

Measuring PPP biases by estimating Engel curves for food

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June 16, 2006

Abstract

The price adjusted data on national incomes used for international comparisons are measured with bias. The bias is due to both substitution in consumption and heterogeneous consumption sets. This paper calculates the bias in the income measures given in Penn World Table by estimating Engel curves for food. The results indicate that income inequality tend to be underestimated if measured from the Penn World Table data.

1 Introduction

Measures for national income and production attract attention from researchers as well as political decision makers. Such measurements influence political decisions and are important instruments to evaluate both national and international policies and reforms. To estimate real incomes it is necessary to deflate by prices. The traditional exchange rate based method simply transforms all national incomes into one common currency. Thus, price differences are not taken into account and so long as there is not purchasing power parity across countries, this method will not reveal true incomes. Although the consensus is that price adjusted (PPP) measures of national incomes should be used, the existing methods are far from perfect and researchers as well as policy makers thus have to work with inaccurate numbers.

The problems facing international researchers constructing PPP indexes for comparison are in structure analog to those facing national statisticians constructing consumer price indexes (CPIs). First, whenever a fixed basket approach is used, substitution in consumption is not taken into account, and thus a substitution bias occurs both in CPI and PPP calculations. Second, in order to construct an overall price index, it is necessary to give weights to different prices for different consumption goods, and thus a homogenous consumption set for comparison is needed. The problems in finding this homogenous set are twofold: Both the quality of a particular good and the set of goods might vary, over time and across countries.

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For example, if there exist different brands of cars in different countries (or in different time periods in one country), and the different brands have different prices, it is not clear whether there are price differences for cars which should be reflected in the price index or whether the price differences simply reflect differences in quality between the brands. Computers on the other hand are an example of a good that has only been in use in recent years, and thus it is hard to compare computer prices today to the prices in 1950. In between countries comparisons statisticians face problems when it comes to compare the price of gur, a sugar substitute, in Pakistan to that in Norway where sugar substitutes are hard to find.

This paper aims at measuring the *overall* bias in the Geary-Khamis measured PPPs and real incomes presented in the Penn World Table. The overall bias is the sum of the substitution bias and the bias caused by heterogeneous consumption sets. The fact that the PPP measurement problems are formally equivalent to those of CPI calculations, gives the rationale behind applying Hamilton's (2001) method for measuring the overall CPI bias to also measure overall PPP bias. He suggests to estimate Engel curves for food and deflate the nominal incomes by the CPIs for different years which is pre-assumed to be measured with bias. The preferences are assumed to be the same over time. Thus, if the Engel curves for different years are systematically different, this indicates that the CPIs are measured with bias. More specifically, Hamilton suggests to include a time dummy for each year and utilize the time dummy coefficients to find the CPI bias in specific years.

This paper applies Hamilton's method to estimate the PPP bias by estimating Engel curves for food across different countries. Thus the time dimension in Hamilton (2001) is changed to a cross-country dimension in this paper. Engel curves for food are estimated at household level in different countries and national price levels measured from the Penn World Table are used to make incomes comparable between countries. Thus a measurement error is introduced through the national price levels and systematic differences in the Engel curves for different countries reveal the PPP bias for different countries relative to a base country.

Since Engel (1857) established the so-called law of Engel, we have known that the budget share for food is decreasing in income. This paper provides the first application of this relationship to measure biases in international income measurements. The Working-Leser specification (Working (1943) and Leser (1963)), further developed to the AIDS specification (Deaton and Muellbauer, 1980), is used to estimate the relationship between budget share for food and total income.

There are some recent contributions in the literature regarding international income measurements. Neary (2004) focuses on the substitution bias and shows that the Geary-Khamis method is exact if and only if preferences are Leontief. He estimates a world demand system and constructs a reference consumer by use of observed consumption. He finds that there is a bias in the real incomes given in the Penn World Table, and that international income differences are underestimated if calculated from these real incomes. Neary (2004) applies macro data from the International Comparison Project (ICP, 1980). Thus his study relies on the aggregation methods used to develop the macro data in the ICP. This paper however, estimates preferences at the household level, and inaccuracies due to aggregation techniques are thus avoided.

