Supplementary Materials for
Is Newer Better? Penn World Table Revisions and Their Impact on Growth Estimates

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May 2012

Abstract

This online supplementary note includes i) a technical appendix that describes in detail the construction of the purchase power parity (PPP)-adjusted level of GDP and its growth rate; ii) a technical appendix discussing valuation issues in the measurement of GDP growth in the PWT; iii) additional tables and figures that support the analysis of the main paper.

Technical Appendix 1

The Penn World Table Calculation of the Level and Growth of PPP-Adjusted GDP

We outline below the construction of the purchase power parity (PPP)-adjusted level of GDP and its growth rate. In the process, we highlight some key and relatively unknown facts about PWT data construction. The description below refers to version 6.1 of PWT.[1]

The procedure used by PWT to construct PPP-adjusted GDPs can be stripped down to two main steps. In the first step, international price levels and PPP-adjusted GDPs are calculated for a benchmark year (for PWT 6.1 in 1996). The second step relates to calculations for nonbenchmark years. To do this, international prices for the benchmark year are extrapolated backward and forward to produce PPP time series for each country considered. Then PPP-adjusted GDP levels and growth rates are calculated for all countries and years using the relevant PPPs from step 2. Next, we look into each of the steps, focusing on what is essential in the final construction of the PWT series.

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[1]Special procedures are used for certain countries (i.e., China and India) at various stages. These are not described here and the interested reader is advised to consult the technical appendix to the PWT 6.1.

Step 1: Obtaining PPPs and PPP-adjusted GDPs for the benchmark year

All calculations start for a benchmark year (the year for which detailed price data are collected; for PWT 6.1 in 1996) and for benchmark countries (the countries that participate in the International Comparison Program [ICP]); that is, benchmark countries are those for which actual and detailed price data are collected.[2]

The raw data for calculating PPPs for the benchmark year are:

1. Expenditures in local currencies $(pq)_{ij}$ (obtained from the national income accounts), where i refers to categories of goods and services and j to the country; in PWT 6.1 there were 31 basic categories of goods and services.

2. The individual prices p_{ij} for these basic goods and services categories in each country covered in the ICP exercise.

Dividing these expenditures by the individual prices yield notional quantities for each of the categories (i.e., $q_{ij} = (pq)_{ij} / p_{ij}$).

These data are used to derive two sets of international prices:

1. A set of international prices for each of the 31 categories of goods and services (π_i); that is, these prices are the same for each category for all countries.[3]

2. Purchasing power parity for each country (pl_j); PPPs for each country.

How are the (π_i)s and (pl_j)s derived? They are obtained from a system of two sets of simultaneous equations, which is also known as the Geary (1958) and Khamis (1972) (GK thereafter) aggregation procedure. These equations follow from the definition of the two sets of prices as follows:

$$\pi_i = \sum_j \left[\left(\frac{p_{ij}}{pl_j} \right) \left(\frac{q_{ij}}{\sum_j q_{ij}} \right) \right]. \tag{A1}$$

Equation A1 defines the international price for each commodity. The first expression on the right-hand side (p_{ij}/pl_j) is the price of a category of goods i in country j deflated by that country's PPP, and the second $(q_{ij}/\sum_j q_{ij})$ is the share of i in country j in the world consumption of that good. The equation makes clear that the international price for each of the 31 commodities is the weighted average of their domestic prices, where the weights are the share of each country in total world consumption of that commodity.

$$pl_j = \frac{\sum_i (pq)_{ij}}{\sum_i \pi_i q_{ij}}. \tag{A2}$$

[2] See table 1 for a list of benchmark years and benchmark countries used for different versions of PWT.

[3] International prices for each category are expressed relative to the United States; $\pi_{US} = 1$ for every i.

Equation A2 defines the price level of a country or its PPP. These relative country prices are the heart of the PWT, subsequently used to produce cross-country comparable GDP measures. For each country, the total expenditure in domestic prices divided by the sum of expenditures on each commodity at international prices yields the PPP for that country.[4,5]

As a result of the GK procedure, in PWT 6.1 there are international prices for 31 individual commodities, denoted as (π_i)s, and a set of country-specific PPPs, denoted as (pl_j)s.

A final point is worth making here. The 31 categories of goods and services are also placed into three more aggregate categories corresponding to the three basic categories of domestic absorption (DA)—consumption (C), investment (I), and government (G). For each country j, the country-specific PPPs for C, I, and G (plC_j, plI_j, plG_j) are also calculated. These will vary across countries simply because the composition of the 31 categories of goods and services (for which there are common international prices) will vary across countries.

These prices are used to calculate the PPP-adjusted GDPs for the benchmark year. GDP is calculated as the sum of real domestic absorption (measured at international prices) plus the net foreign balance. The constituent elements of domestic absorption—C, I, and G—are also measured at international prices by multiplying the quantities of C, I, and G by their respective international price obtained above.

$$C_j = \pi_c q_c, \tag{A3}$$

where C_j is consumption at international prices, π_c is international price of consumption and q_c is the notional quantity of consumption. By a similar procedure real I and real G are produced. Summing these three yields real domestic absorption as follows:

$$DA_j = C_j + I_j + G_j, \tag{A4}$$

$$Y_j = DA_j + NFB_j. \tag{A5}$$

DA_j is domestic absorption in international prices for country j, Y is PPP-adjusted GDP and NFB is net foreign balance. Note that the net foreign balance does not require the calculation of PPPs as they are values at the price level of DA (see footnote 8).

[4] Once the PPPs are calculated for the benchmark countries for the benchmark year, the PWT proceeds to calculate the same for non-benchmark countries. This is done essentially through a two-step regression procedure, which yields coefficients that can be used to estimate the PPPs for non-benchmark countries. For the purpose of this paper, the estimation procedure is not relevant and is therefore skipped.

[5] There are also historical data on PPPs obtained from previous ICP rounds. For example, while for PWT 6.1 the ICP was done for 115 countries for the year 1996, a similar exercise was done in 1985 for 64 countries for version PWT 5.6. These 1985 PPPs can be extrapolated using national income accounts deflators for consumption, investment, and government to yield PPPs for 1996. So, for a number of countries, there are multiple data on PPPs for the benchmark year (1996). The PWT then utilizes a weighting method for these multiple data sources to arrive at a final set of international prices or PPPs for the year 1996 for all countries (see pages 9–11 of technical appendix to the PWT 6.1 for details).

Step 2A: Calculating international prices for the non-benchmark years

Once PPPs for the benchmark year are calculated, the PWT extrapolates these PPPs going forward and backward in time. How does it do so? Take PWT 6.1 and the year 1995, which is one year before the benchmark year. For 1995, the PWT obtains nominal expenditures for the three components of domestic absorption—consumption, investment, and government expenditure—from the national income accounts. Each country j will also have a price level associated with C, I, and G (plC_j, plI_j, plG_j, respectively) for 1995. These are just the 1996 PPPs for each of these categories, calculated as shown above, deflated by the price change between 1995 and 1996 for C, I, and G, where the price changes are obtained from national income accounts.

These extrapolated domestic prices for the three components of domestic absorption obtained (plC, plI, plG) are used in place of the detailed price data collected for the benchmark year. However, unlike in the case of the benchmark year where detailed prices are collected for a large set of commodities, for the nonbenchmark years, each country has only three international prices.

