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Abstract

Measured rates of growth in real per capita income differ drastically depending on the data source. This phenomenon occurs largely because data sets differ in whether and how they adjust for changes in relative prices across countries. Replication of several recent studies of growth determinants shows that results are sensitive in important ways to the choice of data. Previous warnings against using data adjusted to increase cross-country comparability to study within-country patterns over time (growth rates) have been largely ignored at the cost of possibly contaminating the conclusions.

JEL: C82; O47
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Since the path-breaking work of Barro (1991), estimation of cross-country growth regressions has become a boom industry. Literally hundreds of studies have extended the basic framework by incorporating various possible determinants of growth rate differences across countries and over time. Results are often found to be sensitive to specification, time period or sample coverage (see Levine and Renelt, 1992; Sala-i-Martin, 1997; Kalaitzidakis et. al., 2000; and Islam, 2003). Several authors have observed that results may depend on the source and data collection methods for right-hand variables (see, for example, Knowles, 2001 and Atkinson and Brandolini, 2001). In this paper we investigate a heretofore generally overlooked and potentially serious issue regarding the majority of cross-country growth studies. After discussing the main data sources from which growth rates are derived, we compare measures of growth from each data set and show that they differ systematically across various country characteristics. We then show that the results of several recent studies depend critically on which data set is used to derive the growth measure.

I. Data Sources for Growth

Economic research on growth generally uses one of three interrelated, and widely available, data sets: the IMF's International Financial Statistics (IFS), the World Bank's World Development Indicators (WDI) and the Penn World Tables (PWT).

The International Monetary Fund regularly collects and organizes data provided by national statistical agencies into the IFS data, which are distributed in hard-copy, on CD- ROM,

and on-line.[1] Real GDP and growth of real GDP are reported using national price weights and indigenous inflation levels.

The WDI data set combines data from the IFS with additional data directly collected by World Bank staff and ad hoc adjustments based on expert judgement. The data set contains three real GDP measures, GDP in constant local currency units, GDP in constant US dollars (1995 dollars in the latest release) and GDP in Purchasing Power parity adjusted constant US dollars. What is sometimes ignored is that all conversions from local currencies into dollars are made using a single exchange rate for the base year. Thus, growth rates reported in local currency or constant US dollars should be identical. Although in principle the WDI and IFS real GDP estimates should be identical up to a scalar multiplier and should, therefore, yield identical growth rates (see Nordhaus, 2007), in fact, as will be see below, they frequently differ and are far less than perfectly correlated. Nordhaus (2007) suggests that such differences, which are much larger for the entire set of countries we analyze than for the six developed countries for which he reports growth rates, may be due to data revisions and adjustments.

Raw data from in the WDI (except for data for developed countries which is obtained from the Organization for Economic Cooperation and Development (OECD)) are further processed by the Center for International Comparisons at the University of Pennsylvania to produce the Penn World Tables (PWT) data set. Also known by the names of its principle authors as the Summers and Heston data, the PWT are the basis for the widely used Barro-Lee data set. Over the years there have been several major and minor revisions of the PWT, with the latest version available on line at http://pwt.econ.upenn.edu.

[1]Since summaries of the data are also published in the IMF's biannual World Economic Outlook, this data is sometimes referred to in the literature as the WEO data.

The main focus of the PWT project is to create cross-sectional comparability in national accounts data. Thus, each country's disaggregated current price expenditures are converted to a common currency unit using price parities based on the benchmarking studies of the United Nations International Comparison Program (ICP). In effect, relative domestic prices for individual goods are set equal to the weighted average of relative prices for that good in all countries, or what are called "international prices." Because weights are derived from GDP levels, the actual price vector used to compare GDP across countries is roughly that of an upper-middle or even upper income country.[2] This level of prices is then normalized so that the level of GDP in the U.S. is the same in the weighted international currency units and in U. S. Dollars.

As of version 6.1 PWT contains 115 benchmark countries (i.e. countries included in the ICP) and 53 additional nonbenchmark countries. Purchasing power parities for the latter group are obtained as a combination of extrapolation of past benchmark value (if available) and predicted values from an equation regressing the price level for benchmark countries on three international cost of living comparisons that exist for both benchmark and nonbenchmark countries.[3] Since the ICP only benchmarks countries at irregular intervals, data for other years are obtained by extrapolating benchmarked levels using domestic measures of price changes.[4]

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[2] Nuxoll (1994) calculates that the assumed prices are close to those of Hungary in PWT 5.1, while Dowrick and Akmal (2005) suggest that the constant international price vector underlying PWT 5.6 is "most closely represented by the price structure of a relatively rich country such as Hong Kong, Japan or the U.K. (p. 211)."

[3] Regressions are estimated using the United Nation's International Civil Service Index, the U.S. State Department Index and an index provided by Employment Conditions Abroad, an organization of multinational firms, governments and nonprofit agencies.

[4] While other PPP-based times series (e.g. Maddison, 2003) could, in theory, be used to calculate growth rates for empirical studies, these are rarely used and will not be analyzed here.

