CONTRADICTORY TRENDS IN GLOBAL INCOME INEQUALITY: A TALE OF TWO BIASES

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ABSTRACT

Did global income inequality rise or fall over the past twenty years? Exchange rate comparisons suggest that inequality has risen, but the purchasing power comparisons of the Penn World Tables suggest inequality has fallen. We show that both measures are biased. Exchange rate comparisons ignore the relative price of non-tradables, whilst the Penn World Table method of calculating purchasing power parities is subject to substitution bias. Correcting for this bias, using Afriat true indexes, we find no compelling evidence of a significant change in world inequality. The contradictory trends of the exchange rate and PWT measures can be explained by the fact that national price structures became less similar over time.

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1. Introduction

An apparent increase in inequality in international income distribution over the past three or four decades, particularly during the 1980s, has been highlighted by Korzeniewicz and Moran (1997) and by the United Nations Development Project in their recent Human Development Report, UNDP (1999). Whilst the former is reluctant to draw strong conclusions about underlying causes, the UNDP argue passionately for international policies to mitigate rising inequality caused by economic globalisation.

Critics have argued that this view of international income inequality is distorted by the use of currency market exchange rates (FX) to compare incomes across countries. Recent papers by Castles (1998) and Castles (2000) are highly critical of the UNDP claims of rising world inequality. A number of authors have shown that inequality is tending to fall rather than rise when income comparisons are made using purchasing power parities (PPP)[1]. Firebaugh (1999) reports that both the Theil and Gini indexes of inter-country inequality decline between 1965 and 1989 using PPP adjusted incomes, confirming the findings of Schulz (1998) who also reports a decrease in the variance of log income. These results are confirmed by a recent working paper from Melchior, Telle and Wiig (2000) and by our own calculations, which are shown as Figure 1.

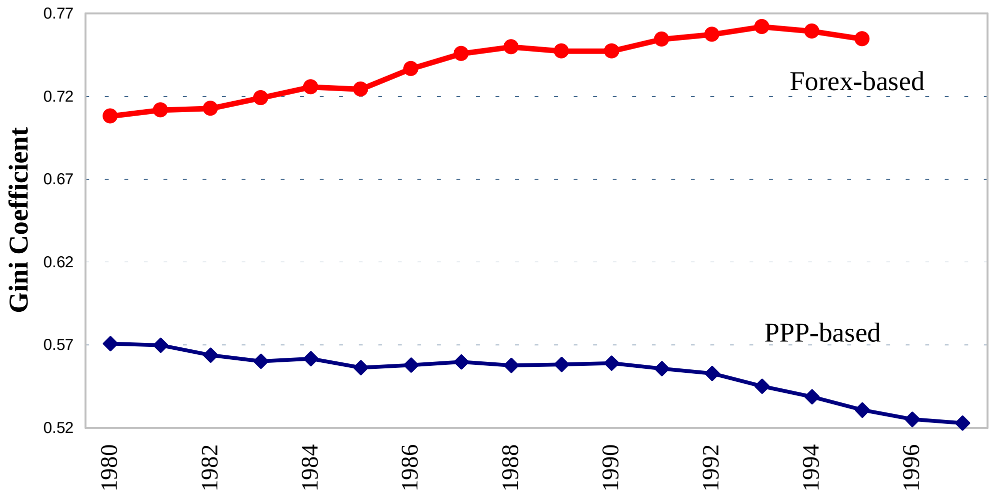
It is well known that the use of market exchange rates to translate international incomes into a common currency introduces a 'traded sector bias'. Whilst exchange

[1] The one exception appears to be Milanovic (1999) who reports rising inequality between 1988 and 1993. Although Milanovic adjusts for purchasing power parities, his income definition is different from all the other studies, which are based on concepts of national or domestic income. He uses household income derived from survey data, ignoring benefits from public spending on health,

rates tend to equate purchasing power over traded goods and services, much of world production is for domestic consumption only. Wide variations across countries in the prices of non-traded goods and services are not reflected in the market for foreign exchange. So FX-converted incomes do not reflect the relative purchasing power of consumers.

Figure 1

INTERNATIONAL INCOME INEQUALITY 1980-97



Note: Gini coefficients are calculated on *per capita* GDP for 115 countries using population weights.

For some specific purposes, such as assessing a nation's capacity to repay foreign debt or its bargaining power in international trade negotiations, the FX income comparison may well be appropriate. For the purpose of measuring inequality in living standards, however, we need to take account of the real purchasing power of national currencies. How to achieve this is problematic. The studies cited above have used estimates of purchasing power parity incomes calculated by the Geary-

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education etc. . He acknowledges that this survey income systematically underestimates national income and that underreporting increases with adjusted GDP per capita.

Khamis (GK) method - see Summers and Heston (1991) - which evaluates national expenditures at 'world-average' prices. But this method is subject to substitution bias: it ignores the fact that a large amount of a good may be consumed not because consumers are rich but because the local price is low.

In Section 2 we develop a simple model that captures the biases in both the FX and GK measures of inequality. This enables us to explain why the two measures are trending in opposite directions: true inequality may be relatively constant, but if both biases are increasing over time as prices become less similar, then the FX method will show rising inequality whilst the GK method may indicate falling inequality.

To test this hypothesis, we examine the similarity of prices. We also calculate the Ideal Afriat Index of real incomes, using the methods developed by Dowrick and Quiggin (1997), to yield real income comparisons free of both substitution bias and traded sector bias.

It is important to note that this paper, in line with all of the studies cited above, uses population weighted measures of inequality, to capture the idea that we think of inequality as a function of income gaps between people (or households). This is in contrast to most of the recent empirical literature on economic growth which focuses on the national economy as the standard unit of observation. To test hypotheses on the determinants of growth, an observation on the growth rate of the Luxembourg economy is typically treated with the same weight as an observation on USA growth, and a common finding is that international incomes have been diverging. We confirm this finding when we construct unweighted measures of inter-country inequality using either foreign exchange or PWT data.

To measure global inequality across individuals is at present impossible, with only the richer countries able to afford detailed income and expenditure surveys. We can, however, go beyond inter-national income comparisons in the direction of inter-personal comparisons by utilising published data on intra-country inequality. Following the examples of Schulz (1998) and Korzeniewicz and Moran (1997) we introduce an element of intra-country inequality by using quintile distribution data.

By carefully examining the methods that have been used to estimate recent trends in world income inequality we hope to provide some important perspective and balance to the current debate.

2. A MODEL OF SECTORAL AND SUBSTITUTION BIAS IN INTERNATIONAL INCOME COMPARISONS

In order to examine international inequality we need to deflate nominal incomes to give some measure of real income. It is well established that international currency markets, driven by capital and trade flows, tend to undervalue the domestic purchasing power of currencies of low productivity / low income countries. This phenomenon has been analysed by Balassa (1964), Samuelson (1964) and Bhagwati (1984). Real wages are low in countries with low labour productivity, so non-traded labour-intensive services are cheap relative to capital-intensive traded goods. Market exchange rates are more likely to equate international prices in the traded sector than in the non-traded sector of the economy. Consequently, markets tend to undervalue the currencies of poor countries in relation to their domestic purchasing power. Hence the common experience of international travellers that their money will go much further in India or Indonesia than it will in Western Europe.

An important implication of this ‘traded sector bias’ is that foreign exchange (FX) income comparisons, because they understate the real incomes of poorer economies, will overstate the degree of international inequality in the real purchasing power of consumers.

A massive research effort, based on detailed price surveys in many countries under the auspices of the United Nations' International Comparison Program (ICP), has resulted in the publication of the Penn World Tables (PWT) which provide ready access to measures of GDP per capita measured at constant international prices for a hundred or more countries over thirty or forty years. These data are commonly referred to as Purchasing Power Parity (PPP) measures of real income.

Many users of the PWT data are unaware, however, that attempts to measure purchasing power parity are problematic. The PWT are based on the Geary-Khamis method of construction of 'average international prices'. The GDP of each country is evaluated at these fixed prices. It is well known, however, that constant price valuations introduce systematic bias by ignoring consumers' ability to substitute towards goods and services that are locally cheap even though they appear to be relatively expensive when valued at international prices. The authors of the PWT themselves describe the problem of substitution bias:

> *"The issue arises out of a familiar problem in price and quantity index number construction. …Valuation at other than own prices tends to inflate the aggregate value of the bundle of goods because no allowance is made for the substitutions in quantities toward the goods that are relatively cheap. … The practical importance of this issue … may loom large in comparisons between countries that have widely divergent price and quantity structures."*
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> Kravis, Heston and Summers (1982), p.7.

