ISSN 0819-2642
ISBN 978 0 7340 4026 8

THE UNIVERSITY OF MELBOURNE

DEPARTMENT OF ECONOMICS

RESEARCH PAPER NUMBER 1062

January 2009

Global Income Distribution and Inequality: 1993 and 2000

by

Duangkamon Chotikapanich, William Griffiths, D. S. Prasada Rao & Vicar Valencia

Department of Economics
The University of Melbourne
Melbourne Victoria 3010
Australia.

Global Income Distribution and Inequality: 1993 and 2000

Duangkamon Chotikapanich*
Department of Econometrics and Business Statistics
Monash University, Melbourne, Australia

William E. Griffiths
Department of Economics
University of Melbourne, Australia

D.S. Prasada Rao
Department of Economics
University of Queensland, Australia

Vicar Valencia
School of Economics, Finance and Marketing
RMIT University, Australia

30 January, 2009

* Part of this research was completed while Duangkamon Chotikapanich was visiting the World Institute for Development Economics Research. She acknowledges helpful comments from the seminar audience at that institution.

Abstract

The nature of global and regional income distributions and the extent of inequality are examined using country-level data on income distributions drawn from World Bank studies and the World Institute for Development Economics Research for the period 1993 - 2000. Beta-2 income distributions are fitted to population and income share data for 91 countries. Regional and global income distributions are obtained as population weighted mixtures of the country-specific income distributions. Gini and Theil inequality measures for countries, regions and the world are expressed in terms of the parameters of the beta-2 distributions, and, for regions and the world, decomposed into their within- and between-country components. Empirical results show a high degree of global inequality, but with some evidence of inequality decreasing between the two years, with the decrease being largely attributable to growth in China.

Keywords: beta-2 distribution; mixture distribution; Gini coefficient; Theil index; inequality decomposition.

JEL classification numbers: C13, C16, D31

1. INTRODUCTION

In the current climate of increasing globalisation and a push for free trade among nations through the World Trade Organisation, there is considerable interest among economists, international development organisations and the general public concerning the overall effects of globalisation on the welfare of the global society. There is a concern that increasing globalisation may lead to increasing inequality, and that increasing global inequality may mean the unsustainability of the current international order. A major difficulty with the ongoing debate about globalisation is the problem of measuring the extent of inequality, and being able to meaningfully compare inequality across countries, regions or time periods. Unless global and regional inequality are accurately measured, it is difficult to evaluate whether various policy initiatives, such as moves towards greater globalisation, are increasing or reducing inequality.

The process of globalisation is perceived to create winners and losers, thus leading to greater inequality. At the country level, it is possible that in the short run only certain sections and population sub-groups benefit from increased trade and deregulation. Also, in the process of achieving increased levels of efficiency and productivity it is conceivable that capital-augmenting and labour-shedding technologies may be preferred, leading to increases in unemployment levels. This outcome is a scenario that points towards increasing inequality within the countries that are active pursuants of globalisation. Moving from the country level to the regional level, globalisation is likely to result in varying levels of growth in real per capita income achieved in different countries and regions. It is now well documented that countries in East and South East Asia have experienced strong growth in income and living standards. However, performance even within this region is not uniform.

Chotikapanich and Rao (1998) have documented this uneven growth performance and its effects on inequality within this region. The African and Latin American regions have lagged behind the Asian region in terms of growth performance. Evidence to date (Chotikapanich *et al* 1997; Chotikapanich and Rao 1998; Melchior *et al* 2000; Milanovic and Yitzhaki 2001; and Milanovic 2002) indicates a steady reduction in inequality *between* countries during the period 1960s to 1998, but, at the same time, there has been an increase in global inequality. This finding can largely be attributed to increases in income inequality within countries. Studies which ignore within country inequality have shown a reduction in global inequality. Schulz (1998), Firebaugh (1999) and Melchior *et al* (2000) report a decline in global inequality measured using inter-country differences in income.

Within the context of assessing the implications of increased globalisation on total welfare, it is necessary to accurately measure inequality at the global, regional and country levels. Despite the increasing recognition of the need to measure inequality on a regular basis at regional and global levels, availability of detailed data from countries is quite limited. Most of the data for the purpose of measuring inequality are drawn from household expenditure and income surveys that are conducted once in five years in most countries. Some countries conduct these surveys more regularly. Compilation of data from these surveys and data dissemination is resource intensive and, consequently, much of these data are not readily available for researchers. More regularly disseminated data take the form of summary statistics that include measures of inequality like the Gini coefficient and incomes shares of quintile or decile groups.