Although, in principle, any of these three interrelated cross-country data sources could be used for empirical work analyzing growth, in practice, the vast majority of studies have used the Penn World Tables. In a quasi-random sample of seventy-five recent studies,[5] three-quarters used the PWT, 15 percent the WDI and the remaining 10 percent the IFS. This pattern may be partly due to the easy accessability of the PWT, but it is more likely to be due to a desire for comparability with previous studies.[6]

There is broad consensus that the PWT represents a reasonable means of normalizing cross-country comparisons in living standards at a given time, particularly given its relative low demands for data. Neary (2004) provides a theoretical justification for this assertion, although Hill (1999) claims that the PWT systematically understates income differentials across countries, while exchange-rate-based comparisons tend to overstate such differentials.

Unfortunately, the adjustments made to create cross-country comparability in the PWT data can introduce problems when analyzing growth. This phenomenon has long been known in theory, even if ignored in practice. Heston and Summers themselves state:

> PWT has been used by many researchers to measure countries' growth rates, unaware that the rates they obtained are *not* the same as the rates implied in the countries' own national accounts. Both sets are weighted averages of the growth rates of GDP components, but the weights are different.... When told this, a number of growth researchers reacted in a predictable way: since they were indifferent as to [which] growth rate they were using..., this clarification was entirely disregarded (Heston and Summers, 1996, p. 24).

[5]The sample consisted of papers on the reading list of a graduate-level course on determinants of growth taught by one of the authors supplemented by papers our research assistant easily found in the Econ-Lit data base.

[6]Coverage of countries and years are somewhat different for the three data sets. The December 2005 version of the IFS provides GDP data for 153 countries, and goes back as far as 1948 for some countries. WDI contain data for 207 countries and begins in 1960, while the PWT consists of data for 168 countries since 1960.

Nuxoll (1994) makes a similar point, observing that due to the Gerschenkron effect (Gerschenkron, 1951), the use of international prices should serve to overstate growth rates for countries richer than the reference price level and understate it for countries poorer than that level. The PWT growth rates will exceed those derived from own-country prices when the sectors growing in importance within a country are those in which domestic prices are lower than the international prices. Intuitively, such a pattern makes economic sense. Relative demand should be increasing for sectors with relatively low prices. In effect, growth rates calculated from PWT data will confound real physical changes in output within a country with changes in that country's price structure relative to world prices. Nuxoll concludes:

> The growth rates in the Penn World Tables do differ from national accounts. International prices are useful for adjusting GDP estimates for differences in price level; they are certainly preferable to using exchange rates. However, using domestic prices to measure growth rates is more reliable, because those prices characterize the trade-offs faced by the decision-making agents, and hence they have a better foundation in the economic theory of index numbers. Probably the ideal is to use Penn World Table numbers for levels and the usual national accounts data for growth-rates (p. 1434).

This point is further reiterated by Temple (1999) and Nordhaus (2007). The latter echoes Nuxoll, stating: "when calculating convergence among different countries, modelers should consider the superlative PPP technique described here. That is, convergence should use true (PPP) measures of output differentials and growth rates at national prices (p. 267)." Despite these cautions, very few empirical papers have adopted the suggested strategy of using PPP adjusted initial income levels and own-country real growth rates to estimate cross-country growth equations. Notable exceptions are Yanikkaya (2003), Butkiewicz and Yanikkaya (2005), and Gerring et. al. (2005).

It turns out that ignoring this caution may have seriously affected our understanding of growth determinants. Below, we engage in two exercises designed to establish the disparities among the different data sets used in the literature to purportedly measure the same concept - economic growth.

II. Comparison of Growth Rates Across Data Sets

Using the observations that all three data sets have in common, we computed growth rates from adjacent year observations of real per capita GDP as reported in the data source.[7] In all, we are able to compute a total of 3,583 comparisons between any two data sets for years in which all three sources report data, and between 3,788 and 4,594 pairwise comparisons across data sets. First we establish that growth rates do, in fact, differ substantially depending on which data source was used to compute them. Table 1 shows the characteristics of growth rates from these three series and the correlation among them, while Tables 2 and 3 show how these relationship vary across level of development and over time.

[7]For more detail on the exact data definitions, see the Appendix.

Table 1 - Sample Characteristics

A) Full-Row Observations

	Number of Observations	Mean Growth Rate*	Standard Deviation	Minimum	Maximum	Correlation with IFS Growth	Correlation with PWT Growth	Correlation with WDI Growth
IFS	3583	2.1%	5.0%	-46.4%	98.0%	1		
PWT	3583	2.2%	5.8%	-41.9%	77.7%	0.68	1	
WDI	3583	2.1%	4.8%	-34.1%	66.7%	0.88	0.74	1

B) All Available Observations

	Number of Observations	Mean Growth Rate*	Standard Deviation	Minimum	Maximum	Correlation with IFS Growth	Correlation with PWT Growth	Correlation with WDI Growth
IFS	3788	2.1%	5.2%	-46.4%	98.0%	1		
PWT	4594	2.1%	6.5%	-41.9%	77.7%	0.68	1	
WDI	4521	2.0%	5.6%	-41.2%	138.9%	0.88	0.70	1

Table 2 - Relationship Between Growth Rate Measures by Country Income

Income Group*	Number of Observa-tions	Mean Difference between IFS and PWT Growth Rate	Correlation between IFS and PWT Growth Rates	Mean Difference between IFS and WDI Growth Rate	Correlation between WDI and IFS Growth Rates	Mean Difference between PWT and WDI Growth Rate	Correlation between PWT and WDI Growth Rates
Low Income Countries	914	-0.20	0.52	-0.04	0.83	0.15	0.62
Lower Middle Income Countries	931	-0.04	0.74	0.06	0.92	0.10	0.79
Upper Middle Income Countries	771	0.19	0.72	0.12	0.87	-0.07	0.79
Upper Income Countries	1040	-0.10	0.82	-0.01	0.93	0.09	0.83

*As determined by the World Bank using 2004 per capita Gross Nation Income. Breakpoints are $825, $3,255 and $10,065.