Dowrick and Akmal (2005) also focus on the substitution bias and show by a theoretical model, assuming Cobb Douglas preferences, that whereas the exchange rate based method will overestimate international inequalities, the Geary-Khamis method will underestimate such inequalities. The authors argue that the biases in both measures are due to divergent trends in the prices for traded and non-traded goods, and that the true international inequality has been constant in the period from 1980 to 1987. Their results build on the findings in Nuxoll (1994) that the more the prices resemble those of richer countries, the less the measured inequality. Nuxoll (1994) finds that the Geary-Khamis method measured prices in the Penn World Table resemble those of richer countries more than poorer countries, and we would thus expect that the degree of inequality calculated from Penn World Table data is lower than actual inequality. However, Nuxoll (1994) does not give a method to calculate the actual inequality. Consequently, the bias cannot be measured directly. Dowrick and Akmal (2005), however, calculate a so-called true inequality based on the assumption of homothetic preferences, i.e. they assume unit income elasticities. However, we know that consumption patterns and budget shares change with income, and assuming homotheticity and specifically Cobb Douglas preferences might not be the best way to approach income measurement problems. Hill (2000) measures the substitution bias by finding the distance between the price vector of each country and a reference country. He also assumes homothetic preferences. Hill's findings are the same as Neary's and Dowrick and Akmal's: The Geary-Khamis method tends to underestimate international income inequalities.

The method applied in this paper gives a measure of the *overall* PPP bias. This paper thus investigates whether the findings of Neary (2004), Dowrick and Akmal (2005) and Hill (2000) can be replicated using household data and Hamilton (2001)'s specific method which also takes into account other biases than the substitution bias.

2 International Income Comparisons - The Exchange rate based versus PPP methods

2.1 The exchange rate based method

The simple exchange rate based method (EX), which simply transforms all national incomes into one common currency, introduces a traded sector bias. If there is purchasing power parity for traded goods and one country has higher prices for non-traded goods than those of other countries, the EX measure will overestimate its real income compared to other countries. On the other hand, if prices of non-traded goods are lower than those of other countries, the EX method will underestimate real income. Consequently, if the prices of non-tradables are higher in high-income countries than those of non-tradables in lower-income countries, the EX measures overestimate international income inequality. See for example Dowrick and Akmal (2005) for a discussion of this.

2.2 The purchasing power parity methods

The measures that try to correct for the traded sector bias, the purchasing power parity (PPP) measures, introduce other biases. There are two specific

problems connected to this group of measurements: The problem of finding a set of identical consumption goods and the substitution bias that occurs when realized consumption is evaluated at different prices than the actual ones.

In any price index for comparison, a homogenous consumption set is needed to measure and compare quantity consumed. The problem related to finding this set is twofold: First, the set itself may vary, both over time and across countries. New goods are created and others disappear from people's consumption basket. Second, the quality of some goods might vary both over time and across countries and thus it is hard to quantify them into the same measurement units.

In any index that belongs to the group of fixed basket approaches, e.g. the Geary-Khamis method which underlies the Penn World Table, a substitution bias occurs. The realized consumption bundles in different countries are evaluated at a constructed set of virtual world prices, different from the country's own prices. If the virtual prices were the actual prices in the different countries, and if people did not have Leontief preferences, the chosen consumption bundle would have been different from the realized one at national prices. Thus the evaluation of the realized consumption bundle is different from the consumers' evaluation of the actual consumption (e.g. Neary (2004)).

This paper focuses on the overall measurement bias due to both substitution bias and heterogenous consumption sets. Specifically, this paper will measure the overall bias in the Penn World Table (PWT 6.1) measured real incomes and investigate whether these data underestimates the international income inequality. If underestimation is supported this will be consistent with the findings in both Neary (2004) Hill (2000) and Dowrick and Akmal (2005). The Geary-Khamis method underlies the PWT and this method is described in the next session.

2.2.1 The Geary-Khamis method for adjusting for price differences

Consider a world with N goods and J countries. The method creates hypothetical world prices, π'_n s for each of the N goods and also purchasing power parity (PPP) factors for each of the J countries. The PPP is the national currency value of GDP divided by the real value of GDP in international dollars, i.e. it is the inverse of the real exchange rate. In the PWT calculations the international dollars has the same purchasing power over total US GDP as the US dollar in a fixed base year. The base year used in PWT 6.1 is 1996.