A significant research problem arises from the need to study regional and global distributions of income based on income distribution data available in a summary form. There have been several attempts in the past addressing these issues. Starting from some earlier work by Theil (1979, 1989 and 1996) where regional and global inequality were estimated ignoring within-country inequality, Chotikapanich *et al* (1997 and 1998) estimated global inequality using a restrictive lognormal distribution as a model of income distribution within each country. More recently, Milanovic (2002) uses data from World Bank sources to generalise the work of Chotikapanich *et al* (1997) and to study global inequality and its decomposition into regional inequality. Although the study by Milanovic (2002) makes use of extensive income distribution data available from various sources, principally from the World Bank, the approach makes use of only the income shares of quintile and decile population groups. An assumption implicit in the study is that all people in a given group, bottom 10% say, receive the same income which is equal to the average income for that group. Sala-i-Martin (2002a, 2002b) reports a similar study with a slightly different approach where country-specific kernel density functions are estimated for each country separately for each year in the study. His study also starts with the assumption that all individuals in a quintile or decile group have the same income. Thus, Milanovic (2002) and Sala-i-Martin (2002a, 2002b) both ignore distributional characteristics within each population sub-group in each of the countries included.

The aim of the paper is to estimate global and regional income distributions for the years 1993 and 2000, using less restrictive assumptions than those employed in earlier studies for the income distributions of individual countries. In particular, the log-normal assumption made by Chotikapanich *et al* (1997) and the constant-income-within-subgroups assumption made by Milanovic (2002) and Sala-i-Martin (2002a, 2002b) are relaxed. While the lognormal distribution is relatively easy to estimate from information on the Gini coefficients and mean income for each country, it is known to be restrictive in that it implies symmetric and non-intersecting Lorenz curves. A large number of less restrictive alternative distributions have been suggested in the literature. See, for example, McDonald and Ransom (1979), McDonald (1984), McDonald and Xu (1995), Creedy and Martin (1997), Bandourian, McDonald and Turley (2003), and Kleiber and Kotz (2003). The beta-2 distribution that we have chosen for our analysis is a member of the generalized beta class of distributions (see McDonald and Xu 1995). It is a flexible distribution that has been shown to provide a good fit to a variety of empirical income distributions. See for example McDonald (1984) and McDonald and Ransom (1979). By fitting beta-2 income distributions to each country, we are able to avoid the implicit assumption that all incomes are constant within each class for which income and population share data are available.

The technique that we use to estimate each beta-2 distribution from summary data comprising population shares and class mean incomes or income shares is the method-of-moments estimator suggested by Chotikapanich *et al* (2007). This estimation makes up the first stage of our research. In the second stage, we derive regional and global income distributions by combining the beta-2 distributions for each country. A combined distribution (regional or global) is a population-share weighted mixture of the income distributions for each of the component countries. Finally, income distributions derived for regional and global levels are used to study the levels and trends in income and inequality using density functions, distribution functions, Lorenz curves, and the Gini and Theil coefficients. Inequality is decomposed into between country and within country inequality.

We find that, at the regional level, Latin America and the Caribbean, and Africa, have high and increasing levels of inequality. Asia has a high, but decreasing level of inequality. Because of rapid growth in China, global inequality has declined slightly. The remainder of the paper is organized as follows. Our methodology, including specification and estimation of the beta-2 distributions, modelling regional and global income distributions, and specification of inequality measures and their decompositions, is described in Section 2. Details of the data used are given in Section 3. The empirical results are presented in Section 4. Section 5 contains a summary of the contribution of the paper.

2. METHODOLOGY

This section consists of four parts. The first part is devoted to analysis of single country income distributions. We summarize the properties of the beta-2 income distribution, describe how to compute inequality coefficients and the Lorenz curve from values of the parameters of a beta-2 distribution, and describe how to assess Lorenz or stochastic dominance when comparing the distributions of two countries or one country at two different points in time. In the second part the method-of-moments estimator introduced by Chotikapanich *et al* (2007) for estimating the parameters of the beta-2 distribution is reviewed. In the third part we move on to the methodology needed to examine regional and global income distributions. These distributions are defined as mixtures of the country distributions introduced in the first and second parts. Expressions for the regional and global Gini and Theil coefficients are written in terms of the parameters of the component distributions; we discuss how to assess regional/global Lorenz or stochastic dominance. In the fourth part we provide expressions for decomposing the regional/global Gini and Theil coefficients into within-country inequality and between-country inequality.