Table 3 - Correlation of Growth Rates Over Time

Time Period	Number of Observations	Correlation between PWT and IFS Growth Rates	Correlation between WDI and IFS Growth Rates	Correlation between WDI and PWT Growth Rates
1961-1965	252	0.51	0.81	0.56
1966-1970	311	0.65	0.82	0.77
1971-1975	391	0.69	0.83	0.84
1976-1980	445	0.65	0.84	0.75
1981-1985	503	0.61	0.87	0.72
1986-1990	554	0.73	0.90	0.81
1991-1995	610	0.69	0.94	0.71
1996-2000	590	0.76	0.93	0.77

Several points stand out from the tables. Most critical, as seen in Table 1, is the fact that while mean real growth rates are almost identical across the three data sets, there is surprisingly low correlation among various measures of what is supposedly the same variable. In particular, the correlation between IFS and PWT growth rates is only 0.68. Table 2 shows that differences between growth rates are generally higher and correlations are substantially lower for Low Income countries, results that may hold implications for studies of the determinants of development and convergence. Table 3 shows very little time trend in the degree of concordance across the growth measures.

The key point is that measured growth rates appear to be sensitive to adjustments made to the basic data to achieve cross-country compatibility in income levels in a single year. Moreover, the data sets frequently do not even agree on the direction of GDP change. Table 4

shows that approximately 14 percent of the time the IFS and PWT have opposite signs, with one series showing positive growth while the other shows the same economy contracting. As with the correlation seen in Table 2, this divergence is especially pronounced in low income countries. Of course, divergence in the direction of the change in GDP is made more likely in low income countries by their lower average growth rate in general. The divergences in sign are symmetrical, such that the combination of positive growth in IFS data and negative growth in PWT data is as likely as the combination of negative IFS growth and positive PWT growth. The surprising lack of concordance between growth rates derived from various sources can be seen in Figure 1, which plots individual country-year growth rates derived from the Penn World Tables against those derived from the IFS data.[8] While there is clearly a positive correlation, the points form a thick cloud with many observations far from the 45° line that would be expected if the measures were identical. In addition, the frequency of pairs with opposite signs is clear in the figure.

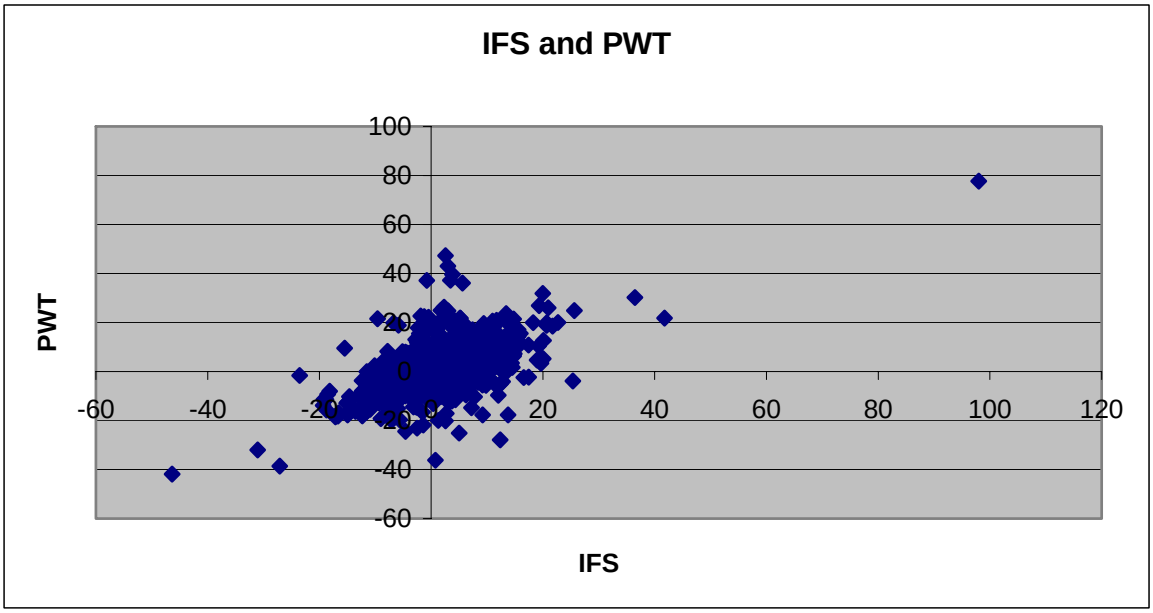
Table 4 - Concordance of Positive and Negative Growth Rates

	IFS & PWT		**IFS & WDI**		**PWT & WDI**	
	Same Sign	Opposite Sign	Same Sign	Opposite Sign	Same Sign	Opposite Sign
All Countries	86%	14%	93%	7%	88%	12%
Low Income Countries	76%	24%	87%	13%	81%	19%
Lower Middle Income Countries	87%	13%	95%	5%	87%	13%
Upper Middle Income Countries	87%	13%	94%	6%	89%	11%
Upper Income Countries	95%	5%	96%	4%	97%	3%

[8]We have excluded outliers where either reported growth rate was greater or less than 40% and years when the IFS reported a change in local methodology.