With these prices and with national income data for 1995 on consumption, investment, and government expenditures, the PWT uses the GK aggregation procedure to calculate international prices (π)s for C, I, and G, as well as the PPPs (pl)s for all countries exactly as in step 1.

These international prices are then used to convert consumption, investment, and government expenditures at domestic prices into expenditures at international prices as in equation A3 in step 1.

Step 2B: Calculating the level of PPP-adjusted GDP and its growth rate for non-benchmark years

Step 2A yields real C, real I, and real G for all countries for nonbenchmark years. How is the level of PPP-adjusted GDP then calculated, say for 1995? Essentially via a circuitous procedure that first calculates the growth rate of domestic absorption between 1995 and 1996 at international prices and then applies this growth rate to the 1996 level of DA to derive the level of DA in 1995. To this, the net foreign balance for 1995 is added to obtain the level of PPP-adjusted GDP for 1995.

$$\widehat{DA}_{95,96} = a_{95}^{C}\hat{C}_{95,96} + a_{95}^{I}\hat{I}_{95,96} + a_{95}^{G}\hat{G}_{95,96} \ , \tag{A6}$$

$$DA_{95} = DA_{96} / \left(1 + \widehat{DA}_{95,96}\right), \tag{A7}$$

$$Y_{95} = DA_{95} + NFB_{95}, \tag{A8}$$

where DA is domestic absorption in international prices, the hat sign over a variable denotes growth, a_t^C , a_t^I , a_t^G are time varying shares of consumption, investment, and government spending, respectively, in domestic absorption, and NFB is net foreign balance.

Three points are worth emphasizing about equation A6. First, the growth rates of real C, I, and G, are from the national income accounts and mostly do not change across PWT versions.

Because they are from national income accounts, these growth rates are at domestic, not PPP, prices. However, the weights assigned to each of these components, the shares of each component in domestic absorption, are measured at international prices in 1995 which are obtained from steps 1 and 2. For example the share of C is given by:

$$a^C = \frac{C}{DA} = \frac{\pi_c q_c}{C + I + G} \tag{A9}$$

Second, the PWT computes two PPP-adjusted GDP series,[6] the chained series (RGDPCH), which is the most commonly used and the one recommended by the authors of the PWT, and an RGDPL (or Laspeyres series). The difference between the two is simply that in the RGDPCH, the shares change for every year the growth rate is calculated; hence note that the shares are time sensitive. In contrast, in the RGDPL series, the shares remain the same for all years and are the shares (calculated at international prices) for the benchmark year. Therefore, when the PWT is revised, the shares are revised for the benchmark year and all subsequent years. But for the RGDPL series, the changes in nonbenchmark years are not relevant.

Third, this leads to understanding why the growth rates differ between the two series in the PWT and in turn how these differ from the PPP-adjusted growth rate calculation in the WDI. In the WDI, the growth rate will typically NOT change across revisions (other than to reflect revisions of national accounts) because the growth rates are calculated from the national income accounts. In terms of equation A4, PWT and WDI use the same numbers for real consumption, investment, and government growth, all obtained from the national income accounts. It is the shares that are different: in the WDI, these shares are from the national income accounts themselves, and therefore measured at domestic prices, and change with time; for the RGDPL series, the shares are at international prices but fixed at the levels of the benchmark year; for the RGDPCH series, the shares are at international prices and change every year based on changing international prices.

Steps 2A–2B are then repeated for each of the years before and after the benchmark year to yield PPP-adjusted GDP growth rates and levels for these years.

[6] There is a third series called RGDPTT that is not discussed here.

Technical Appendix 2

Valuation issues in the Measurement of GDP Growth in the PWT

How are growth rates computed in the PWT? To answer this question and focus on the key points, we assume that GDP comprises consumption (C) and investment (I) and is hence equal to domestic absorption (DA).

One consumption and one investment good

We start with the case where there is only one consumption and one investment good. First, some notation. The quantities of these goods are denoted by small case letters c and i, respectively. Subscripts, which apply only to value and price variables, refer to whether they are measured at domestic or international (i.e., purchasing power parity) prices. Thus P_{dom} refers to domestic price and P_{int} to international prices. Superscripts refer to the year of measurement, and can either be the current year (T) or the base year (B). For example, C^T denotes real consumption for the year T. For the price variables, there will be two superscripts, the first referring to the year of measurement and the second to the good (consumption, c, or investment, i). Thus P_{dom}^{BC}refers to the price of the consumption good measured at domestic prices for the base year. Thus,

$$GDP = DA = C + I = Y, \tag{B1}$$

$$\hat{Y}^T = \frac{C_{int}^T}{Y_{int}^T}\frac{\Delta C_{dom}^T}{C_{dom}^T} + \frac{I_{int}^T}{Y_{int}^T}\frac{\Delta I_{dom}^T}{I_{dom}^T}, \tag{B2}$$

where the hat sign over a variable denotes growth. Equation B2 simply says that GDP growth in year T is a weighted average of growth of consumption and investment. In the PWT's chain series (RGDPCH), the weights are the shares of C and I in domestic absorption measured at current international prices. So, if the growth rate is calculated for the period 1993–1994, the weights are at 1993 PPP prices obtained from the Geary-Khamis aggregation procedure described in step 1 in technical appendix 1. Note that the growth rates of C ($\frac{\Delta C_{dom}^T}{C_{dom}^T}$) and I ($\frac{\Delta I_{dom}^T}{I_{dom}^T}$) are obtained from the national income accounts and are therefore at domestic base-year prices.

Equation B2 can be rewritten as:

$$\hat{Y}^T = \frac{c^T P_{int}^{TC}}{Y_{int}^T}\frac{\Delta c^T}{c^T}\frac{P_{dom}^{BC}}{P_{dom}^{BC}} + \frac{i^T P_{int}^{Ti}}{Y_{int}^T}\frac{\Delta i^T}{i^T}\frac{P_{dom}^{Bi}}{P_{dom}^{Bi}},$$

which in turn simplifies to:

$$\hat{Y}^T = \frac{\left(\Delta c^T P_{int}^{TC} + \Delta i^T P_{int}^{Ti}\right)}{Y_{int}^T}. \tag{B3}$$

Equation B3 shows that the PWT chain series for the growth rate essentially involves valuing the additions to (the quantities) of consumption and investment at current year international prices. This is a chain-weighted index because the prices used for valuing these additions change every year.

As a result, the RGDPCH series does not use benchmark year international prices; it uses current year international prices that are obtained in the PWT by extrapolating from the benchmark years (see technical appendix 1, step 2) and applying the GK aggregation procedure. These prices change with every revision as shown below and the revisions are not random but systematically related to country attributes.

A second feature of these current year international prices is that they are calculated at a highly aggregated level, namely at the level of aggregate consumption and investment. For the benchmark year, aggregate consumption is obtained by adding up consumption of the different goods for which disaggregated price data are available. For nonbenchmark years, it is as if there is only one consumption and one investment good.