We suspect that this issue may be very significant when it comes to assessing trends in world inequality, because we know that the price and quantity structures in the world's poorest economies are very different from those typically obtaining in the richer industrialised economies. Use of the PWT estimates of international incomes, whilst avoiding the sectoral bias in the FX income data, introduces substitution bias instead.

In order to better understand these sources of bias in international comparisons, we construct a simple model of two trading economies. Each produces a non-traded labour-intensive service, S. Only Country 1 is able to produce an intermediate good, A, which we might think of as an agricultural product. Both countries manufacture a final tradeable good, M, using labour and the intermediate good. The production technologies exhibit constant returns to scale and are identical across countries, except that private knowledge (due to research and / or education) in the second country makes labour more productive in its manufacturing sector.

To keep the model simple we assume Cobb-Douglas production functions in manufacturing, we treat labour as the only factor of production, we disregard transport costs for trading the intermediate and manufactured goods and we assume competitive pricing behaviour in product and labour markets, including free trade. We assume that all goods and services must be produced, traded and consumed within the one time period. The production side of the economy in country i can be summarised as follows:

$$S^i = L^i_s$$
$$A^1 = L^1_t$$
$$M^i = (\lambda^i A^i_m)^\alpha.(T^i_m)^{1-\alpha} \quad ; \quad i=1,2 \qquad (1)$$

where Z = S, A, M represent the domestic output of Services, Intermediate Product and Manufactured Product respectively; L^i_z represents the amount of labour employed in production sector Z; and λ^i is the productivity of labour in country i's manufacturing sector.

Given the assumptions of constant returns to scale and competitive pricing, we can solve for the price of the manufactured good in country i, P^{iM} in terms of the domestic currency input prices for labour and the intermediate good, w^i and P^{iA}:

$$P^{iM} \quad = \quad a\,(w^i/\lambda^i)^{\alpha}.(\,P^{iA})^{1-\alpha} \qquad (2)$$

where $a = 1 / [\,\alpha^{\alpha}\,.\,(1-\alpha)^{1-\alpha}\,]$.

We normalise prices and productivity by setting the wage and productivity level in country 1 to unity. We can then use λ (>1) without a superscript to represent manufacturing labour productivity in the high productivity country 2. This allows us to derive the price vector for country 1as:

$$\mathbf{P}^1 \quad = \quad (P^{1S}, P^{1A}, P^{1M}) \;=\; (1, 1, a) \qquad (3)$$

The exchange rate is E units of currency 2 per unit of currency 1. Ignoring transport costs, the domestic price of the intermediate good in country 2 is E. This determines the price of the manufactured good, using (2) as: $P^{2M} \quad = \quad a(w^2/\lambda)^{\alpha}.E^{1-\alpha}$. But trade in the manufactured good requires $P^{2M} = E.\ P^{1M} = aE$. These conditions fully determines the wage in country 2 as $w^2 = \lambda E$, that is to say productivity-adjusted factor-prices are equalised across the traded sectors.

By assumption, there are no differences across countries in the productivity of labour in the production of non-traded services. The price of services is simply the wage. It follows that services are relatively expensive in the high-productivity, high-wage country. The price vector is:

$$\mathbf{P}^2 \quad = \quad (\lambda E, E, aE) \qquad (4)$$

We analyse demand and welfare by assuming common Cobb-Douglas preferences for consumers:

$$U^i(s^i, m^i) = (s^i)^{\beta}.(m^i)^{1-\beta} \qquad (5)$$

where s and m refer to *per capita* consumption of services and manufactured goods. The budget share of services is β in each country. Given that *per capita* income in each countryequals the wage, the *per capita* consumption bundles, $\mathbf{q}^i = [q^{iS}, q^{iM}]$ are:[2]

$$\mathbf{q}^1 = [\ \beta,\ (1-\beta)/a\ ]\ ;$$
$$\mathbf{q}^2 = [\ \beta,\ \lambda(1-\beta)/a\ ]. \qquad (6)$$

Per capita consumption of services is identical in the two countries, despite the fact that services are more expensive in country 2, because the income effect of higher manufacturing productivity offsets the price effect. This exact offsetting is an artefact of the Cobb-Douglas production and utility functions, but it is not crucial to our results.

Substitution of the consumption bundles into the common utility function gives the true *per capita* income ratio between the two countries:

$$U^2 / U^1 = \lambda^{1-\beta} \qquad (7)$$

These findings are summarised in the following proposition:

PROPOSITION 1
With free trade in intermediate and manufactured goods and competitive pricing, a country with higher productivity in manufacturing will exhibit the following features:

i) *per capita* real income is higher;

ii) non-traded services are more expensive relative to manufactures.

In this model, *per capita* National Income and Gross Domestic Product are identical and, measured in local currencies, are simply equal to the wage. So the GDP or

[2] We assume that the productivity differential and relative population size are such that it is feasible for country 1 to produce all of the intermediate good demanded in both countries.

income ratio that is obtained from exchange rate comparison is simply w^2/Ew^1. Substituting in our expressions for wages, we get the FX income ratio:

$$FX^2 / FX^1 = \lambda \qquad (8)$$

which leads to our second proposition.

PROPOSITION 2: Traded sector bias in FX comparisons
(i) International comparisons of *per capita* income which use market exchange rates overstate true income differentials.
(ii) The magnitude of the bias is an increasing function of the underlying productivity differential between the countries and is an increasing function of the domestic expenditure share of the non-traded sector.

Proof: From (7) and (8), where $U^2 > U^1$, $0<\beta<1$ and $\lambda > 1$,

$$(FX^2 / FX^1) = \lambda^{\beta} (U^2 / U^1) > U^2 / U^1.$$

The first part of this proposition confirms the result found in Samuelson (1974) who claims that the result holds irrespective of whether preferences are homothetic or not. The overstatement of true income differentials is due to traded sector bias in exchange rate measures of real income. Whilst the free trade exchange rate, E, achieves purchasing power parity for traded goods, purchasing power parity for non-traded goods and services is higher, λE. It follows that the use of exchange rates to compare incomes exaggerates the degree of inequality.

We turn now to the measurement of the international income ratio by the Geary-Khamis method. This method values each country's GDP at 'world prices'. The world price of manufactures, relative to services, is constructed as a weighted average of the relative prices of all the countries in the GK system. For the purposes of our model we have considered only two countries, but we can allow for other countries with a range of productivity levels.

We represent the GK price vector as:

$$\mathbf{P}^{GK} = (P^{GK,S}, P^{GK,M}) = (1, a/g) \quad (9)$$

writing the relative price of manufactures in the world price vector as a/g to indicate that this corresponds to the price of manufactures in a country with a productivity parameter of g. If the world economy is dominated by countries richer than country 2, g will be greater than λ. If, on the other hand, the rest of the world is poorer than country 1, g will be less than unity.

The Geary-Khamis measure of real GDP *per capita* for country i is the *per capita* consumption bundle evaluated at world prices: $\mathbf{q}^i . \mathbf{P}^{GK}$. The GK income ratio is:

$$GK^{2,1}(g) \equiv \frac{GK^2(g)}{GK^1(g)} = \frac{\beta + (1-\beta)\lambda / g}{\beta + (1-\beta)/g} \quad (10)$$

Whether this under or over-states the true income ratio depends on the value of g. We summarise the relationship in our third proposition.

PROPOSITION 3: Substitution bias in Geary-Khamis comparisons

i) A bilateral international comparison of *per capita* income which values expenditure at constant prices will understate the true income differential if the constant price vector corresponds to that of the high productivity country, or the prices of an even richer country.

ii) A constant price comparison will overstate the true income differential if the constant price vector corresponds to that of the low productivity country, or the prices of an even poorer country.

iii) The bias is an increasing function of the dissimilarity of the reference price vector with respect to the comparison country prices.

iv) Where i) or ii) holds, the magnitude of the bias is an increasing function of the underlying productivity differential between the two comparison countries.