Figure 1

Relationship Between Growth Rates in IFS and PWT Data



It is clear from the wide divergence in growth measures across data sources that the widely-ignored caution that researchers should be sensitive to the source of their data and, in general, use national accounts data to determine growth rates is potentially important. We now establish just how important by replicating several recent studies.

III. Replication Results

Our replication strategy is simple. We selected four studies published in major journals

since 2000 and requested the original data from the authors.[9] In each case we selected a basic equation using relatively simple econometric techniques.[10] We first replicated the results reported in the original paper and then replaced the dependent variable (growth rate) in the original data with growth rates calculated from own-country data as reported in the IFS data base and the income level variable on the right-hand side of the estimated equation with cross-country comparable PPP-adjusted data from the Penn World Tables. Thus, our alternative specification is precisely the one suggested as theoretically correct by Nuxoll (1994) and Nordhaus (2007).[11] Because, as explained in the appendix, we have excluded country/period sets where there are breaks in the underlying series, sample sizes are frequently reduced in the alternative data as we have cleaned them. When this is the case, we have repeated the analysis using the original data (including the growth measure) applied to the reduced sample derived from the alternative data.

A) **Inequality and Growth (Forbes, American Economic Review, 2000)**

[9]We also attempted to replicate Bosworth and Collins (2003) but were unable to create a matched data set containing more than 50% of the original sample and so have not analyzed these results. No replications of growth regressions where we were able to create a matched data set containing more than half the observations have been excluded from the results reported. We hope that the results reported below will encourage others to repeat our exercise with a large number of other studies.

[10]We often tried replications of more sophisticated techniques, but these results were generally even less stable to minor perturbation in data than simple OLS or IV estimates.

[11]We also conducted two alternative data substitution strategies. The first replaced only the dependent variable from the studies being replicated with growth rates calculated from all three commonly used data sets (IFS, WDI and PWT). The second replaced both the growth rate and initial income level with values from the three data sets. Both of these alternative substitutions reinforce the pattern reported whereby results are highly sensitive to the choice of which data source to use. They are not reported here since they are not consistent with the theoretical argument that own-country data should be used to calculate growth rate and data that is adjusted to be comparable across countries should be used for initial income levels All results are available at: **[WEBSITE SUPPRESSED TO PRESERVE ANONYMITY].**

Forbes (2000) investigates the link between income inequality and growth rates, finding that "in the short and medium term, an increase in a country's level of income inequality has a significant positive relationship with subsequent economic growth." Income data for the study is taken from 1995 World Bank data. Table 5 presents OLS estimates of the relationship between growth and income inequality as reported by Forbes as well as alternative estimates of the same specification using growth rates from the IFS and income levels from the PWT. The impact of this substitution is substantial. The variable of interest in her paper, income inequality, no longer has a significant impact on growth, supporting results in the original paper from more sophisticated analytical techniques. Initial income, on the other hand, which was reported as unrelated to growth in the original paper, is significantly negatively related to growth (suggesting convergence) when using the more appropriate data.

Table 5 - Sensitivity of Impact of Income Inequality on Growth to Choice of Growth and Income Measures

	Forbes (Original Data - Table 4 Column 3)[17]	**Replicated Using Penn World Table Levels and IFS Growth Rates**
Initial Income	-0.00196 (0.00304)	-0.00527* (0.00277)
Inequality	-0.00047* (0.00027)	-0.00022 (0.00027)
Male Education	0.039*** (0.008)	0.036*** (0.008)
Female Education	-0.035*** (0.008)	-0.032*** (0.008)
Investment Price Level (Market Distortion)	-0.00013 (0.00009)	-0.00011 (0.00009)

[17]In her paper Forbes reports a sample size of 45 and an R^2 of 0.40 for this specification. The data she provided us, however, contains only 39 observations and reproduces the reported results exactly. Thus, we suspect there is an error in the reported sample size in the paper.

Constant	0.061** (0.026)	0.079*** (0.027)
R^2	0.48	0.47
N	39	39

***Significant at the 1% confidence level,
**Significant at the 5% confidence level,
*Significant at the 10% confidence level

B) Labor Force Quality and Growth (Hanusek and Kimko, American Economic Review, 2000)

Hanushek and Kimko (2000) investigate the effect of labor-force quality as measured by international mathematics and science test scores on economic growth, finding a strong positive and causal relationship. Data on income and growth are taken from Penn World Tables (Summers and Heston). Key results are contained in Table 5 of the original paper.[12] Results replicating column 3 of this table are presented in Table 6.[13] The most striking difference is that the key variable of interest, labor force quality, is not significant when using growth rates measured in own-country prices (IFS data), although the results suggest that this may be due more to changes in sample size resulting from the elimination of yers where the IFS reports breaks in the methodology used to collect data series than to variable definitions.