Two consumption and one investment good

Does this aggregation affect the calculation of growth rates? Suppose there are two consumption goods and one investment good. The spirit of the PWT suggests that all three goods should be valued at international prices. But how are they actually valued? If we had disaggregated international prices, we can write down how growth of *DA* should be computed. Essentially, equation B2 should be rewritten to take account of the extra consumption good. Thus,

$$\hat{Y}^T = \frac{\left(\Delta c^{T1} P_{int}^{T1} + \Delta c^{T2} P_{int}^{T2} + \Delta i^T P_{int}^{Ti}\right)}{Y_{int}^T}. \tag{B4}$$

Now, the second superscript is *1* or *2* for the two consumption goods and i for the investment good. Equation B4 is just an extension of equation B3 and says that GDP growth is obtained by valuing each of the quantity changes (to the consumption goods and investment good) at their respective current international prices.

But for nonbenchmark years, we do not have disaggregated international price data. GDP growth ($\hat{Y}_2^T$) is measured as follows:

$$\hat{Y}_2^T = \frac{\bar{C}_{int}^T}{Y_{int}^T}\left(\frac{\Delta C_{dom}^{T1} + \Delta C_{dom}^{T2}}{\bar{C}_{dom}^T}\right) + \frac{I_{int}^T}{Y_{int}^T}\frac{\Delta I_{dom}^T}{I_{dom}^T},$$

which can be simplified to:

$$\hat{Y}_2^T = \frac{\left(c^{T1} + c^{T2}\right)\bar{P}_{int}^{TC}}{Y_{int}^T}\left\{\frac{\left(\Delta c^{T1} P_{dom}^{B1} + \Delta c^{T2} P_{dom}^{B2}\right)}{\left(c^{T1} + c^{T2}\right)\bar{P}_{dom}^{BC}}\right\} + \frac{\Delta i^T}{Y_{int}^T}\frac{P_{dom}^{Bi}}{P_{dom}^{Bi}}P_{int}^{Ti},$$

and further to:

$$\hat{Y}_2^T = \frac{1}{Y_{int}^T}\left\{\Delta c^{T1}\left(\frac{P_{dom}^{B1}}{\bar{P}_{dom}^{BC}}\bar{P}_{int}^{TC}\right) + \Delta c^{T2}\left(\frac{P_{dom}^{B2}}{\bar{P}_{dom}^{BC}}\bar{P}_{int}^{TC}\right)\right\} + \frac{\Delta i^T P_{int}^{Ti}}{Y_{int}^T}. \tag{B5}$$

Equation B5 shows that each of the quantity changes is valued not at current year international prices (as in equation B4) but at some hybrid of domestic and international prices. The bar sign

over a variable denotes that it refers to the composite good as does the second superscript C. The price term in brackets for the two consumption goods consists of $\left\{\left(\frac{P_{dom}^{B1}}{\bar{P}_{dom}^{BC}}\right)\right\}$which is the domestic relative price of that good (that is, it the domestic price of good 1 relative to the average price of the composite of goods 1 and 2); and $\bar{P}_{int}^{TC}$is the average international price of the composite of goods 1 and 2.

To more clearly identify the difference between how GDP growth ought to be measured and how it is, we can take the difference between equations B4–B5, which yields:

$$\hat{Y}^T - \hat{Y}_2^T = \frac{\bar{P}_{int}^{TC}}{Y_{int}^T}\left\{\Delta c^{T1}\left(\frac{P_{int}^{T1}}{\bar{P}_{int}^{TC}} - \frac{P_{dom}^{B1}}{\bar{P}_{dom}^{BC}}\right) + \Delta c^{T2}\left(\frac{P_{int}^{T2}}{\bar{P}_{int}^{TC}} - \frac{P_{dom}^{B2}}{\bar{P}_{dom}^{BC}}\right)\right\}. \tag{B6}$$

This equation shows that the difference between the two depends on how different the relative price is of a consumption good at domestic prices $(\frac{P_{dom}^{B1}}{\bar{P}_{dom}^{BC}})$ from its relative price at international prices $(\frac{P_{int}^{T_1}}{\bar{P}_{int}^{TC}})$. Note that this difference will vary across time because domestic prices are computed for a fixed base period (which can be different across countries) while the international prices are current prices.

We know that this difference in the relative prices will vary systematically across countries. It will be greater for smaller countries because under the GK procedure domestic prices of larger countries have a greater weight when computing international prices. This is the Gerschenkron effect. Thus, GDP growth rates are likely to be measured with greater error (relative to the true growth rate that is consistent with the spirit of the PWT as represented in equation B4) for smaller countries.

A second problem is that the farther away T is from the base year, the greater the discrepancy. Hence growth rate calculations for years farther away from the benchmark year are likely to have greater measurement error.

References

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Khamis, Salem H. 1972. "A New System of Index Numbers for National and International Purposes." *Journal of the Royal Statistical Society, Series A (General)* 135: 96–121.

Appendix Table 1. Countries in the long-run sample

ISO	Country	GDP	Differences between PWT 6.2 and PWT 6.1				Benchmarks	Grade
			Prices	GDP Growth	I/GDP	C/GDP		
ARG	Argentina	26.69	2%	-0.08%	-9%	-1%	2	B
AUS	Australia	26.77	8%	0.06%	-1%	-5%	3	A
AUT	Austria	25.99	-6%	-0.02%	-7%	-3%	5	A
BDI	Burundi	22.14	5%	0.84%	-30%	2%	0	C
BEL	Belgium	26.14	2%	0.02%	-5%	2%	6	A
BEN	Benin	22.61	8%	0.10%	16%	-9%	2	C
BFA	Burkina Faso	22.92	-2%	-0.32%	3%	13%	0	C
BOL	Bolivia	23.77	4%	0.17%	6%	0%	2	C
BRA	Brazil	27.77	30%	-0.30%	-7%	3%	3	C
BRB	Barbados	22.07	10%	-2.29%	-68%	-15%	2	C
BWA	Botswana	22.94	14%	-0.54%	2%	-7%	3	C
CAN	Canada	27.24	6%	-0.03%	0%	1%	4	A
CHE	Switzerland	25.96	-1%	0.20%	4%	2%	2	A
CHL	Chile	25.74	-5%	-0.34%	11%	-5%	2	B
CHN	China	28.9	25%	1.95%	49%	-16%	0	C
CIV	Cote d'Ivoire	24.12	12%	1.11%	5%	-4%	3	C
CMR	Cameroon	24.09	19%	-0.03%	-33%	-7%	3	C
COG	Congo, Republic of	22.46	-8%	-1.48%	16%	9%	2	C
COL	Colombia	26.13	3%	0.07%	7%	1%	3	C
COM	Comoros	20.55	14%	0.79%	56%	-9%	0	D
CPV	Cape Verde	21.02	-11%	-0.73%	-11%	-7%	0	D
CRI	Costa Rica	23.94	0%	0.17%	-42%	17%	1	C
DNK	Denmark	25.6	4%	0.03%	-6%	-8%	5	A
DOM	Dominican Republic	24.45	-2%	-0.31%	-18%	-3%	1	C
DZA	Algeria	25.8	4%	-0.30%	-9%	-12%	0	D
ECU	Ecuador	24.71	-14%	0.21%	17%	6%	2	C
EGY	Egypt	26.3	4%	0.41%	17%	2%	2	C
ESP	Spain	27.23	1%	0.13%	-7%	-11%	5	B
ETH	Ethiopia	24.33	12%	1.55%	-16%	5%	2	C
FIN	Finland	25.28	4%	-0.32%	10%	-21%	4	A
FJI	Fiji	22.09	3%	-0.22%	-6%	10%	1	C
FRA	France	27.89	0%	0.06%	-7%	-12%	6	A
GAB	Gabon	23.4	4%	-1.65%	-61%	-43%	1	C
GBR	United Kingdom	27.86	0%	0.12%	-5%	-15%	6	A
GER	Germany	28.27	-4%	-0.02%	4%	-1%	1	B
GHA	Ghana	23.82	-3%	0.61%	-4%	17%	0	C
GIN	Guinea	23.64	15%	-0.42%	-28%	-7%	1	C
GMB	Gambia, The	20.66	48%	-0.03%	26%	12%	0	C
GNB	Guinea-Bissau	20.48	23%	-3.30%	-25%	-36%	0	D
GNQ	Equatorial Guinea	20.36	78%	7.18%	-30%	-28%	0	D
GRC	Greece	25.61	5%	-0.14%	-4%	-1%	4	B
GTM	Guatemala	24.46	0%	-0.23%	-7%	-1%	1	C
HKG	Hong Kong	25.88	0%	-0.14%	-2%	1%	3	A
HND	Honduras	23.27	0%	0.23%	1%	1%	1	C
HUN	Hungary	25.32	-1%	0.08%	-3%	-20%	5	C
IDN	Indonesia	27.43	-5%	-0.48%	9%	-9%	2	C
IND	India	28.35	0%	-0.01%	-10%	-9%	4	C
IRL	Ireland	24.89	7%	-0.33%	13%	-8%	5	A
IRN	Iran	26.54	-17%	-0.24%	56%	-19%	4	C