Proof: From (7) and (10), the ratio of the constant price (GK) income ratio to the true income ratio is R(g):

$$R(g) \equiv \frac{GK^{2,1}(g)}{U^2 / U^1} = \frac{\beta g + (1-\beta)\lambda}{[\beta g + (1-\beta)]\lambda^{1-\beta}} \qquad (11)$$

From (11), for $\lambda>1$, $R_g<0$. It can be shown that for $0<\beta<1$, R(1)>1 and R(λ)<1. It follows that R must be greater than 1 for all g <1 (and increasing in the distance below g) and less than 1 (and decreasing in the distance above g) for all g>λ. The relative price of services is monotonically increasing in λ. Hence i), ii) and iii).

R is decreasing / increasing in the productivity differential, λ, as λ<g or λ>g. Hence iv). ***

Proposition 3 formalises and extends the notion of substitution bias in fixed price comparisons. It is well known that the use of country 1's prices is likely to exaggerate country 2's welfare – since goods that are in high demand in 2, because of their relative cheapness, will be overvalued at 1's prices. (In other words, the Laspeyres quantity index is usually larger then the Paasche index - which must be the case if the underlying preferences are common and homothetic.) It follows that valuing demand at country 1's prices will tend to overstate the true income ratio, if 1 is poorer than 2, and *vice versa*. This implication of substitution bias in the measurement of inequality is sometimes referred to as the *Gerschenkron Effect*, after Gerschenkron (1951). Nuxoll (1994) has shown that the Gerschenkron effect will also apply when the income ratio between country 1 and country 2 is measured at the prices of some third country, if relative prices and quantities are inversely correlated across all three countries. Our proposition formalises this result in the context of an explicit model where prices, quantities and the true income ratio are endogenously determined by tastes and technology.

Our Proposition shows that constant price measures of inequality are systematically biased. The level of inequality is understated if a bilateral income ratio is evaluated at a price vector corresponding to the price structures of a reference country that is richer than countries 1 and 2. The magnitude of the bias is an increasing function of both the true bilateral ratio and the income level of the reference country.

The extent of these biases is illustrated in Figure 2 for the case where non-traded services comprise half of total expenditure, i.e. β=0.5. The horizontal axis measures λ, the manufacturing productivity differential between the two countries. The uppermost line shows the extent of positive bias in the foreign exchange comparison: $(FX^2/FX^1) / (U^2/U^1)$. When the underlying productivity ratio is ten, FX comparisons overstate the true income ratio by a factor greater than three. The two lower lines shows bias in GK income comparisons. When the prices of the low productivity country are used, i.e. g=1, the GK method exaggerates the true ratio by up to 60%. But evaluating international income at the prices of a high productivity country (g=10) understates the true income ratio - by up to 40% in this example.

The illustrated biases refer to the measurement of the income ratio between a pair of

countries. We expect to find a similar level of bias in measures of multilateral inequality, because most measures, such as the Gini Index, are constructed from bilateral ratios.

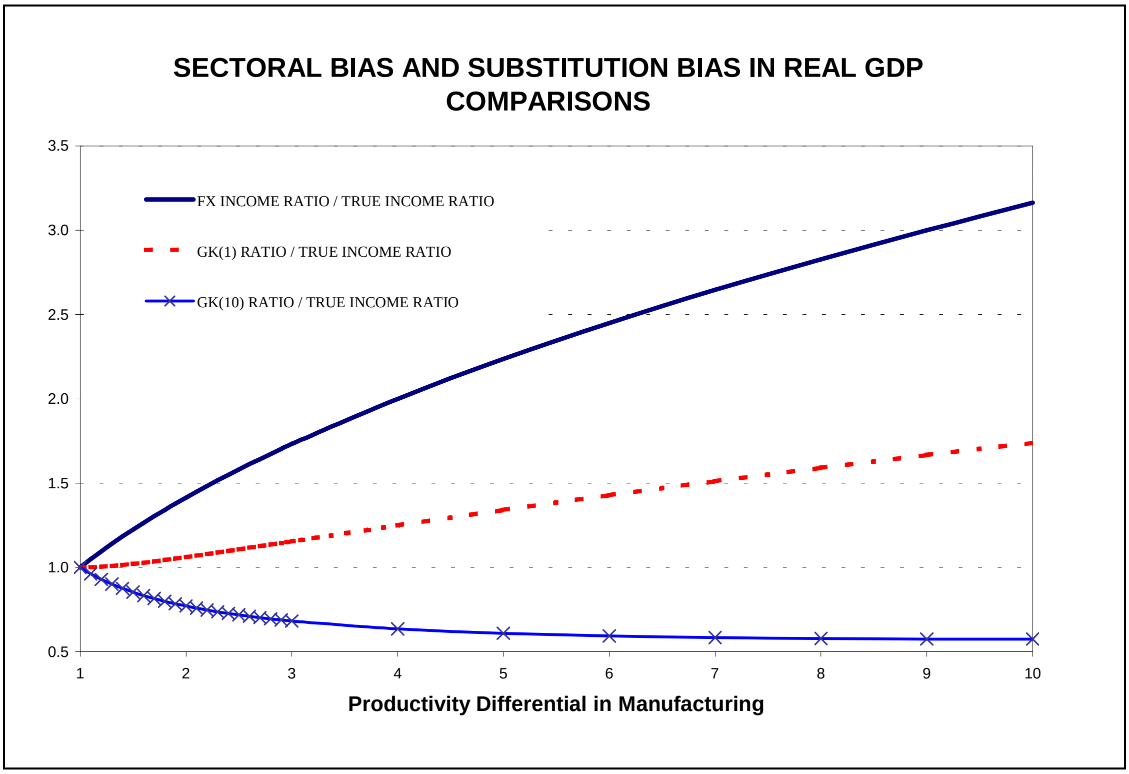


FIGURE 2

3. *Measures of international and global inequality*

There are a number of important questions and debates on methods of assessing the level of world inequality. In this section we go through these questions in turn to clarify the issues and discuss the appropriateness of particular methods. In the following section we will test the degree to which estimates of trends in world inequality are sensitive to these methodological choices.

Foreign Exchange or Purchasing Power Parity Incomes

In the previous section we demonstrated that there are potentially serious biases in the two commonly used methods of measuring international income inequality. If we compare the upper and lower lines in Figure 2, we see that it is possible for the FX measure to overstate the true level of inequality whilst the Geary-Khamis measure understates the true level. This occurs when the GK method is evaluating GDP at a set of 'international' prices that correspond to the price structure of a high productivity economy. This is exactly what we find in the real GDP data provided by the Penn World Tables. The GK method gives a lot of weight in the construction of the international price vector to large high productivity economies such as the USA. Nuxoll (1994) reports that PWT prices correspond to those of countries with relatively high income levels. So we are not surprised to find that the PWT income ratios are typically biased downwards, understating the true level of inequality, as demonstrated by Dowrick and Quiggin (1997) and by Hill (2000).

Moreover, Figure 2 shows that the degree of bias in both measures is likely to increase as the true level of inequality increases. This suggests one possible explanation for the conflicting messages coming from the analysis of FX and GK measures of inequality. If true inequality is rising over time, both the upward FX bias and the downward GK bias will increase. It follows that the trend rate of increase will be exaggerated by FX measures and understated by the GK measure

On its own, this hypothesis is not enough to explain why FX inequality has been trending up and GK inequality trending down. In the simple model of Section 2, where there are only two consumption goods, both measures move in the same direction. In reality, however, there are a multiplicity of relative prices which are influenced to varying degrees by trade and trade restrictions, by international differences in productivity and factor endowments, by monopoly pricing, by government regulation, etc. For instance, Falvey and Gemmell (1996) find that international differences in the price of services are explained by differences in factor endowments as well as by differences in total factor productivity.