Table 6 - Sensitivity of Impact of Labor Force Quality on Growth to Choice of Growth and Income Measures

[12]This table reports results using a data set that expands the original sample of 30 countries for which test scores are available by incorporating predicted values for an additional 50 countries. Although such a procedure introduces measurement error problems, we focus on the results using the full sample of countries because we lose a significant number of observations when shifting to alternative data sets to measure growth rates.

[13]Hanushek and Kimko use two alternative definitions of labor force quality, one that sets the world mean to 50 for each of the tests used and another that accounts for time trends using US time patterns. We report replication results based on the second of these. Our conclusions are not influenced by the measure used.

	Hanushek and Kimko (Original Data - Table 5 Column 3)	Replicated Using Penn World Table Levels and IFS Growth Rates	Replicated Using Original Data but PWT/IFS Sample
Initial Income	-0.453*** (0.078)	-0.292*** (0.077)	-0.430*** (0.098)
Quantity of Schooling	0.112 (0.093)	0.074 (0.141)	0.058 (0.129)
Labor Force Quality	0.076*** (0.027)	0.033 (0.069)	0.048 (0.053)
Assessment Availability	-1.392 (1.455)	-1.490 (3.112)	-1.601 (2.380)
Observed Labor Force Quality	0.054* (0.032)	0.064 (0.072)	0.069 (0.056)
Constant	-0.475 (1.069)	1.581 (2.889)	0.755 (2.227)
R^2	0.49	0.33	0.43
N	78	48	48

***Significant at the 1% confidence level
**Significant at the 5% confidence level
*Significant at the 10% confidence level

C) Equity Markets and Growth (Rousseau and Wachtel, Journal of Banking and Finance, 2000)

Rousseau and Wachtel (2000) investigate the impact of equity market development on growth using three measures of equity market development, the ratio of liquid liabilities (M3) to GDP, the ratio of market capitalization to GDP and the ratio of total value traded to GDP. Income and growth measures come from the WDI data. Of the three measures of equity market development, in cross-sectional IV regressions[14] using eight-year country averages for the periods 1980-1987 and 1988 - 1995 and initial values from 1980 and 1988, only the ratio of

value traded to GDP was a significant predictor of growth. These results are replicated in Table 7 below.[15]

In each case the impact of initial income levels on growth is substantially more negative when growth rates are calculated using own-country prices. The estimated impact of the financial market depth variables is, however, unaffected by the change of data set. On the other hand, the measure of market distortions (the black market exchange rate premium), which was not significantly related to growth in the regressions reported in the paper, significantly inhibits growth using the alternative, more appropriate measure of growth rates.

Table 7 - Sensitivity of Impact of Financial Markets on Growth to Choice of Growth and Income Measures

	Rousseau and Wachtel Original Data - Table 2 Column 3)	**Replicated Using Penn World Table Levels and IFS Growth Rates**	**Replicated Using Original Data but PWT/IFS Sample**
Initial Income	-0.0081*** (0.028)	-0.0134*** (0.0038)	-0.0070** (0.0027)
Initial Secondary Enrollment Rate	0.0107 (0.0066)	0.0067 (0.0059)	0.0032 (0.0068)
Number of Revolutions and Coups	-0.0125 (0.099)	-0.0127 (0.0083)	-0.0138 (0.0094)
Ln (1 + Black Market Exchange Rate Premium)	-0.0292 (0.0188)	-0.0484*** (0.0170)	-0.0376** (0.0184)
Ratio of Total Value Traded to GDP	0.0518*** (0.0182)	0.0517*** (0.0155)	0.0477*** (0.0173)
Constant	0.0362* (0.0203	0.1095*** (0.0267)	0.0601*** (0.0214)
R^2	0.28	0.40	0.32

[14]Instruments include initial values of the regressors, inflation rate, and the ratios of M3, market capitalization, value traded, government expenditure and international trade to GDP.
[15]Replications of results for M3 over GDP and market capitalization over GDP exhibit a similar pattern and are available from the authors.

N	92	89	89

***Significant at the 1% confidence level
**Significant at the 5% confidence level
*Significant at the 10% confidence level

D) Financial Development and Growth (Aghion, Howitt and Mayer-Foulkes, Quarterly Journal of Economics, 2005)

Aghion, Howitt and Mayer-Foulkes (2005) extend the work of Levine, Laoyza and Beck (2000) examining the role of financial intermediation on growth, adding an interaction term between various measures of financial development and initial GDP. A negative coefficient on this term is interpreted as "evidence that low financial development makes convergence less likely." Estimates are performed using a country's legal origins and legal origins interacted with initial output as instruments for financial development. Income level data comes from the Penn World Tables while growth rates were calculated from WDI data.[16] Replications reported in Table 8 are based on the "full conditioning set of variables" that includes the variables of interest plus initial years of schooling, government size, inflation rate, black market premium, openness to trade, number of revolutions and coups, political assassinations and ethnic diversity. Again, the estimated impact of initial income on growth, which was positive and sometimes significant using the original data, becomes much smaller, and sometimes negative although insignificant, using the alternative growth measures. In addition, the key interaction variable tends to be both smaller in magnitude and less significant than reported in the original paper.