Appendix Table 1 (contd.) . Countries in the long-run sample

ISO	Country	GDP	Differences between PWT 6.2 and PWT 6.1				Benchmarks	Grade
			Prices	GDP Growth	I/GDP	C/GDP		
ISL	Iceland	22.5	2%	0.03%	-5%	-7%	2	B
ISR	Israel	25.43	-2%	-0.06%	-11%	-9%	2	B
ITA	Italy	27.8	1%	-0.09%	-1%	-5%	6	A
JAM	Jamaica	23.2	-18%	0.17%	-8%	23%	3	C
JOR	Jordan	23.52	-24%	-2.21%	8%	11%	1	C
JPN	Japan	28.72	5%	-0.07%	-1%	-8%	6	A
KEN	Kenya	24.32	0%	-1.15%	10%	-1%	5	C
KOR	Korea, Republic of	27.19	9%	0.16%	2%	-3%	5	B
LKA	Sri Lanka	24.89	-2%	1.49%	27%	-10%	4	C
LSO	Lesotho	21.78	6%	1.39%	13%	15%	0	D
LUX	Luxembourg	23.44	-5%	-0.09%	8%	-7%	5	A
MAR	Morocco	25.4	0%	-0.08%	-9%	1%	3	C
MDG	Madagascar	23.18	-3%	-0.38%	33%	-9%	3	C
MEX	Mexico	27.21	11%	0.13%	-2%	-6%	3	C
MLI	Mali	22.96	-4%	1.05%	14%	-7%	3	C
MOZ	Mozambique	23.44	89%	1.76%	17%	-8%	0	D
MRT	Mauritania	21.93	16%	1.73%	110%	-2%	0	C
MUS	Mauritius	23.41	-4%	0.09%	-8%	-4%	2	C
MWI	Malawi	22.8	2%	-0.06%	-23%	7%	4	C
MYS	Malaysia	26.03	2%	0.94%	-2%	-2%	2	C
NAM	Namibia	22.81	-26%	0.00%	-36%	1%	0	D
NER	Niger	22.71	-3%	1.25%	-10%	-14%	0	D
NGA	Nigeria	25.47	6%	0.87%	-16%	-3%	3	C
NIC	Nicaragua	23.39	18%	0.92%	-21%	-11%	0	C
NLD	Netherlands	26.6	-1%	-0.20%	-1%	-6%	6	A
NOR	Norway	25.59	-1%	0.06%	-11%	-27%	4	A
NPL	Nepal	24.1	1%	-0.30%	4%	-1%	2	C
NZL	New Zealand	24.97	-1%	0.16%	-3%	-15%	1	B
PAK	Pakistan	26.46	3%	-0.13%	6%	-7%	4	C
PAN	Panama	23.64	2%	0.92%	-9%	14%	2	C
PER	Peru	25.35	-9%	-0.22%	-7%	-1%	2	C
PHL	Philippines	26.23	-2%	0.08%	-7%	-2%	5	C
PNG	Papua New Guinea	23.68	28%	2.69%	-38%	-5%	0	D
PRT	Portugal	25.75	-5%	-0.07%	-4%	-5%	4	B
PRY	Paraguay	23.99	-10%	-0.02%	1%	18%	1	C
ROM	Romania	25.55	22%	0.05%	-28%	-15%	2	C
RWA	Rwanda	22.44	3%	-0.22%	-31%	13%	1	C
SEN	Senegal	23.19	-3%	0.10%	-20%	13%	3	C
SLV	El Salvador	23.97	0%	0.60%	9%	17%	1	C
SWE	Sweden	25.99	1%	-0.05%	0%	-7%	3	A
SYR	Syria	24.09	58%	-0.91%	-34%	-8%	2	C
TCD	Chad	22.56	22%	0.38%	-8%	6%	0	D
TGO	Togo	22.08	10%	0.04%	44%	-7%	0	D
THA	Thailand	26.75	1%	0.10%	1%	6%	3	C
TTO	Trinidad &Tobago	23.24	-13%	-0.65%	91%	-1%	2	C
TUN	Tunisia	24.73	-1%	-0.09%	21%	2%	3	C
TUR	Turkey	26.56	27%	0.02%	-14%	1%	3	C
TZA	Tanzania	23.44	-10%	1.83%	-77%	24%	3	C
UGA	Uganda	23.67	-46%	-1.56%	15%	-6%	0	D
URY	Uruguay	24.24	-3%	0.28%	10%	-1%	3	B
USA	USA	29.74	0%	-0.06%	-2%	0%	6	A
VEN	Venezuela	25.83	1%	1.35%	1%	1%	2	C
ZAF	South Africa	26.45	7%	0.42%	-21%	5%	0	C
ZMB	Zambia	22.74	3%	-0.07%	62%	25%	4	C
ZWE	Zimbabwe	24.28	-25%	-0.34%	-36%	6%	3	C

Appendix Table 2. Ramey and Ramey (1995) replication results

Dependent variable ⟶	**growth of per capita GDP**				
	[1]	[2]	[3]	[4]	[5]
Dataset substitution	None	None	PWT6.2	None	PWT6.2
Sample	Original	Balanced	Balanced	Balanced	Balanced
PWT grades included	All	All	All	A,B,C	A,B,C
Standard deviation of growth rates	-0.177*** [2.426]	-0.151* [1.821]	-0.074 [0.94]	-0.107 [1.254]	-0.132 [1.460]
N	2208	1776	1776	1608	1608

