT assets make up a small portion of overall investment. The tendency for larger differences in higher-income countries (a correlation of –0.31) is likely due to the larger share of ICT assets in investment in those countries. This is a pattern we also see in subsequent figures.

Impact on capital stocks (rnna)

Figure 2 shows the difference in the 1970-2010 average annual growth of the aggregate capital stock between the PWT 10.01 and PWT 10.0 releases, again plotted against log of GDP per capita in 2017. The slower growth of investment prices from Figure 1 leads us to expect that aggregate capital stocks will grow more rapidly over time, and this is indeed what Figure 2 shows. The effect is somewhat smaller than in Figure 1 at 0.38 percent on average versus –0.46, and the correlation between the differences in the two figures is –0.52.

Figure 2: 1970-2010 average annual growth of the capital stock (rnna), PWT 10.01 - PWT 10



Note: Figure shows on the vertical axis the average annual growth rate of the capital stock (RNNA) over the period 1970–2010 in PWT 10.01 minus that in PWT 10.01. The log of CGDP^o per capita in 2017 is on the horizontal axis. Omitted from this graph to improve clarity are Bosnia and Herzegovina (3.3%), Cambodia (2.5%), and the Dominican Republic (2.7%).

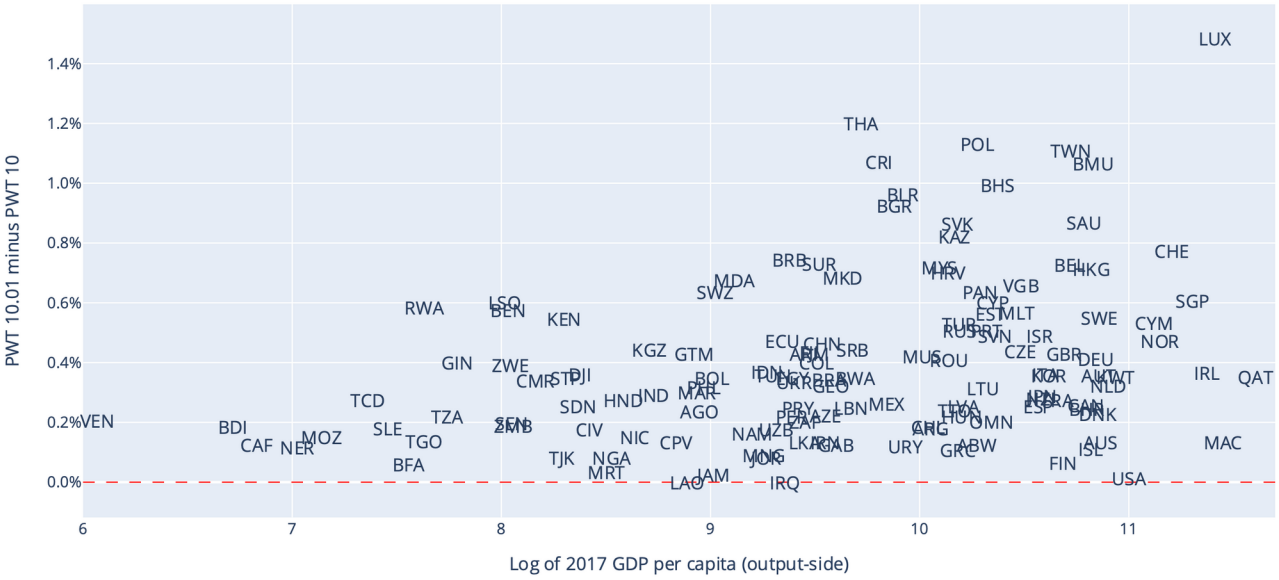
We omit three countries from the figure to improve clarity, Bosnia and Herzegovina (3.3%), Cambodia (2.5%), and the Dominican Republic (2.7%). These are countries for which the change in methodology had a larger effect on capital stock growth rates than what might be expected from the change in the aggregate investment price deflators. More generally, we identified two reasons for why Figures 1 and 2 are not mirror images. First, the change in the investment price deflators lowered estimates of the initial capital stock for some countries, thereby further increasing growth rates for the capital stocks. Second, there are country-specific data issues at play, such as extreme price changes in specific years for specific assets, which can severely affect the shares of particular asset types. This can result in stronger changes in the overall capital stocks growth than expected on the basis of the change in the aggregate price deflators and is the reason for the outliers.

Impact on capital services (rkna)

Figure 3 below shows the changes between the releases using the same graph layout as in Figures 1 and 2. Since is not possible to calculate capital services for each country due to data restrictions, we are left with 137 countries in sample. We again omitted Bosnia and Herzegovina (2.5%) and the Dominican Republic (4.3%) to improve clarity.

The effect on capital services is in the same direction as for capital stocks. However, capital services are affected by the changes in the investment prices in two ways: first through the effect on capital stocks, shown in the previous section; second through the effects on the estimation of asset capital compensation, which is used to calculate capital services. As detailed in Inklaar et al. (2019), the user cost of capital includes the change in asset deflator changes with a negative term, so lower price increases for non-ICT assets will increase the user cost of capital for those assets and thereby increase the share of non-ICT assets. Still, the correlation between the differences in Figures 2 and 3 is very high, at 0.93, and the average difference is similar, with capital services growing 0.44 percent faster compared to 0.38 for capital stocks.