The following $(J-1)+N$ equations will determine the the hypothetical world prices and PPPs:

$$\pi_n = \sum_{j=1}^J \frac{p_{nj}q_{nj}}{p_j \sum_{j=1}^J q_{nj}} \quad n = 1, 2, \dots, N \quad (1)$$

$$p_j = \frac{\sum_{n=1}^N p_{nj}q_{nj}}{\sum_{n=1}^N \pi_n q_{nj}} \quad j = 1, 2, \dots, J-1 \quad (2)$$

When this method is to be applied to multilateral comparisons, a numeraire country is chosen. Using USA as the numeraire, the purchasing power parities and the world prices obtained by ICP inputs are given by:

$$\pi'_n = \sum_{j=1}^J \frac{P_{nj}Q_{nj}}{P'_j \sum_{j=1}^J Q_{nj}} = \frac{\pi_n}{p_{n,US}} \quad n = 1, 2, \dots, N \quad (3)$$

$$P'_j = \frac{\sum_{n=1}^N P_{nj}Q_{nj}}{\sum_{n=1}^N \pi_n Q_{nj}} = p_j \quad j = 1, 2, \dots, (J-1) \quad (4)$$

P_{nj} and Q_{nj} are defined by the following equations respectively:

$$P_{nj} = \frac{p_{nj}}{p_{n,US}} \quad (5)$$

$$Q_{nj} = \frac{p_{nj}q_{nj}}{\frac{p_{nj}}{p_{n,US}}} = p_{n,US}q_{nj} \quad (6)$$

where p_{nj} is the price of commodity n in country j and q_{nj} is the consumption of commodity n in country j .

The two main problems connected with measuring purchasing power parity apply to the Geary-Khamis method: Both the substitution bias and the homogenous set assumption are exemplified in these $N+J-1$ equations. First, the q 's incorporated are the actual consumption levels in the different countries evaluated at the virtual world prices π 's. According to economic theory, the Hicksian or compensated demand should be used when evaluating at a different set of prices than the observed ones (e.g. the π 's). See Neary (2004) for a formalization of this argument. Second, the problem of dividing the consumption in categories of goods for which the prices can be compared across the country occurs, i.e. the problem of finding the right consumption set. To be able to refer to the N dimensional set of goods, and their quantities (q), the goods have to be directly comparable or homogenous across countries.

The next session will present the empirical idea and the framework that will be applied to measure the overall bias in the Penn World table measured real incomes which are calculated using the Geary-Khamis method.

3 Estimating income from Engel curves for food

Engel's Law states that as incomes increase, the proportion of income spent on food falls. Working (1943) studied data from more than 300,000 households in the United States in the mid 1930's. He finds that the budget share for food is linearly dependent on the logarithm of total expenditure. This relationship is negative and his findings are thus consistent with the law of Engel.

Leser (1963) discusses this function in more detail and specifies this relation econometrically:

$$m_f = a_f + b_f \ln y + \epsilon_f \quad (7)$$

This way of denoting the relationship between budget share for food and total expenditure has later been called a Working-Leser specification. Deaton and Muellbauer (1980) included prices in this equation and constructed the so-called almost ideal demand system (AIDS). They showed that this system is consistent with utility maximization and thus gave the theoretical foundation for the Engel relationship observed by Working and Leser.

3.0.2 The Almost Ideal Demand System

The AIDS system of Deaton and Muellbauer (1980) gives budget shares as a function of prices and total expenditure:

$$m_n = a_n + \sum_{i=1}^I \gamma_{ni} \ln p_i + b_n \ln \frac{y}{P} \quad (8)$$

When only the two categories of food and non-food, respectively, are considered, the budget share for food can be expressed as follows:

$$m_f = a + \gamma(\ln P_f - \ln P_n) + b(\ln y - \ln P) \quad (9)$$

Hamilton (2001) exploits this relationship to estimate the bias in the Consumer price index (CPI) for the United States from 1974 to 1991. His framework is used here to estimate the bias in the PPP measure. If the above described demand system is correctly specified and if preferences are constant, i.e. if there exists a representative consumer for food consumption, and if there are no systematic errors in the variables, there should be no difference in the Engel curves for food estimated for different countries. If there are systematic differences however, this might reveal a measurement error.