Dowrick and Quiggin (1997) find that the degree of substitution bias is increasing in the dissimilarity between countries' actual prices. It follows that the degree of bias in both FX and GK measures is likely to increase not only when underlying productivity differentials increase but also when international prices diverge for other reasons. Thus we can propose an explanation for the riddle of GK inequality falling whilst FX inequality rises:

Hypothesis 1 *True inequality changed little between 1980 and 1993, but national price structures became less similar, causing the FX measure of inequality to rise and the GK measure of inequality to fall.*

Firebaugh (1999) discounts this possibility, citing the finding of Dowrick and Quiggin (1997) that price structures had become more similar over the 1980s, reducing the amount of substitution bias in GK measures of income convergence. Those findings were, however, only for the OECD countries where price convergence resulted from EC economic integration. There is no presumption of price convergence across the rest of the world.

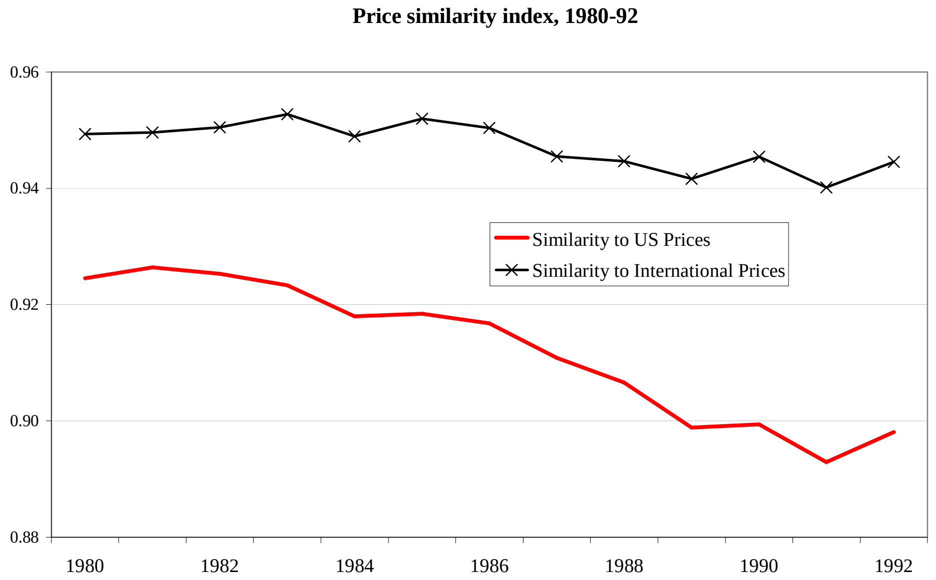
We construct measures of price similarity across the world economies using data from the Penn World Table on the relative prices of private consumption, government consumption and investment. We use the Kravis, Heston and Summers (1982)(page 106) definition of price similarity as the cosine of the angle between a pair of price vectors. We then define a price similarity index, PS^R, in relation to some reference price vector, where the ith element of the index, representing the similarity of prices P^i to P^R, is:

$$PS^{iR} = \frac{\sum_{j=1}^{3} w_j P_{ji} P_{jR}}{\sqrt{\sum_{j=1}^{3} w_j \left(P_{ji}\right)^2 . \sum_{j=1}^{3} w_j \left(P_{jR}\right)^2 .}} \qquad (12)$$

with j indexing the categories of expenditure.

Figure 3 displays the time trends between 1980 and 1992 for the mean of two indexes of price similarity. The first index takes US prices as the reference; the second index relates each country's prices to the GK international price vector.

FIGURE 3



We see that, on average, country's price structures became less similar between 1980 and 1992.

Calculating True (Afriat) Incomes

To test our hypothesis further we need true measures of international incomes, free of both substitution bias and traded sector bias. Dowrick and Quiggin (1997) develop a method that achieves this, based on the economic index number approach of Afriat (1984). This approach compares the values of observed GDP *per capita* bundles of goods and services ($\mathbf{q}_i$) using data on each country's prices ($\mathbf{p}_i$) to test the hypothesis that the $\mathbf{q}_i$ could have been generated by a representative consumer facing the relative prices and budget constraints of each country. Dowrick and Quiggin (1994) have found that this hypothesis is not rejected when they apply revealed preference tests to the International Comparison Project data for 60 countries. This finding makes it possible to produce partial welfare rankings across countries, with $\mathbf{q}_i$ revealed preferred to $\mathbf{q}_j$ if $(\mathbf{p}_i \,.\, \mathbf{q}_j) < (\mathbf{p}_i \,.\, \mathbf{q}_i)$ but it is not the case that $(\mathbf{p}_j \,.\, \mathbf{q}_i) < (\mathbf{p}_j \,.\, \mathbf{q}_j)$.

Using the expenditure function $e(u(\mathbf{q}), \mathbf{p}^r)$ it is then possible to construct money-metric utility comparisons, $e(u(\mathbf{q}_i), \mathbf{p}_r) / e(u(\mathbf{q}_j), \mathbf{p}_r)$, which are consistent with the data and the assumption of common preferences and the choice of some reference price vector, $\mathbf{p}_r$. These utility ratios are preferable to fixed price indices, $(\mathbf{q}_i \,.\, \mathbf{p}_r) / (\mathbf{q}_j \,.\, \mathbf{p}_r)$, because they allow for substitution by consumers. However, they are not unique - varying according to the choice of $\mathbf{p}_r$ – except in the case where the preference function is homothetic.

We find that for a majority of countries (52 out of the 60 countries in the 1980 benchmark study, and 49 out of the 53 countries in the 1993 study) the ICP observations on GDP prices and quantities do satisfy the Afriat test for common homothetic preferences. For this set of observations the money-metric utility comparisons, $e(h(\mathbf{q}_i), \mathbf{p}_r) / e(h(\mathbf{q}_j), \mathbf{p}_r)$, are independent of the choice of $\mathbf{p}_r$. We can then follow Dowrick and Quiggin (1997) in constructing the Ideal Afriat Index, which gives a unique[3] utility-consistent comparison, reflecting true purchasing power and free of substitution bias. We refer to the this measure as true or Afriat income.

Estimating True (Afriat) GDP for non-benchmark countries

We are able to calculate true GDP *per capita* for all of the countries included in the 1980 and 1993 International Comparison (ICP) surveys, using the minimum of the Laspeyres valuations for those countries outside the homothetic sets as recommended by Dowrick and Quiggin (1997). However, in order to get genuinely representative estimates of world inequality, it is necessary to increase population coverage, requiring the extension of PPP estimates to non-benchmark countries. This is especially important because China is not covered in either of the ICP surveys and India is included in the 1980 benchmark only.

In order to predict true incomes for non-benchmark countries, we use a procedure similar to that developed by the authors of the Penn World Tables, see Kravis, Heston and Summers (1982). They use ICP benchmark data to estimate a regression model with GK income as the dependent variable and FX income as an explanatory variable.

Our factor productivity model suggests that FX overstates true income for poorer countries. Substituting (8) into (7), and normalising true income in country 1 to unity, implies that true income *per capita* in country i is:

$$U^i = (FX^i)^{(1-\beta)} \quad \Rightarrow \quad \ln(U^i) = (1-\beta)\ln(FX^i) \qquad 0<\beta<1 \qquad (13)$$

We use this log-linear relationship as the basis of a regression model, augmenting it with a variable, OPEN, capturing the exposure of the country to foreign trade –

[3] The Afriat method yields multiple sets of utility ratios with defined upper and lower bounds. For the

following the procedure reported by Summers and Heston (1991). Deviations between FX and U are driven by price differences between the traded and non-traded sectors of the economy – so where the traded sector constitutes a larger proportion of GDP, we expect the U/FX ratio to be closer to unity. We regress log U on logFX and OPEN for each of the two benchmark years separately, testing for functional form by including the square of logFX and the interaction of OPEN with logFX. Then, data for the two years is combined to obtain pooled estimates.

The regression results are reported in Table 1. Following tests for heteroscedasticity, the 1980 equation and the pooled model were estimated using weighted least squares[4] whereas the 1993-equation was estimated by OLS.

The logarithm of FX income is highly significant across all equations. As expected, the coefficient is less than unity – varying between 0.6 and 0.8 according to the sample. Note that these coefficient estimates are higher than those reported by the authors of the Penn World Table – an example of which is listed in the final column of Table 1 as under 0.5. The PWT's Geary-Khamis method does correct for the sectoral bias in FX income, but it overcorrects due to substitution bias. Our use of the Afriat method demonstrates that true income typically lies between the FX and the GK measures.