Table 8 - Sensitivity of Impact of Financial Development on Growth to Choice of Growth

[16]Thus, if WDI and IFS data did, in fact, yield the same growth rate, results from our replication should parallel those in the original paper. As was discussed above, however, there are substantial differences in growth rates calculated from these two, supposedly identical, data sets.

and Income Measures

	Aghion, Howitt, and Mayer-Foulkes (Original Data - Table 1 Column 3, 6, 9 & 12)	Replicated Using Penn World Table Levels and IFS Growth Rates	Replicated Using Original Data but PWT/IFS Sample
Initial Income	1.131 (0.758)	-0.713 (0.695)	0.426 (1.067)
Private Credit	-0.016 (0.020)	0.012 (0.013)	-0.008 (0.021)
Interaction	-0.063*** (0.014)	-0.022** (0.011)	-0.045** (0.017)
R^2	0.56	0.61	0.44
N	63	44	44
Initial Income	2.384** (1.133)	0.235 (1.024)	0.963 (1.268)
Liquid Liabilities	-0.027 (0.030)	0.005 (0.017)	-0.013 (0.025)
Interaction	-0.073*** (0.020)	-0.037** (0.018)	-0.058** (0.023)
R^2	0.38	0.56	0.47
N	63	44	44
Initial Income	1.365* (0.820)	0.097 (0.936)	1.093 (1.323)
Bank Assets	-0.022 (0.020)	0.004 (0.014)	-0.019 (0.024)
Interaction	-0.081*** (0.018)	-0.041** (0.019)	-0.068** (0.026)
R^2	0.43	0.52	0.31
N	63	44	44

***Significant at the 1% confidence level

Initial Income	5.645 (7.792)	-4.552 (3.902)	-0.829 (9.897)
Commercial-central Bank	0.013 (0.184)	0.136** (0.067)	0.122 (0.167)
Interaction	-0.102 (0.089)	0.024 (0.046)	-0.026 (0.113)
R^2	0.15	0.39	0.15
N	63	44	44

**Significant at the 5% confidence level
*Significant at the 10% confidence leve

III. Conclusions

The message of this paper is clear. Growth rates calculated from different data sets measure conceptually different things, depending on how they treat changes in relative prices across countries over time. In particular, in order to preserve cross-country comparisons in each time period, data contained in the Penn World Tables may confound real growth rates with changes in price structures. This potential problem has long been known but has generally been ignored in cross-country growth regressions.

We have demonstrated that there are substantial differences in growth rates as measured in three widely-available data sets. Correlations across the data sets of what is supposedly the same measure, annual rate of growth in real GDP per capita, are as low as 0.68 overall and as low as 0.52 for low-income countries where relative prices are likely to be very different from those used to calculate PWT comparisons.

We have also replicated simple results from four recent studies of determinants of differences in long-term growth across countries. In each case, we retained the specification and all data from the original study except for initial income levels and measures of growth used as

the dependent variable, which we calculated own-country data for growth rates and PPP adjusted cross-country comparable data for initial income levels. When these alternative sources resulted in a reduced sample size, we also reestimated the relationship using the original data but smaller sample. In each case, the results could most charitably be described as "fragile." Key relationships change in size and significance, frequently leading to fundamentally different conclusions were the analysis to be based on seemingly simple changes of data set.

Much of the time, these changes in interpretation hold even when comparing identical samples. Where they do not, it must be remembered that smaller samples, especially in the IFS data, arise when fundamental breaks in the data collection methodology led us to exclude observations. Thus, researchers should keep in mind that the selection of a data source inherently implies simultaneous selection of a sample period. The fact that results are sensitive to the inclusion of these observations is also a cause for concern. In effect, the observations where the IFS reports a change of methodology are "influential points" in OLS regressions using other data sets that include these observations. These data sets, however, provide no evidence on how, or even if, they adjust for the fundamental underlying incomparability in the data series.

Our replication results support the suggestion of Nuxoll and others that PWT adjustments bias upwards measures of growth for rich countries and downwards those for low-income countries, leading to underestimates of the degree of convergence. It may be that the frequent failure to confirm theoretical expectations of real income convergence has been affected by ignoring cautions against using PWT adjusted data to measure growth in most studies.

Clearly the exact adjustments that make for the large differences in reported growth rates across counties among data that has been used to study growth remain an important area for

future investigation. It is incumbent on researchers to interpret results with caution, be cognizant of the implications concerning price changes implicit in their choice of data, and present sensitivity analyses with respect to the growth measure adopted, and, in general, listen to the advice to avoid using data that has been adjusted to create comparability across countries for a particular year to calculate growth over time within a given country..

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Appendix - Data description

Our analysis is based on comparisons of the growth in real GDP per capita. Real GDP per capita is directly obtainable from the Penn World Table (PWT) and the World Development Indicators (WDI) but must be computed from other series in the International Financial Statistics (IFS).

The **PWT** data were taken from version Mark 6.1 and were downloaded on November 29, 2005 from http://pwt.econ.upenn.edu/. Data are available from 1950 through 2000. There are three available measures of real GDP per capita: (1) in international US dollars at current prices; (2) in international US dollars in 1996 constant prices computed using a Laspeyres index; and (3) in international US dollars in 1996 constant prices computed using a chain index. In line with most cross-country growth studies, we focus on growth rates expressed in international US dollars in 1996 constant prices computed by a chain index.[1] Data are reported for 168 countries, although for some only one value (1996) is available.