3.1 Empirical framework - Econometrical Specification

Hamilton's (2001) empirical specification of the AIDS system is the following:

$$m_{h,r,j} = a + b(\ln y_{h,r,j} - \ln P_j) + \gamma(\ln P_{f,r,j} - \ln P_{n,r,j}) + \epsilon_{h,r,j} \quad (10)$$

where $m_{h,r,j}$ is the budget share for food for household h in region r in year j . In this paper, however, the time dimension in Hamilton (2001) is changed to a cross country dimension, and the j 's will thus indicate which country household $m_{h,r,j}$ belongs to. $y_{h,r,j}$ expresses total consumption for household h in region j and country j . P_j is the overall price level in country j (year j in Hamilton). $P_{f,r,j}$ and $P_{n,r,j}$ give price indexes for food and non-food, respectively, in region r and country j . In order to be able to distinguish between the effect of overall price level and the relative price effect, the prices for food and non-food have to be given at regional levels.

In the case when we have separability between food and non-food, the relative price between food and non-food do not affect the budget share on food and we can simplify the empirical specification:

$$m_{h,r,j} = a + b(\ln y_{h,r,j} - \ln P_c) + \epsilon_{h,r,j} \quad (11)$$

If the demand is specified correctly, the overall price index for food and non-food is given by:

$$\ln P_j = a_0 + a_f \ln P_{f,j} + a_n \ln P_{n,j} + \frac{1}{2} \gamma \ln P_f \ln P_n + \frac{1}{2} \gamma_f P_f^2 + \frac{1}{2} \gamma_n P_n^2 \quad (12)$$

where $P_{f,j}$ and $P_{n,j}$ are the true price indexes for food and non-food in country j respectively. However this true price index is unknown since both prices for food and non-food are measured with bias. Thus, instead of letting P_j be given

by its true level, P_j is expressed from the price level of consumption given in the Penn World Table. In Hamilton's paper the CPI for year j was included. The Penn World Table and CPI measured price levels and the price levels for food and non-food are pre-assumed to be measured with bias. The true price levels can be measured as a function of the biased prices and a measurement error.

$$P_j = P'_j * E_j \quad (13)$$

$$P_{f,r,j} = P'_{f,r,j} * E_{f,r,j} \quad (14)$$

$$P_{n,r,j} = P'_{n,r,j} * E_{n,r,j} \quad (15)$$

where E_j , $E_{f,r,j}$ and $E_{n,r,j}$ are the measurement errors connected to the prices. In order to measure the measurement error a country dummy is included in the specification.

The budget share for food can thus be expressed as follows:

$$\begin{aligned} m_{h,r,j} &= a + \gamma(\ln P_{f,r,j} - \ln P_{n,r,j}) + b(\ln y_{h,r,j} - \ln P_j) + X_{h,r,j}^T \theta + \epsilon_{h,r,c} \\ &= a + \gamma(\ln P'_{f,r,j} + \ln E_{f,r,j} - \ln P'_{n,r,j} - \ln E_{n,r,j}) + b(\ln y_{h,r,j} - \ln P'_j - \ln E_j) + X_{h,r,j}^T \theta + \epsilon_{h,r,c} \\ &= a + \gamma(\ln P'_{f,r,j} - \ln P'_{n,r,j}) + b(\ln y_{h,r,j} - \ln P'_j) + X_{h,r,j}^T \theta + \sum_{j=1}^J d_j D_j + \epsilon_{h,r,c} \end{aligned} \quad (16)$$

Thus, the country dummy coefficient, d_j , is given by:

$$d_j = \gamma(\ln E_{f,r,j} - \ln E_{n,r,j}) - b \ln E_j \quad (17)$$

If the biases in the price for food and non-food totally outweigh each other or if there is separability between food and non-food, we can write the PPP bias simply as a function of the country dummy coefficient and the coefficient of the real income:

$$E_j = e^{-\frac{d_j}{b}} \quad (18)$$

The higher the country dummy coefficient, the higher the measured error, i.e. the more the price tends to be underestimated and the more the income tend to be overestimated.

Letting p_c indicate the logarithm of the country price level, we can write:

$$p_c = p'_c - \frac{d_j}{b} \quad (19)$$

Thus, whenever d_j is positive, the price level is underestimated and the income is overestimated.

If the bias in the food price is positive and larger than that in the non-food price, the E'_j will underestimate the PPP bias. The opposite is true if the bias in the non-food price is larger than that in the measured food price.