The square of logFX adds significant explanatory power to the regression only in the 1980 sample. The openness variable is statistically significant in the 1993 regression, along with the interaction term. The 1993 results imply that there is less of a gap between FX income and true income in economies that are more exposed to world

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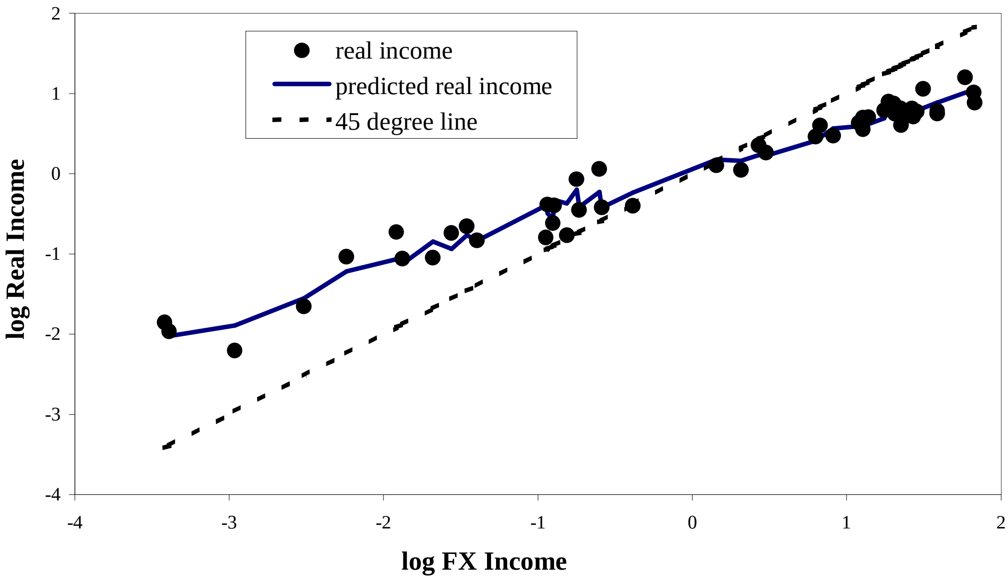
purposes of this paper, we use the mid-points of the multilateral bounds.

[4] By plotting the 1980 sample and the pooled data on *r* and *n*, it was observed that the scatter of *U* was falling with rising *FX*. As a result, the absolute values of the residuals from OLS-estimated equations

trade. The explanatory power, as defined by $\bar{R}^2$, is close to 97 percent for the 1993 sample and the standard error of the regression is around 16 percent, similar to the standard errors for the PWT regression reported in Table 1 and other PWT regressions reported in Summers and Heston (1991). The 1993 data are displayed in Figure 4 along with the predicted value of the regression. We see that the basic log linear relationship predicted by (13) fits the data reasonably well, with only minor additional explanatory power coming from the other variables.

FIGURE 4

Real (Afriat) Income vs FX Income, 1993
actual and predicted values for 48 countries



It is not clear why the OPEN variable is not significant in the 1980 sample, when we have a strong theoretical prior that the level of openness should be important in reducing the gap between FX and PPP incomes. One possible explanation is that we have misspecified the relationship between FX income and true income, perhaps

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were regressed, in the spirit of the Glejser test, on n. The estimated residuals were used as weights to re-estimate the two equations.

through omission of important variables or through incorrect functional form. This poses a problem when it comes to predicting true incomes for the non-benchmark countries in each year. Do we use the particular coefficients for that year, or do we use the coefficients from the pooled regression. The former method may yield more accurate predictions for each particular year, but it creates further problems. The object of the exercise is to compare levels of true income inequality between 1980 and 1993. If we are using two different models to predict true incomes for non-benchmark countries, we cannot be sure whether any changes in estimated inequality are due to changes in the real income distribution or to the different methods used for predictions. Because we are primarily interested in the intertemporal comparison we focus on the results from the pooled regressions. We recognise that the misspecification of the exact relationship reduces the accuracy of the incomes predicted for non-benchmark countries.

Table 1

A. Regression Results

The dependent variable is log real GDP per capita (Afriat PPP) in columns 1-3, and the PWT measure in column 4.

	1980	**1993**	**Pooled data**	***PWT Comparison***
Estimation Method	**WLS**	**OLS**	**WLS**	***OLS***
Intercept	0.075 (1.36)	-0.137 (2.75)	-0.044 (0.70)	*-0.086* *(0.87)*
D93	-	-	-0.121** (2.25)	
Log(FX)	0.795 *** (27.1)	0.632 *** (16.3)	0.742 *** (16.3)	*0.493 **** *(4.3)*
$[\text{Log(FX)}]^2$	-0.045 * (1.89)	-	-	*-0.047 ** *(1.84)*
OPEN	-	0.200*** (2.71)	0.163* (1.77)	
OPENx Log(FX)	-	-0.104* (1.79)	-0.100 (1.53)	
Sample size	60	48	108	*34*
S.E.R.	0.251	0.159	0.270	*0.157*
$\bar{R}^2$	0.936	0.968	0.915	*0.967*

Note: t-statistics in brackets; *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.
The regression summarised in column 4 is for 1975 PWT measures of real GDP; it also contained statistically insignificant openness variables.
Source: Authors' estimations for columns 1-3. Kravis, Heston and Summers (1982), p.335, for column 4.

B. Descriptive Statistics

	Mean	**St. Dev.**	**Min.**	**Max.**
1980				
log Income (Afriat)	0.00	1.31	-2.65	2.07
log Income (FX)	0.00	1.09	-2.36	1.62
OPEN	0.62	0.32	0.12	1.81
1993				
log Income (Afriat)	0.00	1.52	-3.42	1.83
log Income (FX)	0.01	0.89	-2.20	1.20
OPEN	0.80	0.60	0.16	3.49

Source: Penn World Tables 5.6a (http://pwt.econ.upenn.edu/home.html) for OPEN;
World Bank Global Development Network Growth Database for FX income (GDP *per capita*): http://www.worldbank.org/research/growth/GDNdata.htm;
Note: Both FX and Afriat incomes have been normalised to a geometric mean of unity.

Different measures of inequality

Four alternative measures of inequality – Gini (G), Theil (T), the squared coefficient of variation (CV^2) and the variance of logarithmic income (L) – are employed in this paper. The four measures, following Firebaugh (1999), can conveniently be represented by a distance function of the form:

$$I_m = \sum_{i=1}^{N} p_i f_m(y_i); \qquad m = G, T, CV^2, L \tag{1}$$

where y_i is the ratio between the income per capita of the i^{th} country and the average income (per capita) across N countries and p_i is the share of the i^{th} country's population in the total population of N countries. We choose to use the population weights as a dollar change in per capita income in China or India has a lot more significance for world income distribution than a similar change in income in Luxembourg or Iceland.

Specific functional forms distinguish the four indexes:

$$\begin{aligned} G &= \sum_{i=1}^{N} p_i y_i (q_i - Q_i), \\ T &= \sum_{i=1}^{N} p_i y_i \log y_i, \\ CV^2 &= \sum_{i=1}^{N} p_i (y_i - 1)^2, \\ L &= \sum_{i=1}^{N} p_i \{\log y_i - E[\log y_i]\}^2, \end{aligned} \tag{2}$$

where E is expected value; log is the natural logarithm; q_i is the proportion of population in N countries that is poorer than country i and Q_i is the proportion of population richer than country i. Clearly, the three population proportions, that is, p_i, q_i and Q_i sum to unity.

Intra-country inequality

Historically, studies of world income distribution have analysed income inequality across countries while ignoring the intra-country component, probably because of data constraints - see, for, instance, Theil (1979), Theil and Seale (1994), Theil (1996) and Firebaugh (1999). More recently, however, the within-country dimension is being taken into consideration, giving a more accurate picture of overall inequality across all households in the world – as in Berry, Bourguignon and Morrisson (1983), Grosh and Nafziger (1986), Chotikapanich, Valenzuela and Rao (1997), Schulz (1998) and Milanovic (1999).