2.1 Modelling country income distributions

The probability density function (pdf) for the three-parameter beta-2 distribution used to model the country income distributions is defined as:

$$f(y) = \frac{y^{p-1}}{b^p B(p,q)\left(1+\frac{y}{b}\right)^{p+q}} \qquad y > 0 \qquad (1)$$

where $b > 0$, $p > 0$ and $q > 0$ are parameters and $B(p,q)$ is the beta function

$$B(p,q) = \frac{\Gamma(p)\,\Gamma(q)}{\Gamma(p+q)} = \int_0^1 t^{p-1}(1-t)^{q-1}dt$$

For the mode of $f(y)$ to be nonzero $p > 1$ is required; for the mean to exist $q > 1$ is required. The corresponding cumulative distribution function (cdf) is given by

$$F(y) = \frac{1}{B(p,q)} \int_0^{[y/(b+y)]} t^{p-1}(1-t)^{q-1}dt = B_{y/(b+y)}\left(p,q\right) \qquad (2)$$

where the function $B_t(p,q)$ is the cdf for the normalized beta distribution defined on the (0,1) interval. This representation is a convenient one because $B_t(p,q)$ is a readily-computed function in most statistical software. If T is a standard beta random variable defined on the interval (0, 1), then the relationship between T and Y is

$$T = \frac{Y}{b+Y} \qquad\qquad Y = \frac{bT}{1-T}$$

The mean, mode and variance of Y are given by

$$\mu = \frac{bp}{q-1} \qquad\qquad m = \frac{(p-1)b}{q+1}$$

$$\sigma^2 = \mu\left[\frac{b(p+1)}{q-2} - \mu\right] = \frac{b^2 p(p+q-1)}{(q-1)^2(q-2)} \qquad (3)$$

For measuring inequality, the most popular index is the Gini coefficient, which, when expressed in terms of the parameters of the beta-2 distribution, is given by (McDonald, 1984)

$$G = \frac{2B\left(2p, 2q-1\right)}{pB^2(p,q)} \qquad (4)$$

The other inequality measure that we consider is Theil's L index (Theil 1967, p. 127; Theil 1979). The continuous version of this index is

$$L = \int_0^\infty \ln\left(\frac{\mu}{y}\right) f\left(y\right)\, dy \qquad (5)$$

Using results in McDonald and Ransom (2008), this measure can be expressed in terms of the parameters of the beta-2 distribution as

$$L = \ln\left(\frac{p}{q-1}\right) + \psi\left(q\right) - \psi\left(p\right) \qquad (6)$$

where $\psi(x) = d\ln\Gamma(x)/dx$ is the digamma function. Like the beta function, this function is readily calculated by most statistical software.

Also of interest are the Lorenz curves for each country, relating the cumulative income proportion $\eta(y)$ to the cumulative proportion of population $F(y)$. A visual comparison of two Lorenz curves across time or across countries reveals whether or not inequality has unambiguously increased or decreased. Given values *b*, *p* and *q* for a beta-2 distribution, points from which to graph a Lorenz curve can be obtained as follows. First a grid of values for *y* is selected – values at equal intervals of $\ln(y)$ are likely to be suitable. Then, values of $F(y)$ are calculated from (2) and values for $\eta(y)$ can be found from

$$\begin{aligned}\eta(y) &= \frac{1}{\mu}\int_0^y z\, f\left(z\right)dz \\ &= B_{y/(b+y)}\left(p+1, q-1\right)\end{aligned} \tag{7}$$

An income distribution $F_1(y)$ is said to Lorenz dominate another distribution $F_2(y)$ in the sense that it exhibits less inequality if $\eta_1(y) \geq \eta_2(y)$ for all *y* and $\eta_1(y) > \eta_2(y)$ for at least one *y*. In addition to checking for Lorenz dominance visually, necessary and sufficient conditions for dominance can be stated in terms of the parameters of the beta-2 distribution (Kleiber 1999, Wilfling 1996). Specifically, country 1 Lorenz dominates country 2 in the sense that inequality is less in country 1 if

$$p_2 \leq p_1 \quad \text{and} \quad q_2 \leq q_1$$

with at least one inequality being a strict inequality.

We also consider first-order stochastic dominance, a welfare criterion that examines whether the level of income from one distribution is greater than the level of income from a second distribution for all population proportions. The income distribution $F_1(y)$ first-order stochastically dominates $F_2(y)$ if $F_1(y) \leq F_2(y)$ for all *y*, and $F_1(y) < F_2(y)$ for at least one *y*. Conditions on the parameters that imply first order stochastic dominance do not appear to be available, but the condition can be checked visually from graphs of the distribution functions.