***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. t-statistics in brackets.

Notes: This table presents a replication exercise of Ramey and Ramey (1995) by updating their original PWT 5.6 GDP data with PWT 6.2 data. The equation estimated is: $\Delta y_{it} = \lambda \sigma_i + \theta X_{it} + \varepsilon_{it}$, where y is the log-level of per-capita GDP, σ_i is the standard deviation of ε_{it} in i across t, and X is a vector of controls including initial investment share of GDP, initial population growth rate, initial human capital, initial per-capita GDP, lagged GDP, and several time trend and dummy variables. All specifications replicate Table 1, equation (1), in Ramey and Ramey (1995). For presentation purposes we focus only on the key parameter - variation of growth rate - and omit other parameter estimates. Specification [1] replicates the main result in Ramey and Ramey (1995) using their original data. Specification [2] presents the same result using PWT 5.6 after dropping observations to balance the data with available observations in PWT 6.2. Specification [3] presents our main result when we replace the balanced sample using PWT 5.6 with PWT 6.2. Specification [4] replicates [2] when countries with quality grading "D" are dropped. Specification [5] replicates [3] when countries with quality grading "D" are dropped.

Source: Authors' calculations based on Ramey and Ramey (1995).

Appendix Table 3. Jones and Olken (2005) replication results

Dependent variable →	**Annual growth rate**				
Hypothesis →	**Leader deaths affect growth (Wald p-value)**				
	[1]	[2]	[3]	[4]	[5]
Dataset substitution	None	None	PWT6.2	None	PWT6.2
Sample	Original	Balanced	Balanced	Balanced	Balanced
PWT grades included	All	All	All	A,B,C	A,B,C
Years after leader's death	All leaders				
t	0.057*	0.054*	0.093*	0.012**	0.110
1	0.085*	0.122	0.218	0.028**	0.130
2	0.067*	0.133	0.203	0.039**	0.141
Number of leader deaths	57	52	52	45	45
Years after leader's death	All leaders, tenure >=2 Years				
0	0.039**	0.039**	0.04**	0.011**	0.049**
1	0.054*	0.087*	0.140	0.021**	0.068*
2	0.031**	0.076*	0.102	0.023**	0.049**
Number of leader deaths	47	42	42	36	36
Years after leader's death	Autocrats				
0	0.019**	0.032**	0.199	0.012**	0.304
1	0.016**	0.049**	0.356	0.011**	0.227
2	0.028**	0.100*	0.314	0.026**	0.183
Number of leader deaths	29	26	26	21	21
Years after leader's death	Democrats				
0	0.460	0.326	0.044**	0.236	0.039**
1	0.552	0.415	0.092*	0.291	0.069*
2	0.432	0.370	0.134	0.359	0.113
Number of leader deaths	22	20	20	19	19

***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. t-statistics in brackets.

Notes: This table presents a replication exercise of Jones and Olken (2005) by updating their original PWT 6.1 GDP data with PWT 6.2 data The equation estimated is: $g_{it} = \alpha_z PRE_z + \beta_z POST_z + \nu_i + \nu_t + \varepsilon_{it}$, where *g* is growth of per-capita GDP and v_i and v_j are fixed country and time effects. For each leader death at *t*, there are location-specific time dummy variables equal to 1 in one of *t-5, t-4,...,t-1*, *t+1, t+2,...,t+5* and equal to 0 otherwise. These vectors of dummy variables are denoted *PRE* and *POST*. Results are Wald p-values of the joint test that $PRE_z = POST_z$. All specifications replicate results from Tables III and V in Jones and Olken (2005). Specification [1] replicates the main result in Jones and Olken (2005) using their original data. Specification [2] presents the same result using PWT 6.1 after dropping observations to balance the data with available observations in PWT 6.2. Specification [3] presents our main result when we replace the balanced sample using PWT 6.1 with PWT 6.2. Specification [4] replicates [2] when countries with quality grading "D" are dropped. Specification [5] replicates [3] when countries with quality grading "D" are dropped. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Source: Authors' calculations based on Jones and Olken (2005).

Appendix Table 4. Hausmann, Pritchett and Rodrik (2005) replication results

PWT 6.1 (Hausmann, Pritchett, and Rodrik)		PWT 6.2		PWT 6.1 (Hausmann, Pritchett, and Rodrik)		PWT 6.2		PWT 6.1 (Hausmann, Pritchett, and Rodrik)		PWT 6.2	
ARG	1963	ARG	1963	IDN	1967	IDN	1967	PAK	1979	PAK	1977
ARG	1990	ARG	1990	IDN	1987	IDN	1985	PAN	1959	PAN	1959
AUS	1961	**No break**		IND	1982	**No break**		PAN	1975	PAN	1975
BEL	1959	BEL	1959	IRL	1958	IRL	1958	PER	1959	PER	1959
BRA	1967	BRA	1968	IRL	1985	IRL	1986	**No break**		PHL	1970
No break		BWA	1984	**No break**		IRN	1966	PNG	1987	**No break**	
CAN	1962	CAN	1961	ISR	1957	ISR	1957	POL	1992	POL	1992
CHL	1986	CHL	1986	**No break**		ISR	1989	**No break**		PRT	1959
CHN	1978	CHN	1977	ISR	1967	ISR	1967	PRT	1985	PRT	1985
CHN	1990	CHN	1991	JOR	1973	**No break**		PRY	1974	PRY	1974
CMR	1972	**No break**		JPN	1958	JPN	1958	ROM	1979	ROM	1971
No break		CMR	1978	**No break**		JPN	1984	RWA	1975	RWA	1975
COG	1969	COG	1968	KOR	1962	KOR	1963	SGP	1969	SGP	1967
COG	1978	COG	1976	KOR	1984	KOR	1984	**No break**		SGP	1987
COL	1967	COL	1967	LKA	1979	**No break**		SYR	1969	SYR	1969
DNK	1957	DNK	1957	**No break**		LKA	1958	SYR	1974	**No break**	
DOM	1969	DOM	1969	LSO	1971	LSO	1971	SYR	1989	SYR	1991
DOM	1992	DOM	1991	**No break**		LSO	1992	TCD	1973	**No break**	
DZA	1975	**No break**		MAR	1958	MAR	1958	THA	1957	THA	1957
ECU	1970	ECU	1970	MLI	1972	MLI	1973	THA	1986	THA	1986
EGY	1976	EGY	1975	MUS	1971	MUS	1970	TTO	1975	**No break**	
ESP	1959	ESP	1959	MUS	1983	MUS	1983	TUN	1968	TUN	1968
ESP	1984	ESP	1984	MWI	1970	MWI	1970	TWN	1961	TWN	1961
No break		ETH	1988	MWI	1992	MWI	1990	**No break**		TWN	1985
FIN	1958	FIN	1958	MYS	1970	MYS	1967	**No break**		TZA	1992
FIN	1967	**No break**		MYS	1988	MYS	1988	UGA	1977	**No break**	
No break		GAB	1969	**No break**		NER	1974	UGA	1989	**No break**	
FIN	1992	FIN	1992	NGA	1957	**No break**		URY	1974	URY	1974
GBR	1982	GBR	1982	NGA	1967	NGA	1968	URY	1989	URY	1988
GHA	1965	GHA	1965	NIC	1960	NIC	1960	USA	1961	USA	1961
GNB	1969	**No break**		NOR	1991	NOR	1992	**No break**		VEN	1971
GNB	1988	**No break**		NZL	1957	NZL	1957	**No break**		ZMB	1963
No break		HND	1974	PAK	1962	PAK	1961	ZWE	1964	ZWE	1967
HTI	1990	**No break**									