4 Data

The Engel curves are estimated at household level and the data for total budget and total food consumption are found from household surveys. A total of 15383 households are contained in the data set. One of the advantages of using household data is that it is possible to analyze household with the same size and composition and thus avoid inaccuracies due to equivalence scaling. 2605 of the households have two adults and two children.

Two regressions are run on the two different data sets. First, all households are included and the number of children and the number of adults are included as controls. Second, all household with two adults and two children are used in the analysis. This is called the *preferred* set throughout this paper. The advantage of including households with same size and composition is that inaccuracies due to equivalence scaling is avoided. We know however, that income or wealth might affect household composition and thus this selection process might cause a selection bias problem. It is evident from table1 that there is a different ratio of the households that has the preferred composition in different countries. However, there does not seem to be systematic differences between high-income and low-income countries.

Table1

Country	Total hh	Percent (2x2)
Azerbaijan	2016	9.22 percent
Bulgaria	2500	7.30 percent
Tanzania	800	5.76 percent
USA	5054	10.16 percent
Nicaragua	4209	9.57 percent
India	2250	6.14 percent
Cte D'Ivoire	1588	4.03 percent
Hungary	7531	4.87 percent
Peru	5120	11.42 percent

Household data from Azerbaijan, Bulgaria, China, Cte D'Ivoire, Hungary, India, Nicaragua, Peru, Tanzania and USA. The data from Hungary are from the national Household Budget Survey, 1996. The US data are gathered by the United State Department of Labor, Bureau of Labor Statistics, in the Consumer Expenditure Survey 1996. The data for the rest of the countries are conducted by local authorities in the different countries together with the World Bank. These studies are part of the World Bank's Living Standard Measurement Surveys¹. All the household studies except those of Tanzania, China, Peru and India are constructed to be nationally representative. The data from Tanzania is gathered from the Kagera region in 1994, while the Indian survey is from the regions of Bihar and Uttar Pradesh in 1997-1998. The study of Chinese households was conducted in the province of Hebei and Liaoning (northern and northeast China)) in 1995 and 1997. The data from Peru are from Lima only and gathered in 1990. The survey in Azerbaijan was conducted in 1995. The Nicaraguan data were gathered in 1998-1999 and the Hungarian data are taken

¹Detailed information about these studies can be found at the World Bank web site <http://www.worldbank.org/lsms/>

from a survey conducted in 1996. The data from Cte d'Ivoire was gathered in 1985.

Ideally, all the studies should have been nationally representative. Instead of measuring the error in the income measurement from the Penn World Table for the whole countries of Tanzania, India and China it measures the bias for the income of the regions of Kagera, Bihar and Uttar Pradesh, Lima and Heibei and Liaoning. The reason why the studies of China and India are used, is that these two countries are large countries and if there is a measurement error for these countries' real incomes this will influence international inequality measurements considerably. It is thus better to have them represented, even if not nationally representative, than to leave them out of the analysis completely. (For Tanzania and the Kagera region, there exists a national study, which I was not aware of until now, and this will be included later instead of the Kagera data.)

The technique used to gather data in such surveys is interviewing one member of each household. The advantage of this method is that detailed information is revealed and inaccuracies due to aggregation techniques are avoided. However, on the other hand, inaccuracies might also occur in the micro data from such surveys. First, not all will respond to the questions in the interviews and there is no reason to believe that the part of the population that answers constitutes a random drawn part of the population. Second, inaccuracies might occur due to under- or over-reporting from the object of the interview. Third, different interviewees might give the questions different interpretations and this might be more of a challenge in cross country data sets than in national ones.

However, we know that the macro data in the Penn World Table and the World Bank are built on micro data, and thus we would expect macro data in such studies to inherit inaccuracies due to these factors in addition to the aforementioned inaccuracies related to aggregation techniques.

The reported value of total consumption is interpreted as the household budget or total expenditure.. The value of food consumption, i.e. the reported total expenditure on food plus home produced food consumed, is interpreted as total expenditure on food. Many of the countries included in the analysis are farm households, and for many of these a considerable part of consumption is from own produced food and thus it is important to include that in the "expenditure" definition when estimating the Engel curves for food. The reported "use value" of durables is included in the household budget.

The price data are taken from the Penn World Table 6.1 (PWT) from the years that the household surveys in the respective countries were accomplished. The price level of consumption for the different countries are given in US dollars (USD). Since the total value of consumption included in the Engel equations are given in national currencies, the price levels of consumption are multiplied by the exchange rate, also given in PWT, and divided by 100.

