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# **Are the Penn World Tables Data on Government and Investment Being Misused?**

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## **Abstract**

This paper argues that it is inappropriate to measure G/Y and I/Y using Penn World Tables data. The Penn World Tables impose a set of international relative prices on the data, which are inappropriate for assessing the sizes of the government and investment sectors. It is argued that it is preferable to measure these ratios using local prices. It is shown that the empirical results of Barro and Lee (1994) are sensitive to whether G/Y and I/Y are measured in local or international prices.

Keywords: Penn World Tables; International prices; Economic growth; Investment; Government consumption

JEL classification: O40

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# **Are the Penn World Tables Data on Government Consumption and Investment Being Misused?**

## **1. Introduction**

Many empirical studies on the determinants of economic growth across countries include the investment share in output (I/Y) and the share of government consumption in output (G/Y) as explanatory variables. More often than not these ratios are measured using data from the Penn World Tables (PWT). This means that I/Y and G/Y are calculated, for each country, using the relative prices that prevail in the world economy on average, rather than the relative prices that exist in that country. This paper will argue that this distorts the data, in some countries quite substantially. Section 2 will discuss more fully the issue of whether G/Y and I/Y should be measured in local or international prices. Section 3 will analyse whether the empirical results of Barro and Lee (1994), a paper that measures both G/Y and I/Y in international prices from the PWT, are sensitive to whether these ratios are measured in local or international prices. Section 4 will conclude.

## **2. Measuring G/Y and I/Y in local versus international prices**

The development of the PWT data set by Summers, Kravis and Heston (1980) and Summers and Heston (1984; 1988; 1991)<sup>1</sup> has led to a vast quantity of empirical research on the determinants of economic growth. The PWT was developed in response to concerns about the validity of making cross-country comparisons of variables such as income per capita. Before the development of the PWT income per capita data were typically measured in United States dollars for the purposes of cross-country empirical work. However, this method failed to take into account that the purchasing power of a United States dollar varies greatly across countries. The other problem associated with conversions to United States dollars is that changes in income per capita tend to be driven more by exchange rate fluctuations than changes in the size of the real economy. The PWT solves both of these problems by adjusting United States dollar based measures of income per capita to allow for the different purchasing power of a United

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<sup>1</sup> Version 1 of the PWT was published in Summers, Kravis and Heston (1980); version 2 was never published but was used in Kravis, Heston and Summers (1982). Version 3 of the PWT was published in Summers and Heston (1984), version 4 in Summers and Heston (1988) and version 5 in Summers and Heston (1991). It is versions 4 and 5 of the PWT that have been used most often in cross-country empirical work on the determinants of economic growth (see note 3).

States dollar in different countries. This is sometimes referred to in the literature as measuring variables in “international dollars” or “international prices”.

The PWT data are derived from the United Nations’ International Comparison Project (ICP) (see, for example, United Nations and Commission of the European Communities, 1987). The ICP compares the prices of identical goods across countries in order to obtain price parity estimates for each country at a number of levels of aggregation, including an overall purchasing power parity (PPP). These price parities and PPPs are then used to convert the countries’ local currency expenditures to a common currency unit (international dollars) (Summers and Heston, 1991, p. 329). The ICP data are available for a limited number of countries and time periods.<sup>2</sup> The PWT data set is obtained by “extrapolating these [ICP] cross-section comparisons interspatially to many additional countries and then intertemporally to other years” (Summers and Heston, 1991, p. 328).

The construction of the ICP data, and hence the PWT data, involves setting relative prices for each individual good equal to the weighted average of relative prices for the same goods in all countries. Therefore, relative prices in each country are determined by the world average. The level of prices is then normalised so that GDP in the United States is identical in American and international dollars (Summers and Heston, 1991, p. 334). The key point to note in the context of the current discussion is that relative prices for each country are determined by the weighted world average, not the relative prices that prevail in each country individually.

Data on I/Y and, to a lesser extent, G/Y from the PWT have often been included as explanatory variables in cross-country growth regressions.<sup>3</sup> Not only is the conversion to an international currency unnecessary for such ratios, as they can be measured validly in local currencies, but it also distorts the data by imposing a set of international relative prices on each country. If the price of goods produced in the government sector, relative to the price of goods produced in the non-government sector, is lower than the world average, conversion to international prices will

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<sup>2</sup> For version 5 of the PWT, 81 countries have at least one ICP benchmark figure, 47 countries have more than one observation (Summers and Heston 1991, p. 345). For version 4 of the PWT, 70 countries have at least one ICP benchmark figure (Summers and Heston 1988, p. 13).