Notes: This table compares growth breaks in per capita GDP (RGDPCH series) obtained from using the original PWT 6.1 in Hausmann, Pritchett, and Rodrik (2005) with those obtained using PWT 6.2. Growth breaks are reproduced using Hausmann, Pritchett, and Rodrik (2005) original Gauss code. **No break** indicates an inconsistency between PWT 6.1 and PWT 6.2 in obtaining growth break dates that are more than three years apart for each country considered. Hausmann, Pritchett, and Rodrik (2005) identified an additional break for BWA in 1969 using PWT 6.1, but data for Botswana does not go farther back than 1970 in PWT 6.2. There are 35 cases (out of 100; 35 percent) where such inconsistencies are detected.
Source: Authors' calculations based on Hausmann, Pritchett, and Rodrik (2005).

Appendix Table 5. Miguel, Satyanath and Sergenti (2004) replication results

Dependent variable	→		**log (civil conflict)**			
	[1]	[2]	[3]	[4]	[5]	[6]
Estimation	OLS	OLS	OLS	2SLS	2SLS	2SLS
Dataset substitution	None	None	PWT	None	None	PWT
Sample	Original	Balanced	Balanced	Original	Balanced	Balanced
PWT grades included	All	All	All	All	All	All
Economic Growth Rate, t	-0.145	-0.144	-0.327*	-0.383	-0.284	-1.985
	[0.767]	[0.727]	[1.668]	[0.276]	[0.217]	[1.351]
Economic Growth Rate, t-1	0.071	0.079	0.006	-2.139**	-2.078**	-2.307**
	[-0.368]	[-0.395]	[-0.029]	[2.078]	[2.096]	[2.327]
N	743	724	724	743	724	724
R-squared	0.52	0.50	0.49	0.39	0.38	0.29

***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. t-statistics in brackets.

Notes: This table presents a replication exercise of Miguel, Satyanath and Sergenti (2004) by updating their original PWT 5.6 GDP data with PWT 6.2 data. The estimated equation is: $conflict_{it} = \alpha_i + X_{it}'\beta + \gamma_0 growth_{it} + \gamma_1 growth_{it-1} + \delta_i year_t + \varepsilon_{it}$, with $growth_{it}$ instrumented by $rainfall_{it}$ and $rainfall_{it-1}$ in the 2SLS specifications. X contains the log of per-capita GDP in 1979, a lagged democracy index (Polity IV), ethnolinguistic fractionalization, religious fractionalization, an oil-exporter dummy variable, an index of topography (mountains), and the log of lagged population. All specifications replicate table 4, equations 3 and 5, in Miguel, Satyanath and Sergenti (2004). For presentation purposes we focus only on the key parameter - current and lagged growth rates - and omit other parameter estimates. Specification [1] replicates the main OLS result in Miguel, Satyanath and Sergenti (2004) using their original data. Specification [2] presents the same result using PWT 5.6 after dropping observations to balance the data with available observations in PWT 6.2. Specification [3] presents our main result when we replace the balanced sample using PWT 5.6 with PWT 6.2. Specifications [4], [5], [6] replicate specifications [1], [2], [3], respectively, using 2SLS, using rainfall as an instrument for current and lagged economic growth.

Source: Authors' calculations based on Miguel, Satyanath, and Sergenti (2004).

Appendix Table 6. Aghion, Howitt and Mayer-Foulkes (2005) replication results

Dependent variable	→		**log (growth gap)**		
	[1]	[2]	[3]	[4]	[5]
Dataset substitution	None	None	PWT6.2	None	PWT6.2
Sample	Original	Balanced	Balanced	Balanced	Balanced
PWT grades included	All	All	All	A,B,C	A,B,C
Financial development	-0.015	-0.015	0.011	-0.009	0.013
	[0.93]	[0.94]	[0.93]	[0.60]	[1.21]
Financial development	-0.061***	-0.061***	-0.041***	-0.048***	-0.031**
* Initial GDP gap (1960)	[5.35]	[4.84]	[4.16]	[3.87]	[3.25]
Initial GDP gap (1960)	1.507***	1.505***	0.402	1.031*	0.090
	[3.14]	[2.83]	[1.02]	[1.95]	[0.25]
N	71	60	60	57	57
R-squared	0.51	0.34	0.37	0.31	0.37
Implied convergence threshold, $-\beta_y / \beta_{fy}$	24.70	24.83	9.76	21.61	2.92
Number of countries above threshold	37 out of 71	37 out of 71	65 out of 71	48 out of 71	71 out of 71
Instruments: legal origins, legal origins * initial GDP gap					
Conditioning set: EMPTY					

***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. t-statistics in brackets.

Notes: This table presents a replication exercise of Aghion, Howitt, and Mayer-Foulkes (2005) by updating their original GDP data obtained from Levine, Loayza and Beck (2000) dataset with PWT 6.2 data. The equation estimated is: $g_i - g_1 = \beta_0 + \beta_f F_i + \beta_y (y_i - y_1) + \beta_{fy} F_i (y_i - y_1) + \varepsilon_i$, where y_i-y_1 is the gap in output between country *i* and the country at the technology frontier, g_i-g_1 is the gap in per capita GDP growth, and *F* is the level of financial development. All specifications replicate table 1, equation (1), in Aghion, Howitt, and Mayer-Foulkes (2005). Specification [1] replicates the main result in Aghion, Howitt, and Mayer-Foulkes (2005) using their original data. Specification [2] presents the same result using Levine, Loayza and Beck's data after dropping observations to balance the data with available observations in PWT 6.2. Specification [3] presents our new result when we replace the balanced sample using Levine, Loayza and Beck's data with PWT 6.2 data. Specification [4] replicates [2] when countries with quality grading "D" are dropped. Specification [5] replicates [3] when countries with quality grading "D" are dropped.

Source: Authors' calculations based on Aghion, Howitt, and Mayer-Foulkes (2005).