The main results presented in next section rely on the assumption of separability. The reason for this is simply that the data for calculating regional for comparison are missing. First, very few countries report regional price variation, and if they do so, it is done by regional price indexes, which are all set to 100 in one common year. These indexes are good instruments to study differences in regional relative prices over time, but they cannot be used in a cross-regional sense. Hamilton (2001) and Costa (2001) includes regional price changes over time, and estimate a γ coefficient in their panel data context. Second, to compare regions in different countries, it is necessary to have an absolute level of

price difference *between* countries. The same problems as with the national regional variations occurs here: the World Bank publishes food price indexes and consumer price indexes for different countries, but they are all set to 100 in a common year, and thus they cannot be used in cross-country comparisons.

However, the International Comparison Project (ICP) published absolute prices for food and non-food items for the year 1980. Combining these prices with the price indexes of the World Bank, I was able to construct relative prices for India, Hungary and the US. It is however impossible to identify γ within the data set, since there is no regional observations neither in the ICP nor the World Bank price data. The γ coefficient estimated for the US in Hamilton's study and the two different γ coefficients in Costa (2001) are used to see if the main result changes when relative prices are included and non-separability is allowed for.

5 Empirical findings

5.1 Separable case

The logarithm of real income has a significant negative coefficient as we would expect from the Law of Engel. The coefficients are comparable to Hamilton's coefficient for the US for the time series from 1975 and 1991. His coefficient is -0.097, which is lower, but not considerable lower than the one here found for the sample with the preferred household composition. The constant term is also highly significant and comparable to Hamilton's coefficient of 0.997. This is also lower than the one found here and the fact that no controls are included yet might very well explain the higher coefficients for these countries. However none of them are considerably different.

Figure ... and figure plots the ranking of the bias calculated from the dummy coefficients in the regression on the total population and the "preferred size population", respectively. Both figures indicate a decreasing trend between them, i.e. the lower income, the higher the bias. The international inequality measured from Penn World Table data thus seems to be underestimated.

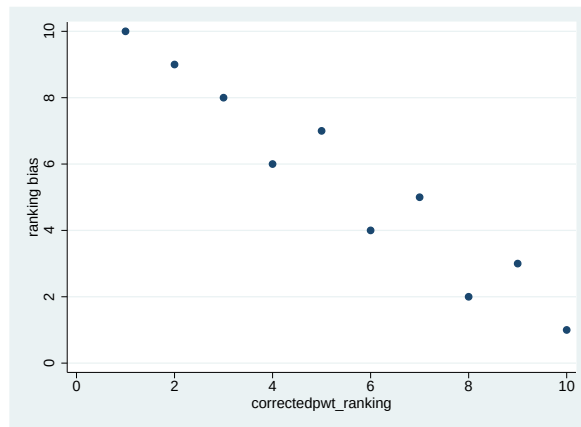


Figure 1: Ranking of measured bias to the real corrected GDP ranking, total population

	All-households	Pref-composition
	(1)	(2)
LnRealCons	-.088*** (.002)	-.102*** (.005)
children	.008*** (.0007)	
adults	.004*** (.0008)	
d-Azerbaijan	.561*** (.005)	.563*** (.014)
d-Bulgaria	.149*** (.004)	.164*** (.013)
d-China	.357*** (.005)	.346*** (.011)
d-Tanzania	.146*** (.005)	.145*** (.017)
d-Nicaragua	.016** (.007)	-.033* (.019)
d-India	.449*** (.004)	.425*** (.013)
d-CoteDIvoire	.356*** (.006)	.388*** (.019)
d-Hungary	.042*** (.003)	.029*** (.009)
d-Peru	.523*** (.008)	.554*** (.013)
cons	.892*** (.013)	1.051*** (.042)
e(N)	27145	2085

Table 1: Regression result under the assumption of separability. The column "All households" gives the results for the total sample, whereas the column "Pref composition" gives the result for the preferred sample