All the above quantities – means and variances of the distributions, the density and distribution functions, the Lorenz curves, and the Gini and Theil coefficients – depend on the unknown parameters of the beta-2 distributions *b*, *p* and *q*. We turn now to the problem of estimating these parameters. A summary of the method-of-moments procedure suggested by Chotikapanich *et al* (2007) follows.

2.2 Estimation

Suppose we have N income classes $(a_0, a_1), (a_1, a_2), \ldots, (a_{N-1}, a_N)$, with $a_0 = 0$ and $a_N = \infty$. Let the mean class incomes for each of the N classes be given by $\bar{y}_1, \bar{y}_2, \ldots, \bar{y}_N$; and let the population proportions for each class be given by $c_1, c_2, \ldots, c_N$. If data are available for $\bar{y}_i$ and c_i, but not for a_i, our problem is to estimate the parameters of a beta-2 distribution, along with the unknown class limits $a_1, a_2, \ldots, a_{N-1}$. The approach is to fit a beta distribution to the data such that the sample moments $\bar{y}_i$ and c_i are "close" to their population counterparts. This approach is equivalent to fitting a distribution such that $\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_{2N}$ are "close to zero" where

$$c_i = \int_{a_{i-1}}^{a_i} f(y)dy + \varepsilon_i \qquad i = 1, 2, \ldots, N \tag{8}$$

and

$$\bar{y}_i = \frac{\int_{a_{i-1}}^{a_i} y f(y)dy}{\int_{a_{i-1}}^{a_i} f(y)dy} + \varepsilon_{N+i} \qquad i = 1, 2, \ldots, N \tag{9}$$

Chotikapanich *et al* (2007) show how to find estimates of the parameters, *b, p, q* and the class limits $a_1, a_2, \ldots, a_{N-1}$ that minimize the weighted sum of squares function

$$\sum_{i=1}^{N} \left[\left(\frac{\varepsilon_i}{c_i} \right)^2 + \left(\frac{\varepsilon_{N+i}}{\bar{y}_i} \right)^2 \right] \tag{10}$$

This can be achieved by recognizing that equations (8) and (9) can be rewritten in terms of the beta distribution function as

$$c_i \;=\; B_{a_i/(b+a_i)}\left(p,q\right) - B_{a_{i-1}/(b+a_{i-1})}\left(p,q\right) \;+\; \varepsilon_i$$

and

$$\bar{y}_i \;=\; \frac{bp}{q-1}\left(\frac{B_{a_i/(b+a_i)}\left(p+1,q-1\right) - B_{a_{i-1}/(b+a_{i-1})}\left(p+1,q-1\right)}{B_{a_i/(b+a_i)}\left(p,q\right) - B_{a_{i-1}/(b+a_{i-1})}\left(p,q\right)}\right) \;+\; \varepsilon_{N+i}$$

where $B_{a_0/(b+a_0)}\left(p,q\right)=0$ and $B_{a_N/(b+a_N)}\left(p,q\right)=1$.

The estimation can be done using the non-linear least squares options available in a standard econometric package like EViews. The relationship between population moments and the parameter values given in equation (3) can be used to provide a guide to starting values for the non-linear optimisation problem by replacing the population moments with observed sample moments,

2.3 Modelling regional/global income distributions

Suppose that a region of interest is made up of K countries. This region may be the whole globe or it could be a smaller subset of countries such as Africa or Asia. After estimating the country income distributions we are in a position to combine them to form a regional income distribution. If the K countries have beta income pdf's, $f_k(y),\ k=1,2,\ldots,K$, and population proportions $\lambda_1,\lambda_2,\ldots\lambda_K$, the pdf for the income distribution for the region is given by the mixture

$$f(y) \;=\; \sum_{k=1}^{K}\lambda_k f_k(y) \qquad (11)$$

Henceforth a k subscript denotes a quantity for the k-th country, whereas regional quantities will carry no subscript. The regional cumulative distribution function is given by the same weighted average of the country cdf's

$$F(y) = \sum_{k=1}^{K} \lambda_k F_k(y) = \sum_{k=1}^{K} \lambda_j B_{y/(y+b_k)}\left(p_k, q_k\right) \tag{12}$$

Regional mean income is given by

$$\mu = \sum_{k=1}^{K} \lambda_k \mu_k = \sum_{k=1}^{K} \frac{\lambda_k b_k p_k}{q_k - 1} \tag{13}$$

where $\mu_k = b_k p_k / (q_k - 1)$ is mean income for the k-th country. The regional cumulative income shares are given by

$$\begin{aligned} \eta(y) &= \frac{1}{\mu} \int_0^y z\, f(z)\, dz \\ &= \frac{1}{\mu} \sum_{k=1}^{K} \lambda_k \int_0^y z\, f_k(z)\, dz \\ &= \frac{1}{\mu} \sum_{k=1}^{K} \lambda_k\, \mu_k\, B_{y/(y+b_k)}\left(p_k + 1, q_k - 1\right) \end{aligned} \tag{14}$$

A regional cumulative distribution function can be graphed by using equation (12) to compute $F(y)$ for a grid of values of y. A regional Lorenz curve, relating income shares to population shares, can be graphed by using equations (12) and (14) to compute $F(y)$ and $\eta(y)$ for a grid of values of y. Lorenz dominance and stochastic dominance at a regional level can be assessed by visually comparing Lorenz curves and distribution functions, respectively.