Appendix Table 7. Mankiw, Romer, and Weil (1992) replication results

Dependent variable ⟶	**Log of GDP per capita in 1985**				
	[1]	[2]	[3]	[4]	[5]
Dataset substitution	None	None	PWT6.2	None	PWT6.2
MRW sample	Non-Oil	Non-Oil	Non-Oil	Non-Oil	Non-Oil
Sample	Original	Balanced	Balanced	Balanced	Balanced
PWT grades included	All	All	All	A,B,C	A,B,C
log(I/GDP)-log(n+g+d)	0.738***	0.713***	0.431***	0.754***	0.430***
	[5.96]	[5.21]	[3.22]	[5.28]	[2.99]
log(school) –log(n+g+d)	0.657***	0.622***	0.711***	0.639***	0.761***
	[9.07]	[7.92]	[6.98]	[7.59]	[6.86]
N	98	83	83	77	77
R-squared	0.78	0.79	0.73	0.78	0.71
Solow restriction p-value	0.654	0.653	0.210	0.584	0.166

***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. t-statistics are in brackets.

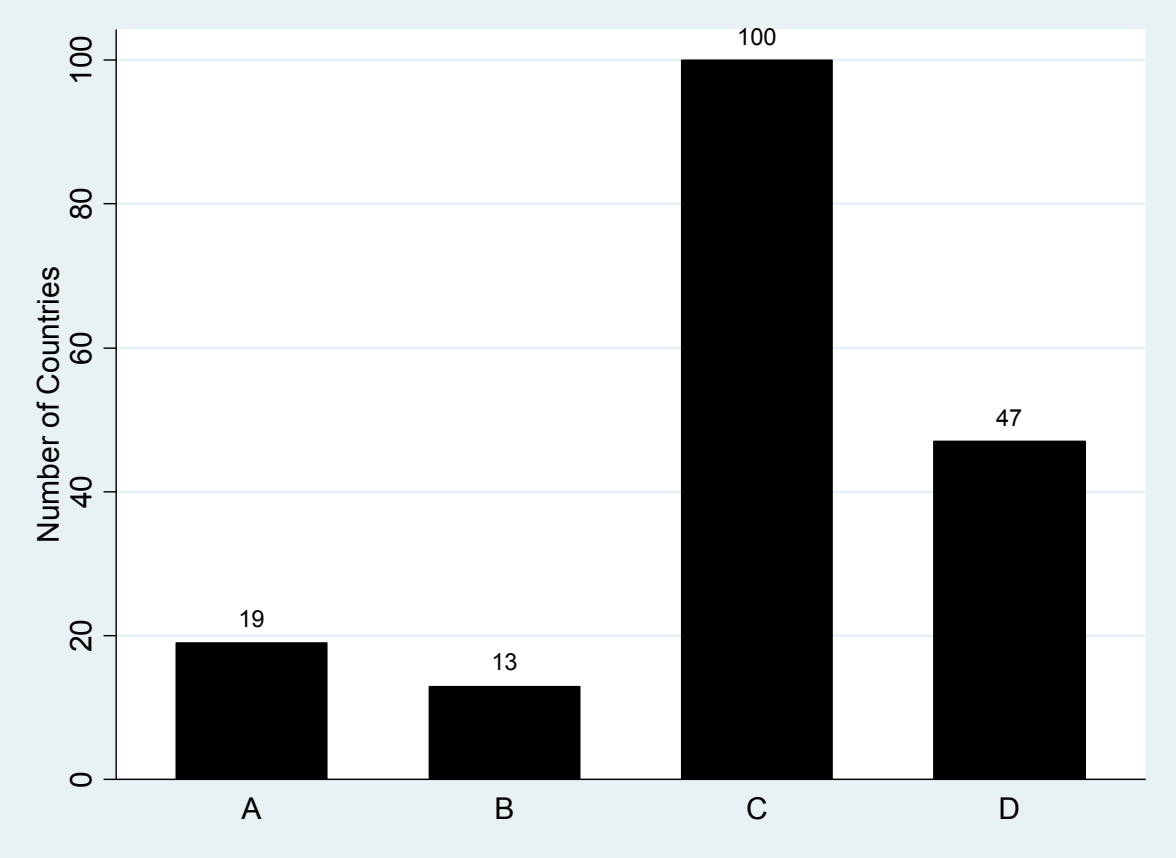
Notes: This table presents a replication exercise of Mankiw, Romer, and Weil (1992) by updating their original PWT 4.0 GDP and I/GDP data with PWT 6.2 data. The equation estimated is:

$$\ln(Y/L) = \pi_0 + \pi_1[\ln(I/GDP) - \ln(n+g+\delta)] + \pi_2[\ln(school) - \ln(n+g+\delta)] + \varepsilon,$$

where *Y/L* is GDP per worker, *I/GDP* is the investment share of GDP, *n* is the population growth rate, *g* is the technology growth rate, δ is the rate of capital depreciation, and *school* is average number of working age adults in school from 1960-1985. All specifications replicate the Table 2 restricted regressions in Mankiw, Romer, and Weil (1992). The "Solow Restriction" is the restriction that $\pi_1 = \pi_2$. Specification [1] replicates the main result in Mankiw, Romer, and Weil (1995) using their original data. Specification [2] presents the same result using PWT 4.0 for the sample of non-oil countries after dropping observations to balance the data with available observations in PWT 6.2. Specification [3] presents our main result when we replace the balanced sample using PWT 4.0 with PWT 6.2. Specification [4] replicates [2] when countries with quality grading "D" are dropped. Specification [5] replicates [3] when countries with quality grading "D" are dropped.

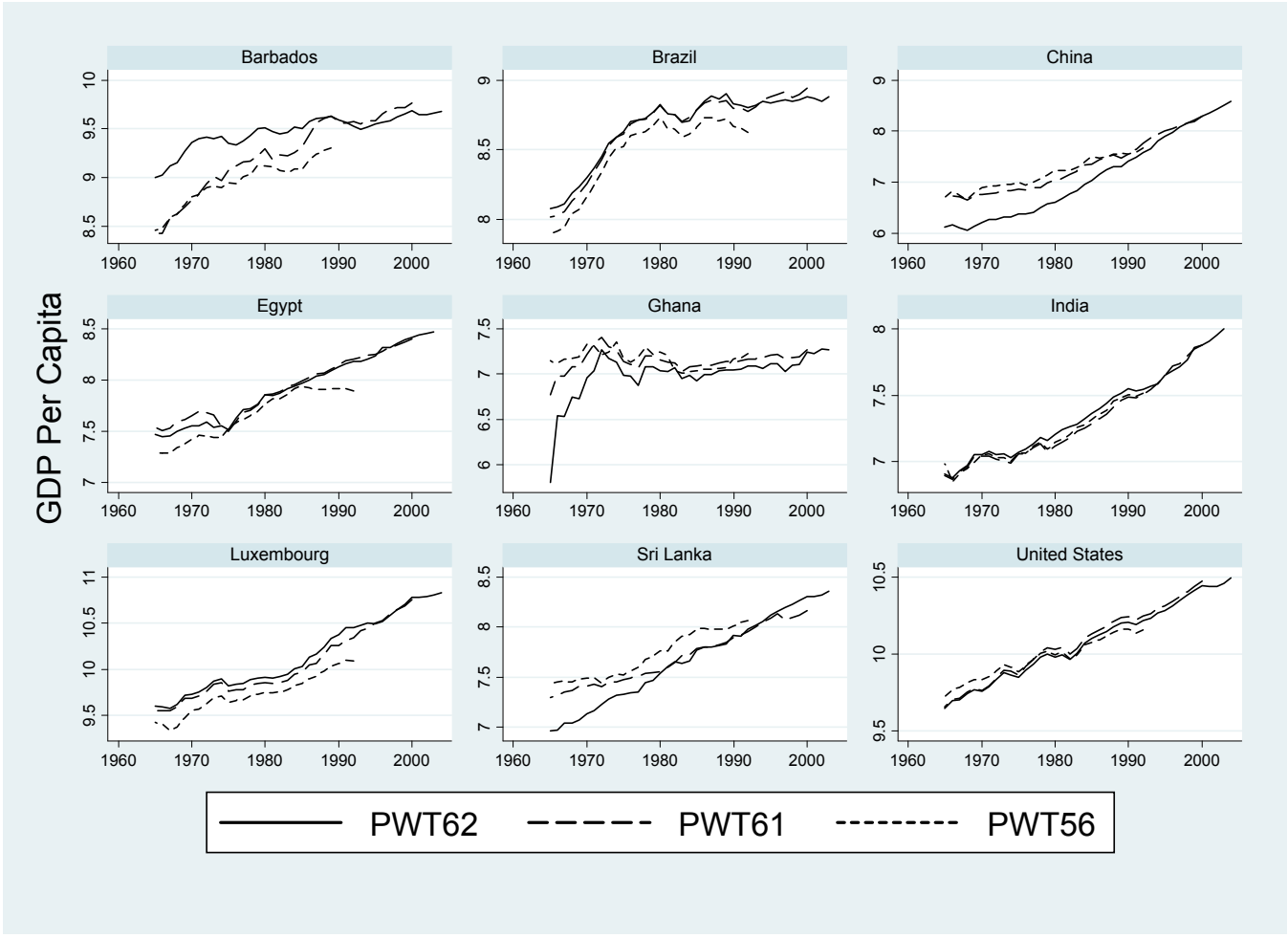
Source: Authors' calculations based on Mankiw, Romer, and Weil (1992).