Initially, in this paper, we present time-series estimates of international income inequality based only on the between-country component for the period beginning from 1980 for each of the three income measures, that is FX, PPP (Afriat) and PPP (PWT). The PPP (PWT) based inequality indexes are reported annually for 1980-97 covering 115 countries with 86 per cent of world population in 1997. The FX-based indexes, which incorporate 138 countries representing 83 per cent of world population in 1995, are presented annually for the 1980-95 period. The PPP (Afriat) based indexes are calculated for 1980 and 1993 only.

Intra-country inequality measures have been taken from Deininger and Squire (1996) who have put together a data set containing quintile income shares and Gini coefficients classified by country, year, income type (gross or net), coverage (national or sub-national), form of recipient unit (person or household) and, importantly, by data quality. The data set includes 682 observations of the highest quality. Relying almost exclusively on the highest quality data, mostly on quintile distribution and occasionally on Gini, the four inequality indexes are computed for 1980 and 1993 for 47 countries covering nearly 70 per cent of the world population in both years.

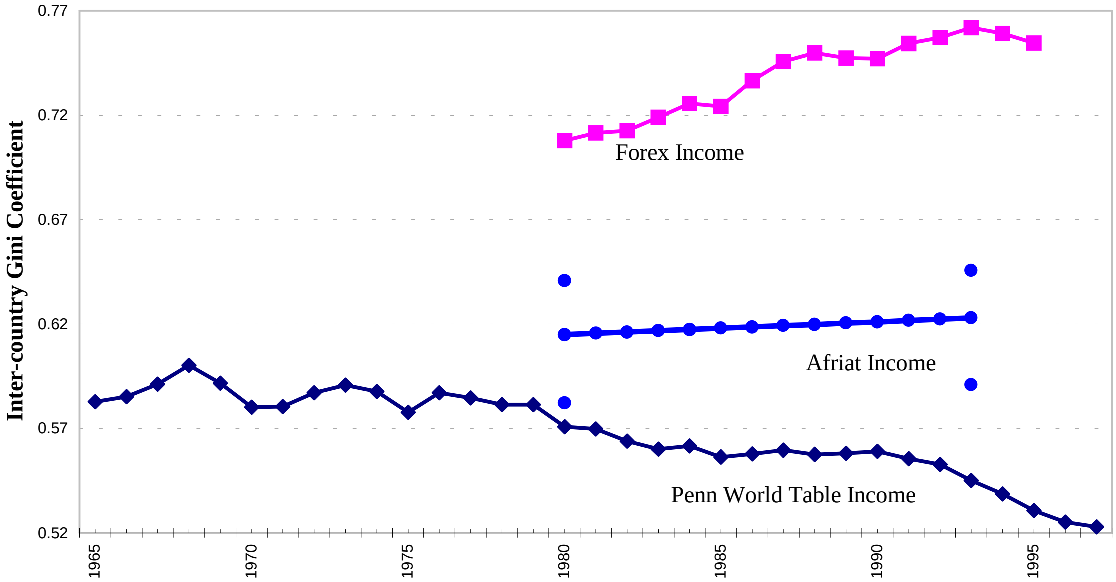
For many countries Deininger and Squire do not report quintile distribution data of reliable quality for the two years. In order to increase the number of countries included in the sample, the distribution data for the closest year, while constraining the departure to at most three years from the year of interest – 1980 or 1993, are chosen as a proxy. In a few cases, only the Gini coefficient and not the distribution data was available. Ginis were used in those cases to approximate the underlying quintile distribution using the single-parameter functional form of the Lorenz curve suggested by Chotikapanich (1993).[5] The mean per capita income for different quintiles are obtained by multiplying the relevant quintile income share with country's per capita income and then dividing by 0.2, the population share per quintile. We then treat each country-quintile, with its average income and appropriate population weight, as a single observation in re-calculating global inequality.

[5] Chotikapanich approximates the Lorenz curve by the following single-parameter specification: $LC = \left(e^{kp} - 1\right) / \left(e^{k} - 1\right)$. The corresponding Gini coefficient is given by: $G = \left[(k-2)e^{k} + (k+2)\right] / k(e^{k} - 1)$, where *p* is the population share and *k* is a parameter, which is required to be greater than zero. In the first step, the Gini equation is solved for *k* which then is used to obtain the estimates of quintile income distribution.

4. *Inequality Results*

Figure 3A repeats the illustration of FX and PWT Gini coefficients, but adds in our estimates of inequality based on the estimates of true Afriat incomes. Our predictions of bias are confirmed. The FX measure overstates true inequality whilst the PWT measure understates it.

FIGURE 3A
The Inter-Country Gini Coefficient – three income measures

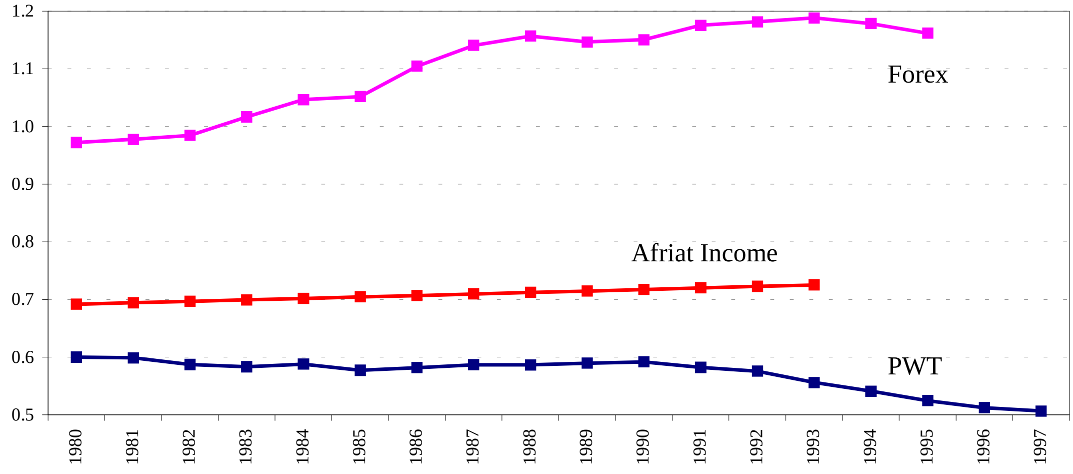


With respect to trends, our estimates of true income inequality indicate a very slight rise in the inter-country Gini coefficient, from 0.615 in 1980 to 0.623 in 1993. This finding is not, however, robust to the inequality index employed. Figures 3B-D display the other indexes of inequality – Theil, CV^2 and Log variance. We see a slight reduction in the variance of logs true income, from 1.551 to 1.522, between 1980 and 1993.

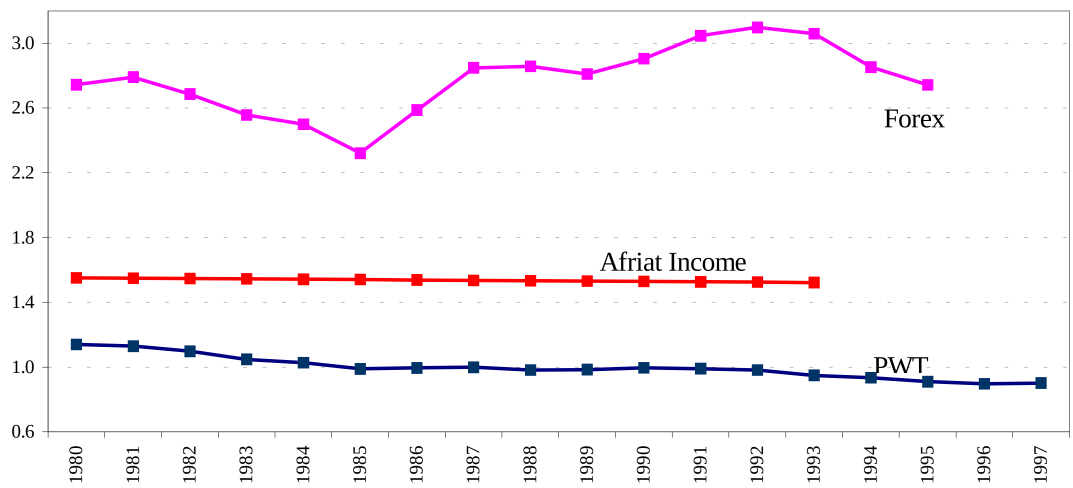
The three non-Gini measures of inequality give us a somewhat different picture. We find that two of the FX-income measures are higher in 1993 than in 1980, whilst the three PWT figures are lower. But looking at changes from 1980 to different end