<sup>3</sup> Ram (1986) uses PWT version 3 data to measure both G/Y and I/Y. Studies using PWT version 4 data include Barro (1991) for G/Y, Barro and Lee (1994) for G/Y and I/Y, Mankiw Romer and Weil (1992) for I/Y, Knowles and Owen (1995, 1997) for I/Y, Gemmell (1995, 1996) for I/Y, Temple (1998) for I/Y and Temple and Johnson (1998) for I/Y. Studies using PWT version 5 data include Barro and Sala-i-Martin (1995) for G/Y and I/Y and Knowles, Lorgelly and Owen (1998) for I/Y.

increase government's share of output. In practice conversion to international prices does tend to increase the share of output devoted to government consumption for poor countries, but reduce it for rich countries. This is because the price of labour, relative to capital, in poor countries is lower than in rich countries and the government sector tends to be labour intensive in poor countries (see Collins and Bosworth, 1996). This leads to the relative price of government output being lower in poor countries than in rich countries, artificially increasing G/Y for low-income countries.<sup>4</sup>

How then should G/Y be measured, in local currencies or in international dollars? It would seem strange to calculate the size of government in Somalia, using relative prices that prevail in other countries, but this is exactly what conversion to international prices achieves. What we really want to know is what the government's share of output is in Somalia, given the relative prices that prevail in Somalia. The fact that government's share in output would increase if an alternative set of relative prices were used seems irrelevant.

As Summers and Heston (1991, pp. 337-339) point out, the conversion to international dollars reduces I/Y in low-income countries and increases it in high-income countries. This is due to the fact that investment goods are capital intensive in nature and that the price of labour relative to capital is higher in high-income than in low-income countries. Again, the question has to be asked whether it is more valid to measure I/Y in local, rather than international prices. If it is inappropriate to measure G/Y in international prices, the same arguments presumably apply to I/Y. Summers and Heston (1991, p. 360) appear to agree, arguing that "if the share of GDP devoted to capital formation is the form the country's savings takes, the share calculation should be based on domestic prices rather than international prices."

If it is preferable to measure G/Y and I/Y in local prices, why have so many studies used PWT data for these ratios? The PWT data are probably the best available measure of income per capita to use in cross-country empirical work.<sup>5</sup> Once the decision has been made to use the PWT data for income per capita, it is perhaps only natural to use the same data set for the other variables in the regression equations. It should also be noted that several of the studies which

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<sup>4</sup> Dowrick and Quiggin (1997) also show that the imposition of a common set of relative prices by the ICP and PWT understates the degree of dispersion in the levels of income per capita across countries.

<sup>5</sup> Although the growth rate of income per capita could be measured in local currencies, most cross-country growth studies include base-period income per capita as an explanatory variable, and this can not be measured in local currencies.

have used I/Y data from the PWT are extensions of Mankiw, Romer and Weil (1992) and therefore use Mankiw, Romer and Weil's data set, which includes I/Y data from the PWT.

The discussion so far raises the question of just how sensitive the data are to whether G/Y and I/Y are measured in international or local prices. The Barro and Lee (1994) data set contains data on G/Y and I/Y from World Bank sources (which are measured in local prices) and from the PWT versions 4 and 5 (which are measured in international prices). Given that Barro and Lee (1994) use data from version 4 of the PWT the most relevant comparison would seem to be between the World Bank data and the PWT version 4 data.

For the 117 countries for which data are available for both measures of G/Y, the PWT measure exceeds the World Bank measure by 10 percentage points or more for 15 countries. All 15 countries are developing countries. For 26 additional countries, the PWT measure exceeds the World Bank measure by 5 percentage points or more. The most extreme example is Somalia: G/Y is 12.3% in the World Bank data set, but 33.5% in the PWT data set. For most industrialised countries and oil-exporting countries the World Bank measure is higher than the PWT measure. The correlation coefficient between the two data sets is 0.65.<sup>6</sup>

The World Bank measure of I/Y exceeds the PWT version 4 measure by 10 percentage points or more for 17, out of a total of 116, countries. For an additional 34 countries the World Bank measure is greater by 5 percentage points or more. The vast majority of these countries are developing countries. For one country the World Bank measure is less than the PWT version 4 measure by 10 percentage points or more. For an additional 4 countries the World Bank measure is 5 percentage points or more lower than the PWT measure.<sup>7</sup>

Whether I/Y and G/Y are measured in local or international prices does make a difference, suggesting that empirical work examining the effect of these variables on economic growth will be sensitive to which measure is used. One paper which makes use of PWT data for both G/Y

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<sup>6</sup> It is also interesting to note that there are some large discrepancies between versions 4 and 5 of the PWT. For example, G/Y for Nepal is 11.9% in version 4 and 47.4% in version 5. For 11 countries there is a difference of more than 10 percentage points between the two measures; in some cases the version 4 measure is higher, in other cases the version 5 measure is higher. The correlation coefficient between PWT versions 4 and 5 is only 0.61.