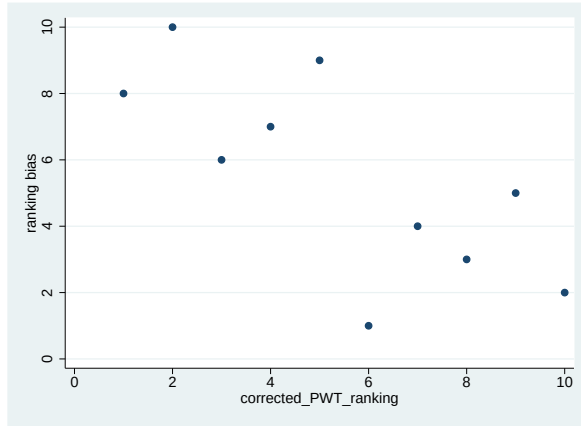


Figure 2: Ranking of measured bias to the real corrected GDP ranking, preferred population

The Gini coefficients increase dramatically when correcting for the measured bias. For the whole population the gini coefficient was 0.59 before and 0.83 after the correction. For the preferred sample, the gini increased from 0.59 before to 0.82 after the correction. If weighting by population sizes in the ten countries the differences are even higher; from 0.49 to 0.89 in the whole population sample and from 0.49 to 0.88 in the preferred sample. We see that the estimated coefficients, and thus biases, are high and changes in the gini indexes tremendously high. There are reasons to believe that there are some omitted variables and that the true gini indexes are lower than the ones estimated here. We will see in the next section that the gini increases less when relative prices are included. However the trend seems evident both from the ranking of the different countries biases and from the estimated ginis.

5.2 Non-separable case - prices included

Hamilton's (2001) γ coefficient of 0.039, Costa's (2001) measured coefficient of 0.006 for the years 1919-1935 (called Costa I) and for the coefficient of -0.008 (insignificant) for the years 1960-1994 (called CostaII) are all used in the regressions showed in table and table.

We see that the ranking is exact in this case, India as the poorest country has the highest coefficient and thus the highest bias in measured income, whereas the US has the lowest coefficient.

The differences between the gini indexes are lower than the ones estimated in the last section, but the main qualitative results are the same: The Penn World table underestimates international inequality.

The estimated gini coefficients for the three countries are as follows:

Table2

Gini	Popunw	Prefunw	Popw	Prefw
GiniPWT	0.45	0.45	0.56	0.56
GinicorrH	0.57	0.58	0.77	0.78
GinicorrCI	0.58	0.59	0.78	0.78

	Hamilton	CostaI	CostaII
	(1)	(2)	(3)
LnRealCons	-.080*** (.006)	-.080*** (.006)	-.080*** (.006)
d-India	.401*** (.012)	.445*** (.012)	.464*** (.012)
d-Hungary	.042*** (.010)	.054*** (.010)	.060*** (.010)
cons	.850*** (.048)	.854*** (.048)	.857*** (.048)
e(N)	917	917	917

Table 2: Prices included for the preferred set. Hamilton means that Hamilton's (2001) γ is used while CostaI refers to Costa's γ for the periode 1919-1935, while CostaII indicates that the estimated γ fort the period 1960-1994 in Costa (2001). The latter is insignificant and it is there given no attention in the discussion later

	Hamilton	CostaI	CostaII
	(1)	(2)	(3)
LnRealCons	-.089*** (.002)	-.089*** (.002)	-.089*** (.002)
d-India	.370*** (.004)	.413*** (.004)	.433*** (.004)
d-Hungary	.026*** (.003)	.038*** (.003)	.043*** (.003)
adults	.012*** (.001)	.012*** (.001)	.012*** (.001)
children	.014*** (.0009)	.014*** (.0009)	.014*** (.0009)
cons	.881*** (.012)	.885*** (.012)	.887*** (.012)
e(N)	13828	13828	13828

Table 3: Prices included for the whole set.

The differences for the non-weighted case are lower than the ones estimated for the all the ten countries without the relative prices. In the weighted case,

5.3 What about the functional form?

The functional form is a main issue in the empirical analysis conducted in this paper. If the functional form was wrong, the estimated bias could show up simply because a wrong functional form was forced on the data. When a squared term of the logarithmic real incomes was included, the coefficient showed up as insignificant.

Semi-parametric functional form analysis to come here.

6 Concluding remarks

Micro data and Hamilton's (2001) specific method for measuring price index bias reveal an underestimation of international inequality measured from Penn World Table. Thus the results from studies relying on macro data can be replicated by studying household surveys and the claim of underestimation is more convincing than earlier.

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