FIGURES 3b-d
International Income Inequality – Three Alternative Indexes

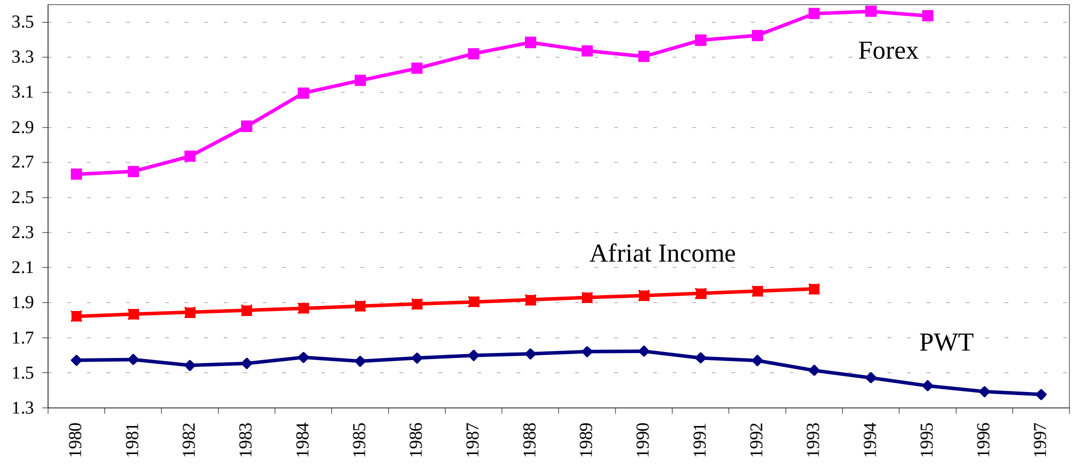
Theil Index



Variance of log Income



Squared Coefficient of Variation



years yields different results. Most noticeably, if we measure inequality as the variance of log income, FX inequality declines from a peak in 1992 to be at exactly the same level in 1995 as it had been in 1980.

Estimation error for countries not included in the ICP benchmark surveys

Because China is not included in either of the International Comparison Project surveys of prices, both the PWT and our own Afriat measures of real income are predicted using the regression equations reported in Table 1.[6] Given that China accounts for over one-fifth of world population, it is crucial to analyse the robustness of measured inequality with respect to the prediction errors associated with Chinese real income. We have seen that the standard error of the PPP regressions are at least fifteen percent within the sample of benchmark countries – and we expect the error to be even greater when making predictions outside the sample. To check robustness, we calculate upper and lower bounds for real GDP *per capita* in China by adding or subtracting two standard errors from the baseline prediction. The results are displayed in Table 2.

In the case of the PWT income estimates, the upper and lower estimates suggest that *per capita* income in China in 1993 was between seven and thirteen percent of US income. For the Afriat income estimates, the bounds are three and eight percent.

[6] The Appendix to Penn World Table 5.6 reports a series of broadly similar regressions explaining the relationship between GK and survey expenditure. The standard error of regression for the PPP (PWT) is taken from Summers and Heston (1991) who report seven alternative regression equations which are used for prediction depending on the availability of data on different countries. The median standard error of 0.15 is used to perform the sensitivity analysis in this paper.

Table 2
Estimated GDP *per capita* of China
(percentage of US income)

	1980			1993		
	FX	Afriat	PWT	FX	Afriat	PWT
Lower Prediction		*2.6*	*4.7*		*2.5*	*6.7*
Baseline	**1.7**	**4.7**	**6.4**	**1.5**	**4.5**	**9.2**
Higher Prediction		*8.5*	*8.7*		*8.1*	*12.6*

The four inequality indexes are re-calculated for 1980 and 1993 using the upper and lower estimates of Chinese real GDP. Results are reported in Table 3. Not surprisingly the low and high values of the Gini differ significantly from their baseline counterparts. Similarly, the high estimate of the Gini coefficient for Afriat income exceeds the baseline estimate by more than 4 per cent in 1980 and by 3.6 per cent in 1993. These 'confidence intervals' for true income inequality are displayed as dots in Figure 3A.

Table 3

Sensitivity of Inter-country Inequality to Estimates of Chinese income

	PWT Income			**Afriat Income**		
	Low estimate	Baseline	High estimate	Low estimate	Baseline	High estimate
1980	0.552	0.571	0.592	0.582	0.615	0.641
1993	0.526	0.545	0.566	0.591	0.623	0.646

In another experiment we dropped China from our sample and computed inequality indexes for the rest of the 114 countries in the sample. We know that, as a country with relatively low income but exhibiting relatively high growth, China is lowering global inequality over time. As expected, using either the FX or Afriat definitions of income, inequality increases more sharply when China is excluded. Surprisingly, when we use the PWT estimates of PPP income, the decline in world inequality disappears altogether when China is excluded.

We are not suggesting that China should be excluded from measures of world inequality. But it is important to emphasise that international comparisons of average real income for China are based on regression estimates, not on direct price measurement by the International Comparison Program. In the absence of such direct measurement, any estimates of recent trends in international inequality are subject to substantial uncertainty.

Global inequality

Adding the dimension of within-nation inequality to our measures of international inequality allows us to analyse global inequality. The Deininger and Squire (1996) data set allows us to examine changes in intra-country inequality by Gini coefficient and by income quintile for 47 countries, covering over two thirds of the world's population. The Gini coefficient data is summarised in Table 4. Somewhat surprisingly, given extensive recent publicity on rising income inequality in industrialised economies, the unweighted country average shows a slight drop in inequality. Weighted by population, however, the average value of the Gini coefficient rises.

Table 4

	Within-country Gini Coefficients for 47 countries		
	1980	**1993**	**Change**
Unweighted average (%)	39.5	38.9	-0.6
Population weighted average (%)	34.3	36.4	1.9

We augment our measures of inter-country inequality, utilising intra-country income distribution by quintiles, to derive estimates of global inequality. Table 5 presents estimates of the global Gini coefficient for 1980 and 1993. We again find that global income inequality has been rising if we use the FX income definition, whilst the PWT measure of income records a fall. Our estimates of true (Afriat) income suggest a slight rise in global inequality.

Table 5

Gini Coefficients of Global Income Inequality (by Country Quintiles)

	PWT Income	**Afriat Income**	**Forex Income**
1980	0.659	0.698	0.779
	(86.7%)[1]	(88.0%)	(90.9%)
1993	0.636	0.711	0.824
	(85.6%)	(87.7%)	(92.4%)
Percent Change[2]	-3.4%	1.7%	5.8%

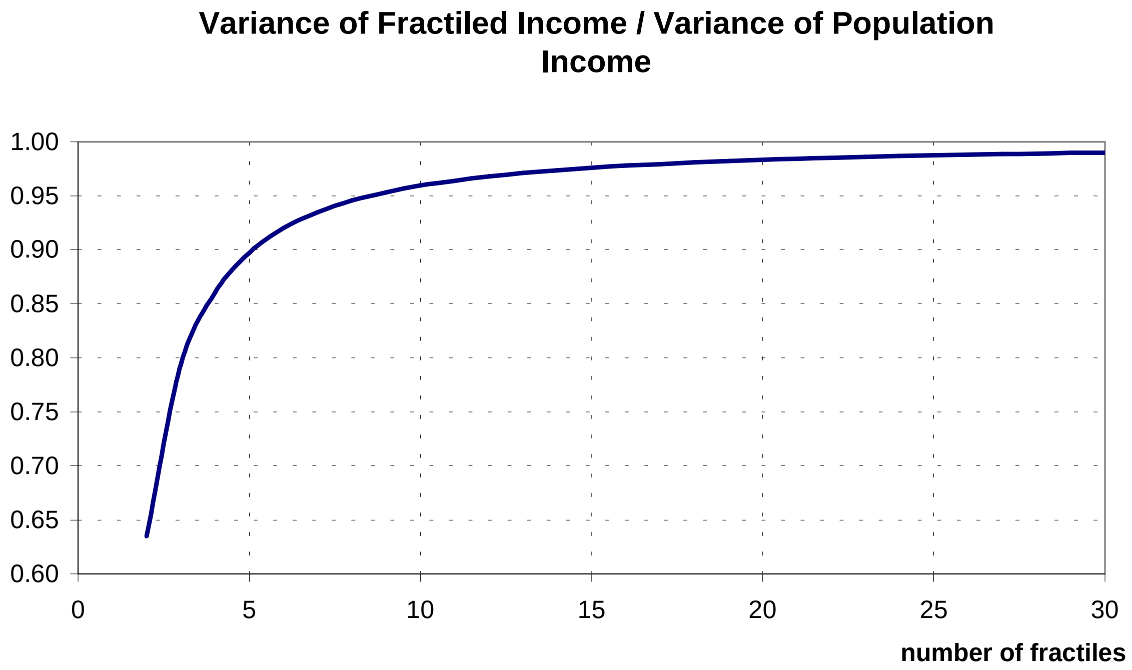
Notes:
1. Inter-country values of the index are given in parentheses as a percentage of global values.
2. Percentage change of global index between 1993 and 1980.