The **WDI** data were obtained from the CD-ROM "WDI 2004" issued by the World Bank. The date series cover 1960-2002. We use GDP per capita in constant units of local currency. At least partial data are available for 191 countries.

The **IFS** data were downloaded from an electronic version of IFS on January 21, 2006 and cover the period 1945-2004. The variable real GDP per capita must be calculated from separate series for real GDP and population. For many countries, several time series are available for real GDP, expressed in constant prices using different base years. We used the series with 2000 as the base year where available and that with a base of 1995 otherwise. Per capita growth rates were computed as the ratio of the growth in real GDP to population growth.

Of the three databases compared, only the IFS database indicates possible problem points in the data, marked by a color code in the data base along with a comment explaining the reason for the warning. Unfortunately, the text of the warning is available only when working with the database on line and does not carry through to the downloaded dataset.. For the real GDP variable, there are three possible caveats: the existence of a break in comparability, a point where two series are spliced to create continuity, and a new or changed data definition. We have excluded years where growth rates in either GDP or population would have to have been computed from incomparable series. In addition, in some special cases, the growth rate implied by the IFS was considered as unlikely and relevant observations were also left out of the analysis. Finally, we have made two ad hoc adjustments in the IFS data. There appears to be a decimal point misplaced in the 1954 value of the GDP volume index for Peru. This supposition is supported by the values of the neighboring observations and the number of digits available elsewhere for this time series. Therefore, this observation was corrected by moving the decimal point one place to the left. In addition, the series in 1995 prices we used for real GDP implied illogical growth rates for Austria (over 1000 per cent in 1994) that were inconsistent with those derived from figures in 1983 prices also contained in the data set. We, therefore, used growth rates derived from the 1983-base series for Austria.

[1] This is correlated at .999 with the Laspeyres index.

Excluded observations are listed below in Table A-1. Table A-2 contains our reasoning for excluding the observations we excluded on our own discretion. Finally, Table A-3 contains a list of the countries for at least some years in all three data sets and used in our base comparisons.

Table A-1 Observations Excluded From IFS Data

country	year	D P ul ati ɔ D ɔ	country	year	D P ul ati ɔ D ɔ
Angola	1960	*	Italy	1999	*
Angola	1975	*	Jordan	1961	*
Argentina	1975	*	Jordan	1977	*
Austria	1975	*	Jordan	1984	*
Austria	1999	*	Kazakhstan	1994	*
Belgium	1999	*	Kenya	1972-1985	*
Benin	1979	*	Kenya	1990	*
Bolivia	1975	*	Kenya	1993	*
Bolivia	1984	*	Kenya	1997	*
Brazil	1960	*	Korea, Rep.	1960	*
Brazil	1985	*	Kyrgyz Republic	1993	*
Bulgaria	2000	*	Luxembourg	1985	*
Burkina Faso	1973	*	Luxembourg	1999	*
Burkina Faso	1998	*	Madagascar	1975	*
Burundi	1965	*	Madagascar	1984	*
Burundi	1975	*	Madagascar	1990	*
Cambodia	1975	*	Madagascar	1992	*
Cambodia	1998	*	Malaysia	1960	*
Cameroon	1960	*	Mali	1961	*
Cameroon	1965	*	Mali	1975	*
Cameroon	1978	*	Mali	1977	*
Cameroon	1990	*	Mali	1986	*
Colombia	1977	*	Malta	1968	*
Congo, Dem. Rep.	1975	*	Malta	1975	*
Congo, Dem. Rep.	1979	*	Malta	1979	*
Congo, Dem. Rep.	1992	*	Malta	2000	*
Cote d'Ivoire	1968	*	Morocco	1982	*
Dominica	1999	*	Namibia	1990	*
Ecuador	1962	*	Nepal	1970	*
El Salvador	1961	*	Netherlands	1967	*
El Salvador	1972	*	Netherlands	1970	*
Ethiopia	1960	*	Netherlands	1999	*
Ethiopia	1967	*	Nigeria	1960	*
Ethiopia	1977	*	Nigeria	1984	*
Fiji	1989	*	Pakistan	1972	*
France	1999	*	Pakistan	1976	*
Gambia, The	1968	*	Pakistan	1998	*
Gambia, The	1971-1981	*	Panama	1979	*
Gambia, The	1992	*	Papua New Guinea	1997	*
Germany	1991	*	Philippines	1991	*
Germany	1999	*	Poland	1960	*
Ghana	1960	*	Poland	1980	*
Ghana	1963	*	Portugal	1960	*
Ghana	1965	*	Portugal	1979	*
Ghana	1979	*	Portugal	1999	*
Grenada	1983	*	Spain	1999	*
Guatemala	1964	*	Swaziland	1997	*
Guatemala	1974	*	Syrian Arab Republic	1960	*
Guatemala	1976	*	Syrian Arab Republic	1978	* *
Guinea-Bissau	1970	*	Tanzania	1976	*
Guyana	1977	*	Tanzania	1987	*
Guyana	1984-1985	*	Tanzania	1998	*
Hong Kong, China	1961	*	Trinidad and Tobago	1975	*
Hong Kong, China	1977	*	Tunisia	1973	*
Hungary	1988	*	United Kingdom	1961	*
Chile	1978	*	United States	1960	*
India	1961	*	Uruguay	1975	*
India	1978	*	Venezuela, RB	1975	*
Indonesia	1976	*	Vietnam	1975	*
Indonesia	1990	*	Vietnam	1977	*
Indonesia	1998	*	Yemen, Rep.	1994	*
Israel	1970-1979	*	Zimbabwe	1975	*