<sup>7</sup> It is also of interest to note that there are some large discrepancies between the PWT version 4 and PWT version 5 measures of I/Y. For 10 countries the difference is 10 percentage points or more (in some countries PWT version 4 is greater, for others PWT version 5 is higher). The correlation between I/Y in PWT versions 4 and 5 is 0.82.

and I/Y is Barro and Lee (1994). The remainder of this paper will explore how sensitive Barro and Lee's empirical results are to the use of G/Y and I/Y data measured in local, rather than international, prices.

### 3. Empirical results

Barro and Lee (1994) estimate the following system of two equations using the seemingly unrelated regressions (SUR) technique.

$$\begin{aligned} \ln(\text{GDP})_{1j} = & \alpha_{10} + \alpha_{11} \ln(\text{GDP}_{1j}) + \alpha_{12} \text{MALE}_{1j} + \alpha_{13} \text{FEMALE}_{1j} + \alpha_{14} \ln(\text{LE}_{1j}) \\ & + \alpha_{15} (\text{I/Y})_{1j} + \alpha_{16} (\text{G/Y})_{1j} + \alpha_{17} \ln(1 + \text{BMP}_{1j}) + \alpha_{18} \text{REVOL}_{1j} + \epsilon_{1j} \end{aligned}$$

where  $j = 1, \dots, 85$  (1)

$$\begin{aligned} \ln(\text{GDP})_{2j} = & \alpha_{20} + \alpha_{21} \ln(\text{GDP}_{2j}) + \alpha_{22} \text{MALE}_{2j} + \alpha_{23} \text{FEMALE}_{2j} + \alpha_{24} \ln(\text{LE}_{2j}) \\ & + \alpha_{25} (\text{I/Y})_{2j} + \alpha_{26} (\text{G/Y})_{2j} + \alpha_{27} \ln(1 + \text{BMP}_{2j}) + \alpha_{28} \text{REVOL}_{2j} + \epsilon_{2j} \end{aligned}$$

where  $j = 1, \dots, 95$  (2)

Subscript  $i$  denotes time period 1 (1965-75) and time period 2 (1975-85) and subscript  $j$  denotes country  $j$ .  $\ln \text{GDP}$  is the average annual growth rate in GDP per capita over the relevant decade (1965-75 for time period 1 and 1975-85 for time period 2).  $\text{GDP}$  is base-period GDP (1965 for time period 1 and 1975 for time period 2).  $\text{MALE}$  and  $\text{FEMALE}$  denote base period average years of secondary schooling for males and females respectively.  $\text{LE}$  is life expectancy at birth, averaged over the preceding five years (1960-4 for time period 1 and 1970-74 for time period 2).  $\text{I/Y}$  and  $\text{G/Y}$  are the respective shares of real investment and real government consumption (net of nominal spending on education and defence) in real GDP, averaged over the relevant time period.  $\text{BMP}$  is the black market premium on foreign exchange, averaged over the relevant ten-year period and  $\text{REVOL}$  is the number of revolutions and coups from 1960-85.

Note that Barro and Lee estimate an unbalanced panel in the sense that there are ten more observations for 1975-85 than for 1965-75. Barro and Lee do not discuss how they obtained estimates for this unbalanced panel. However, Lorgelly and Owen (1999) show that very similar empirical results to Barro and Lee are obtained if equations (1) and (2) are estimated for a

balanced panel of 85 countries. Column (1) of Table 1 reproduces the results from Barro and Lee, whereas column (2) gives the results obtained by Lorgelly and Owen.

[Table 1 about here]

The results reported in column (3) are obtained by re-estimating Barro and Lee's equation for a balanced panel of 81 countries, but with G/Y (net of spending on education and defence) and I/Y data measured in local prices. The data are originally from World Bank sources and are reported in the Barro and Lee (1994) data set. The coefficient on I/Y remains significant at the one percent level, but the t-statistic is substantially lower than that obtained by Barro and Lee. The coefficient on G/Y is now only significant at the ten percent level, with the point estimate having fallen by almost one half.