Appendix Figure 1. Countries with respective PWT data quality grades



Source: ICP benchmark studies and quality grades used in PWT 6.1.

Appendix Figure 2. GDP per capita: PWT 6.2, PWT 6.1, and PWT 5.6



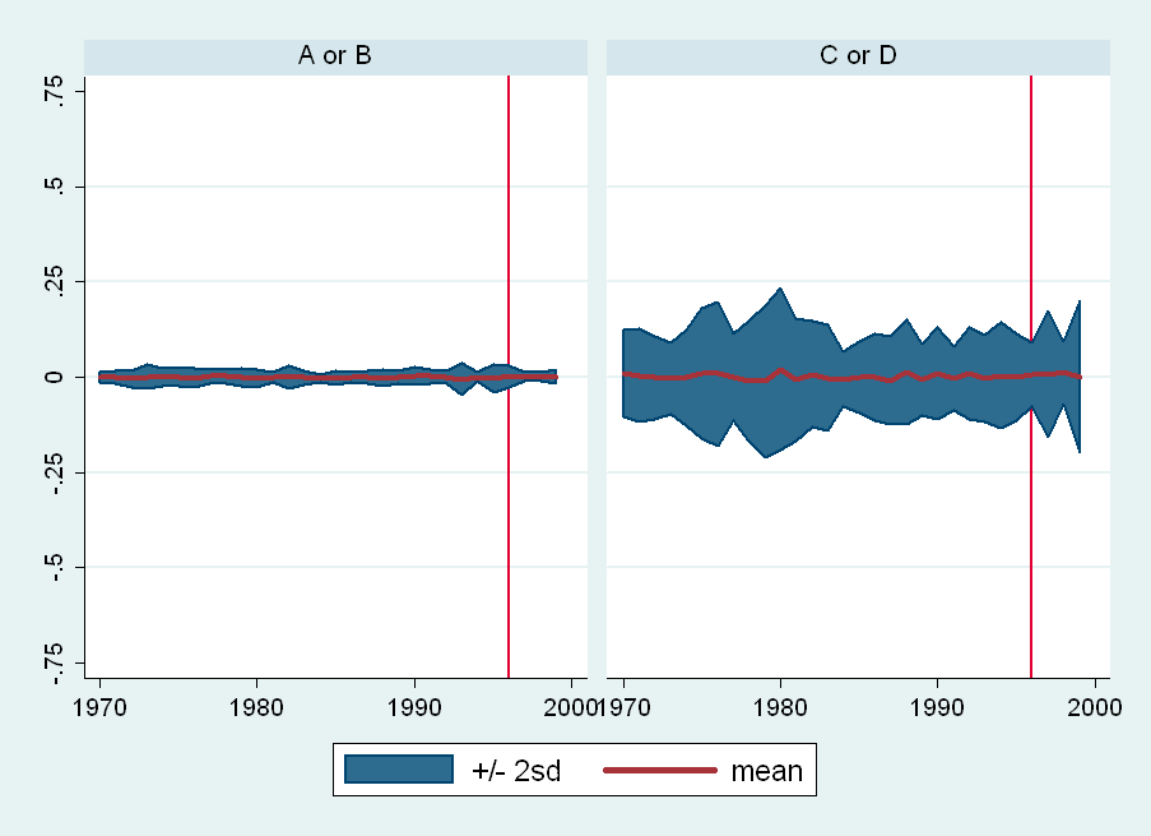
Notes: The figure above shows some prominent cases of revisions in the GDP level numbers, consequential upon revisions in growth rates, across the three latest PWT versions. This affects many of the narratives about growth and the associated policy discussion for some low income countries stemming from the very basic question of who has done well and who has done badly, say over the past 25 years. This basic and important question was asked, for example, by the World Bank's Growth Commission, headed by Michael Spence. Per capita GDP is measured in 2000 international dollars. Because PPPs in each version of the Penn World Table are relative to USA, and base years in each version of the PWT are different, re-basing requires USA GDP deflators for the base years in each of the PWT versions.
Source: Authors' calculations.

Appendix Figure 3. 10-year average per capita GDP growth by decade between PWT 6.2 and PWT 6.1

Notes: The figure above depicts ten-year average annual per capita GDP growth rates are computed using the RGDPCH series for the period 1960–2000. Average annual growth rates are calculated as *[log(RGDPCH$_{t+10}$)-log(RGDPCH$_t$)]/10*. Differences in growth rates between the two versions of PWT are calculated as GDP growth from PWT 6.2 minus GDP growth from PWT 6.1. 1960s: avg. difference = .0001; sd of difference = .0123; avg. growth rate = .0279. 1970s: avg. difference = .0012; sd of difference = .0217; avg. growth rate = .0212. 1980s: avg. difference = -.0008; sd of difference = .0163; avg. growth rate = .0084. 1990s: avg. difference = .0028; sd of difference = .0130; avg. growth rate = .0168. The sample of countries is constant across decades, and consists of 96 of the 104 countries in the "long-run sample" used in other tables and figures. Eight countries were dropped because they did not have data for all four decades. This sample is called the "decades sample."

Source: Authors' calculations.

Appendix Figure 4. Evolution of differences in per capita GDP growth across time between PWT 6.2 and PWT 6.1



Notes: The figure above depicts the relationship between growth variability and distance from benchmark year. GDP is the real per-capita GDP (RGDPCH) series. Differences in growth rates between the two versions of PWT are calculated as the log difference of RGDPCH from PWT 6.2 minus the log difference of RGDPCH from PWT 6.1. Each mean and standard deviation is computed across countries for a given year. Sample of countries for each year includes countries for which there is data for every year between 1970 and 1999. Vertical line denotes benchmark year, 1996. The sample consists of the 104 countries in the "long-run sample" used in other tables and figures.
Source: Authors' calculations.