In Table 5, the figures in parentheses give the ratio of the inter-country Gini to the world Gini. This ratio varies between 85 and 89 per cent for the PPP-based estimates and between 91 and 92 per cent for the FX income-based Gini. This seems rather surprising – that intra-country inequality contributes relatively little, no more than fifteen percent, to overall world inequality. These results are, however, consistent with the findings of Berry, Bourguignon and Morrisson (1983), Milanovic (1999), Korzeniewicz and Moran (1997) and Li, Squire and Zou (1998). Examining the quintile shares of income within countries, we find that the ratio of income earned by the richest 20% is, on average, eight times the income earned by the poorest 20% of households. This is substantially less than the dispersion of income shares across countries: in 1993, the inter-country quintile ratio of real *per capita* income was 25 and the USA was nearly 60 times richer than both Ethiopia and the Congo.

We are still concerned that the use of grouped income data may substantially understate the contribution of intra-country inequality to global inequality. As an experiment, we generated ten thousand log-normally distributed incomes and computed the variance of log income when the income is grouped into various fractiles – as shown in Figure 5. We find that the variance of log income grouped into quintiles is 90% of the variance of the full sample. Grouping into deciles gives over 95% of the population variance. We conclude, therefore, that the quintile income shares that we and other researchers have used are likely to come close to capturing the full contribution of intra-country inequality to world inequality.

Given that intra-country inequality is only a minor component of world inequality, it is not surprising to find that world inequality displays similar trends to inter-country inequality. The inclusion of within-country inequality tends to rescale the indexes upwards, without greatly altering rates of change over recent years.

FIGURE 5



The corresponding results for the other three inequality indexes – Theil (T), coefficient of variation squared (V^2) and variance of log income (L) – are presented in Table 6.

We find that on these three indexes of inequality the contribution of within-country inequality is proportionally greater than was the case with the Gini index. This perhaps reflects the fact that the Gini coefficient is relatively insensitive to changes at the tails of the distribution. We find, nevertheless, that the trends identified for the global Gini index, are essentially robust to the choice of inequality index. Global inequality falls between 1980 and 1993 for PWT incomes, but it increases for true Afriat income and FX income, according to all four indexes.

Table 6
Alternative Indexes of Global income inequality

	PWT	Afriat	FX
Theil Index			
1980	0.847	0.968	1.258
	(70.9%)	(71.5%)	(77.3%)
1993	0.790	1.016	1.503
	(70.4%)	(71.4%)	(79.0%)
Percent Change*	-6.7%	5.0%	19.5%
Squared CV			
1980	2.860	3.343	4.338
	(55.0%)	(54.5%)	(60.7%)
1993	2.734	3.632	5.731
	(55.4%)	(54.5%)	(61.9%)
Percent Change*	-4.4%	8.7%	32.1%
Variance of log			
1980	1.743	2.214	3.672
	(65.3%)	(70.1%)	(74.7%)
1993	1.511	2.402	4.238
	(62.8%)	(63.4%)	(72.2%)
Percent Change*	-13.3%	8.5%	15.4%

Note:
1. Values in parentheses are the between-country index as a percentage of the intra-country index.

2. * Percentage change in Gini between 1993 and 1980.

Finally, Table 6 presents results of a further sensitivity analysis to take account of the fact that China has not been surveyed in any of the International Comparison Program's detailed price surveys. We calculate a pseudo-95%-confidence-interval for the value of the Chinese *per capita* GDP income by quintiles - increasing and reducing the PWT and Afriat estimates of Chinese income by two standard errors of the relevant predicting regression equation. We then calculate extreme bounds for the ratio of 1993 inequality to 1980 inequality by calculating the ratio of the 1993 upper bound to the 1980 lower bound, and *vice versa*.

We find that these bounds encompass unity on all measures. None of our measures of changing levels of global inequality are robust when we take account of the errors involved in estimating the real income level of China.

Table 6 Extreme Bounds for Growth in Global Inequality

	PWT Income		**Afriat Income**	
	Low ratio	High ratio	Low ratio	High ratio
Gini (G)	0.91	1.03	0.94	1.10
Theil (T)	0.81	1.08	0.87	1.25
CV-squared (CV^2)	0.81	1.12	0.89	1.30
Var-log (L)	0.69	1.10	0.68	1.71

Notes: Low ratio = Low value of Index in 1993 relative to the high value of Index in 1980, High ratio High value of Index in 1993 relative to the low value in 1980.

4. Concluding Comments

The emerging orthodoxy on recent international trends is that when incomes are compared on the basis of purchasing power parity, rather than currency market rates, world inequality has been tending to fall over the past two decades. We confirm these findings when we use the estimates of purchasing power parity incomes compiled in the Penn World Tables.

What is not at all clear, however, is the reason why the inequality trends measured by FX and PWT income should be in opposite directions. If real incomes are in fact converging, as suggested by the PWT measures, then real wages in poorer countries should be catching up on wages in the richer economies and the relative prices of labour-intensive non-traded services should be converging. If this were so, we would expect the sectoral bias in FX income comparisons to be diminishing over time as well. Looking back at our Figure 2, we see that in 1980 the level of inequality in FX incomes was substantially higher than the level of inequality in PWT incomes. By the 1990s, with falling real inequality, the gap between the two lines should have diminished. In other words, with falling inequality in real income we should expect FX measures of income inequality to have been falling even faster. But the exact opposite has occurred, the gap between FX and PWT inequality has increased dramatically.

One plausible explanation is that the biases in both the PWT and Foreign Exchange estimates have been increasing over the period. The PWT method of calculating purchasing power parity income values goods and services in all countries and in all years at 1985 international prices. Nuxoll (1994) shows that these constant prices correspond to those of fairly wealthy economies and will therefore tend to overstate the true incomes of the poorer economies. So we are not surprised to find that the PWT measure understates true inequality. If real income differentials have in fact been approximately stable, then as we move further away in time from the 1985 base year, we expect the bias in the PWT to increase. This source of increasing bias in the PWT income measures is likely to have been exacerbated by other factors such as trade barriers that increase inter-country price dissimilarity.

Here we have a potential explanation for the radical differences in measured inequality trends. Inequality has been increasing slightly – as suggested by our Afriat measures of true PPP income. The sectoral bias inherent in FX income comparisons, which exaggerates true income differences, has therefore been increasing as well, causing FX income inequality to rise substantially. The bias in the PWT income goes the other way. As countries' price structures have become less and less similar to 1985 international prices, PWT increasingly overstates the true income levels in poorer countries, causing PWT income inequality to fall.

Whilst this story is plausible, we cannot be sure that it is true. There are substantial errors involved in predicting real incomes for countries that have not been included in the ICP benchmark surveys – whether we are predicting GK income or true Afriat incomes. Whilst our preferred method of calculating true incomes does indeed suggest a rise in inequality between 1980 and 1993, another other method suggests the opposite. These methodological problems need further research. Moreover, unless and until the International Comparison Program extends its detailed price surveys to China, all methods of calculating purchasing power parities have to resort to imprecise guesstimates of real income for one fifth of the world's population.

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