Another possible explanation for the reduced significance of G/Y and I/Y could be due to the reduction in sample size from column (2) to column (3). To eliminate this possibility, Barro and Lee's equations (with G/Y and I/Y measured in international prices) were re-estimated for the reduced sample of 81 countries. The results are reported in column (4). As the absolute value of the point estimate and t-statistic for G/Y are higher than in column (2) it would seem that the omission of these four countries is not responsible for the reduced significance of G/Y in column (3).

Lorgelly and Owen (1999) have shown that the significance of the human capital variables is reduced if Hong Kong, Singapore, Taiwan and South Korea are omitted from the sample. It is, therefore, of interest to see how sensitive the results in this paper are to the exclusion of these four countries. The results obtained when these countries are omitted from the data sample are reported in column (5). Note that G/Y is now insignificant. Once G/Y is measured in local currencies and four potentially influential observations are removed from the sample, there is no significant partial correlation between economic growth and G/Y. I/Y is now significant at the five percent, rather than the ten percent, level.

#### **4. Conclusion**

Several studies examining the effect of G/Y and I/Y on economic growth have used data from the PWT to measure these ratios. The PWT data are transformed so that world average relative

prices are imposed on all economies. This has the effect of artificially increasing  $G/Y$  for developing countries and reducing it for developed countries. The opposite pattern occurs for  $I/Y$ . This paper has argued that this is inappropriate. When measuring the size of government in a particular country it makes little sense to ask what government's share in output would be if a different set of relative prices prevailed, but this is exactly what occurs if these ratios are taken from the PWT data.

By re-estimating the empirical results obtained by Barro and Lee (1994) it has been shown that empirically it does make a difference whether or not  $G/Y$  is measured in local or international prices. When local prices are used the significance of  $G/Y$  is substantially reduced. When the four fastest growing East Asian economies are omitted from the data sample, there is no significant relationship between government consumption and economic growth at all. The results for  $I/Y$  are not as sensitive to whether local or international prices are used, although the t-statistic on  $I/Y$  does fall substantially when  $I/Y$  is measured in local prices. It would seem that the PWT data need to be used with more caution. The PWT data are appropriate when comparing income per capita across countries, but ratios such as  $G/Y$  and  $I/Y$  are more appropriately measured in local currencies.

Table 1

Re-estimation of Barro and Lee's equations with G/Y and I/Y measured in local prices

Variable	(1)	(2)	(3)	(4)	(5)
ln(GDP)	-0.0264** (-8.80)	-0.0251** (-7.82)	-0.0192** (5.44)	-0.0254** (-7.85)	-0.0188** (-5.17)
Male	0.0134** (3.27)	0.0151** (2.98)	0.0170** (2.94)	0.0163** (3.22)	0.0137* (2.02)
Female	-0.0084# (-1.86)	-0.0114* (-2.03)	-0.0130** (-2.00)	-0.0121* (-2.17)	-0.0101 (-1.39)
ln(LE)	0.0727** (5.51)	0.0722** (4.81)	0.0865** (4.97)	0.0739** (4.81)	0.0871** (4.90)
I/Y	0.120** (6.00)	0.114** (5.35)	0.0859** (2.84)	0.1033** (4.69)	0.0650* (2.10)
G/Y	-0.170** (-6.54)	-0.156** (-5.24)	-0.0892# (-1.74)	-0.1606** (-5.37)	-0.0644 (-1.25)
ln(1+BMP)	-0.0279** (-5.81)	-0.0264** (-5.16)	-0.0277** (-4.89)	-0.0268** (-5.19)	-0.0271** (-4.81)
Revol	-0.0171* (-2.09)	-0.0166# (-1.92)	-0.0108 (-1.06)	-0.0139 (-1.58)	-0.0099 (-0.10)
R <sup>2</sup>		0.7597	0.6681	0.7670	0.5984
N	85, 95	85, 85	81, 81	81,81	77, 77

Notes: SUR estimates with asymptotic t-statistics in parentheses. \*\*, \* and # denote significance at the 1 percent, 5 percent and 10 percent levels respectively (against two-sided alternatives). N denotes the sample size, with the first number being the number of observations in period one, and the second number the number of observations in period two. Results in column (1) are reproduced from Barro and Lee (1994). The results in column (2) are for a balanced sample of 85 countries in each time period. Column (3) reports the results obtained when G/Y (with G measured net of spending on education and defence) and I/Y are both measured in local currencies. Column (4) presents the results for the Barro and Lee model for the reduced sample of 81 countries. The results in column (5) are the same as in column (3) except that Hong Kong, Singapore, South Korea and Taiwan are excluded from the sample.

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