Figure 3: 1970-2010 average annual growth of capital services (rkna), PWT 10.01 - PWT 10

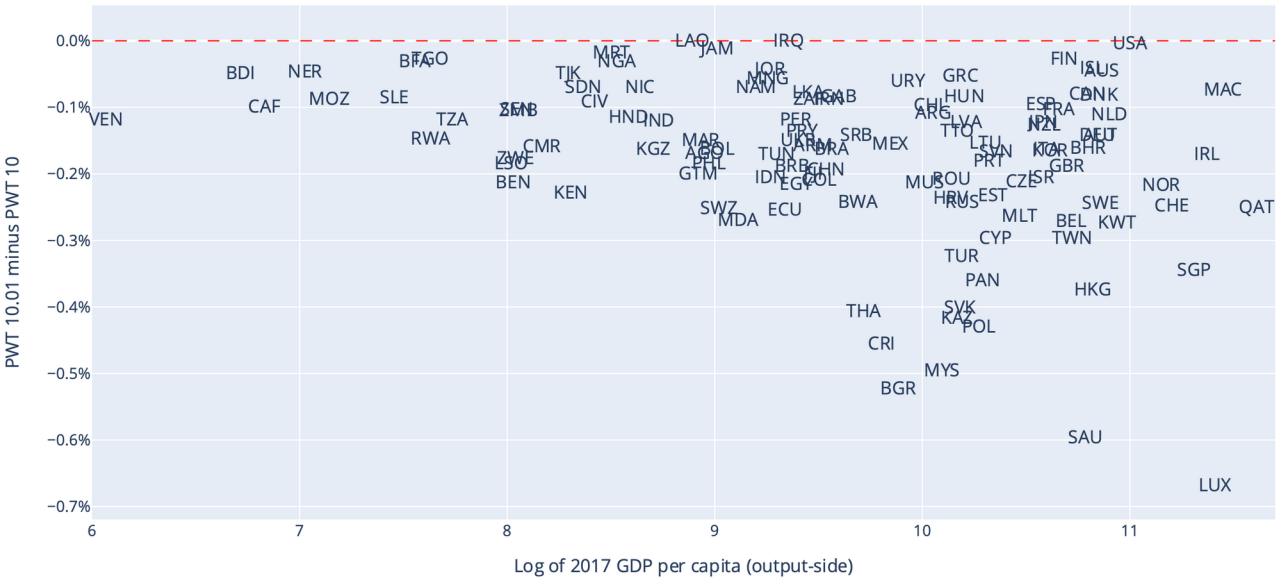


Note: Figure shows on the vertical axis the average annual growth rate of capital services (RKNA) over the period 1970–2010 in PWT 10.01 minus that in PWT 10.01. The log of CGDP^{o} per capita in 2017 is on the horizontal axis. Omitted from this graph to improve clarity are Bosnia and Herzegovina (2.5%) and the Dominican Republic (4.3%).

Impact on Total Factor Productivity (rtfpna)

Figure 4 shows the impact on the 1970-2010 average annual Total Factor Productivity (TFP) growth for 118 available countries. Again, the Dominican Republic is omitted as an outlier (–1.6 percent). Since TFP is calculated as the residual of the growth of output minus the growth of labour and capital services weighted by their cost shares, faster growth in capital services growth implies slower TFP growth. The average difference is –0.19 percent and the correlation with the differences in Figure 3 is –0.92.

Figure 4: 1970-2010 average annual growth of Total Factor Productivity (rtfpna), PWT 10.01 - PWT 10



Note: Figure shows on the vertical axis the average annual growth rate of total factor productivity (RTFPNA) over the period 1970–2010 in PWT 10.01 minus that in PWT 10.01. The log of CGDP^{o} per capita in 2017 is on the horizontal axis. Omitted from this graph to improve clarity is the Dominican Republic (–1.6%).

To summarise the differences in the four figures, Table 2 shows the average difference, the standard deviation of the differences and the correlation of the differences with (log) GDP per capita. To put these differences into perspective, the table also shows average annual growth in PWT 10.01. For the growth in capital stocks and services, the differences are fairly modest, at 0.38–0.44 percent compared to an average annual growth of 4.40–4.54. The impact on TFP growth is more substantial reducing average growth from 0.41 to 0.22. Yet the cross-country patterns of all four variables are much less affected, the correlation of average growth between 10.0 and 10.01 is 0.98–0.99, even for TFP growth.

Table 2: Summary statistics

Figure	Variable	Difference: PWT 10.01–10.0			PWT 10.01
		Mean	StDev	Correlation GDP/cap	Mean
1	Investment deflator growth	-0.46	0.31	-0.31	16.09
2	Capital stock growth	0.38	0.43	0.18	4.54
3	Capital services growth	0.44	0.47	0.19	4.40
4	TFP growth	-0.19	0.18	-0.24	0.22

Notes: The table shows the mean and standard deviation for the differences shown in Figures 1–4, average annual growth for the period 1970–2010 in PWT 10.01 minus 10.0; the correlation of these differences with GDP per capita and the average annual growth in PWT 10.01 for the four variables. Omitting the three outliers from Figure 2 (Bosnia and Herzegovina, Dominican Republic and Cambodia) mostly affects the correlations with GDP per capita, changing these to –0.32, 0.30, 0.33 and –0.35.

References

Feenstra, Robert C., Robert Inklaar and Marcel P. Timmer. (2015). "The Next Generation of the Penn World Table" American Economic Review, 105(10), 3150-3182.

Inklaar, Robert, Pieter Woltjer and Daniel Gallardo Albarran. International 2019. Productivity “The Composition Monitor of Capital and Cross-country Productivity Comparisons” 36(1): 34-52.