Table A2 - Reasons for Exclusion from IFS Data

Country	Years	Reason
Gambia	1971 - 81	Illogical value of deflator in 1971, 1974 and 1980 leading to reported change in real GDP substantially different from other sources
Germany	1991	Effect of reunification. The IFS database indicates a break in the series for nominal GDP and the deflator, but not for the GDP volume. Statistical Office of Germany reports a "." growth for this year.
Grenada	1983	A drop in the deflator by 16%
Guyana	1984 - 85	The deflator moved up and then back down by an equal amount.
Israel	1970 - 79	IFS GDP volume data report zero growth in 1969, 1971, 1972 and 1974. 1975 and 1980 are marked as points where multiple series have been linked by splicing (this is not considered by IFS as a break in comparability). Problem may lie in the deflators for 1970, 1973 and 1977, no obvious explanation was found. As a result, level GDP volume moves down and up in 1977 and 1978. Data on Israeli GDP are also available from the Israeli Statistical Office and do not share this characteristic.
Kenya	1972 - 85	Probably a problem with the deflator. No break is indicated in the database, but could be in years 1972, 1977, 1978 and 1979. 1972 GDP volume is marked as linking multiple series by splicing. GDP volume decreases in 1978 and returns to about its previous levels in 1979. No obvious explanation was found for the 23% rise in 1985 (some student riots in Kenya in 1985 and 1987, but no change in regime).
Luxenbourg	1985	Nom GDP growth 22%, GDP defl 15%, GDP vol. (2000=100) -40% (while Series GDP at constant 1985 prices indicates a growth of 3%) – might be a base shift in this year.
Netherlands	1967, 1970	Probably a problem of deflators for 1966 and 1969. Eurostat provides data on real GDP from 1969 onwards. Implied growth rate for 1970 is about 5 % (IFS has about 29 %). Netherlands´ statistical office has data since 1921, respective real growth rates for 1967 and 1970 are 5.3% and 5.7%.
Panama	1979	Probably a problem of deflator in this particular year leading to reported change in real GDP substantially different from other sources

Table A3 - Countries Included in the Analysis

Country	Income Group	Country	Income Group	Country	Income Group
Albania	2	Gambia, The	1	Nigeria	1
Angola	2	Germany	4	Norway	4
Antigua and Barbuda	3	Ghana	1	Pakistan	1
Argentina	3	Greece	4	Panama	3
Armenia	2	Grenada	3	Papua New Guinea	1
Australia	4	Guatemala	2	Paraguay	2
Austria	4	Guinea-Bissau	1	Peru	2
Bangladesh	1	Guyana	2	Philippines	2
Barbados	3	Haiti	1	Poland	3
Belarus	2	Honduras	2	Portugal	4
Belgium	4	Hong Kong, China	4	Romania	2
Belize	3	Hungary	3	Rwanda	1
Benin	1	Iceland	4	Senegal	1
Bolivia	2	India	1	Seychelles	3
Botswana	3	Indonesia	2	Sierra Leone	1
Brazil	2	Iran, Islamic Rep.	2	Singapore	4
Bulgaria	2	Ireland	4	Slovak Republic	3
Burkina Faso	1	Israel	4	Slovenia	4
Burundi	1	Italy	4	South Africa	3
Cambodia	1	Jamaica	2	Spain	4
Cameroon	1	Japan	4	Sri Lanka	2
Canada	4	Jordan	2	St. Kitts and Nevis	3
Cape Verde	2	Kazakhstan	2	St. Lucia	3
Chad	1	Kenya	1	St. Vincent and	
Chile	3	Korea, Rep.	4	the Grenadines	3
China	2	Kyrgyz Republic	1	Swaziland	2
Colombia	2	Latvia	3	Sweden	4
Congo, Dem. Rep.	1	Lesotho	1	Switzerland	4
Congo, Rep.	1	Lithuania	3	Syrian Arab Republic	2
Costa Rica	3	Luxembourg	4	Tanzania	1
Cote d'Ivoire	1	Macao, China	4	Thailand	2
Croatia	3	Madagascar	1	Togo	1
Cyprus	4	Malawi	1	Trinidad and Tobago	3
Czech Republic	3	Malaysia	3	Tunisia	2
Denmark	4	Mali	1	Turkey	3
Dominica	3	Malta	4	Uganda	1
Dominican Republic	2	Mauritius	3	United Kingdom	4
Ecuador	2	Mexico	3	United States	4
Egypt, Arab Rep.	2	Morocco	2	Uruguay	3
El Salvador	2	Mozambique	1	Venezuela, RB	3
Equatorial Guinea	3	Namibia	2	Vietnam	1
Estonia	3	Nepal	1	Yemen, Rep.	1
Ethiopia	1	Netherlands	4	Zambia	1
Fiji	2	New Zealand	4	Zimbabwe	1
Finland	4	Nicaragua	1		1

France	4	Niger	1	1

4 = > $10,065 GPD per capita
3 = $3255 to $10,064
2 = $825 to $3,254
1 = < $825

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