The regional Gini coefficient can be written as (Chotikapanich *et al* 2007)

$$G = -1 + \frac{2}{\mu} \sum_{j=1}^{K} \sum_{i=1}^{K} \lambda_j \lambda_i m_{ij} \tag{15}$$

where

$$m_{ij} = \int_0^\infty y\, F_j(y)\, f_i(y)\, dy = E_{f_i}\left[y\, F_j(y) \right] \tag{16}$$

While we can calculate m_{ii} using the result

$$m_{ii} = \mu_i \left[\frac{B\left(2p_i, 2q_i - 1\right)}{p_i B^2\left(p_i, q_i\right)} + \frac{1}{2} \right] \tag{17}$$

a corresponding result for m_{ij} when $i \neq j$ is not available. As an alternative, the m_{ij} can be estimated by drawing observations $y_i^{(h)}$, $h = 1, 2, \ldots, H$ from the beta-2 pdf's for each country $f_i(y)$, computing values $y_i^{(h)} F_j\left(y_i^{(h)}\right)$, $j = 1, 2, \ldots, K$ for each draw, and finding the averages

$$\hat{m}_{ij} = \frac{1}{H} \sum_{h=1}^{H} y_i^{(h)}\, F_j\left(y_i^{(h)}\right) \tag{18}$$

For large *H* (we chose *H* = 50,000) the $\hat{m}_{ij}$ are accurate estimates of the m_{ij}.

The regional Theil coefficient is given by

$$\begin{aligned} L &= \int_0^\infty \ln\left(\frac{\mu}{y}\right) \sum_{k=1}^{K} \lambda_k\, f_k(y)\, dy \\ &= \ln(\mu) - \sum_{k=1}^{K} \lambda_k \int_0^\infty \ln(y)\, f_k(y)\, dy \\ &= \ln(\mu) - \sum_{k=1}^{K} \lambda_k \ln\left(b_k\right) + \sum_{k=1}^{K} \lambda_k \left[\psi\left(q_k\right) - \psi\left(p_k\right) \right] \end{aligned} \tag{19}$$

This quantity can be readily calculated from the population shares and the parameters of the country income distributions.

2.4 Decomposition of income inequality

When considering regional or global income inequality it is informative to decompose total inequality into the inequality contributions from within countries and between countries. A number of decompositions of the Gini coefficient and interpretations of the components have been suggested in the literature. See, for example, Silber (1989), Lambert and Aronson (1993), Dagum (1997), Griffiths (2008) and references therein. The most common one, and the one that we employ, is

$$G = G_W + G_B + I \tag{20}$$

where the first component

$$G_W = \sum_{i=1}^{K} \lambda_i s_i G_i \tag{21}$$

is the component attributable to within-country inequality. It is a weighted average of the Gini coefficients for each country G_i, defined in equation (4), with weights given by the product of the population share λ_i and the income share

$$s_i = \frac{\lambda_i \mu_i}{\mu}$$

The second component G_B is that part of total inequality attributable to the inequality between countries. It is equal to the Gini coefficient that would be obtained if every person in a given country is given the mean income of that country. It can be calculated from

$$G_B = \frac{1}{2\mu} \sum_{i=1}^{K} \sum_{j=1}^{K} \lambda_i \lambda_j \left| \mu_i - \mu_j \right| \tag{22}$$

The third component I is known as the interaction or overlapping effect; it is calculated as the residual $I = G - G_W - G_B$. If none of the country income distributions overlap, then $I = 0$. If the country income distributions do overlap, then a ranking of all income units in the region is different to the ranking that is obtained when countries are first ranked according to their mean incomes, and then income units within each country are ranked. The component *I* is equal to the area between the concentration curve from the country-based ranking and the Lorenz curve for the regional ranking (Lambert and Aronson 1993).

When the Theil coefficient is decomposed (Theil 1979), inequality within countries is defined as the population weighted average of the Theil coefficients for each country. That is, using (6),

$$\begin{aligned} L_W &= \sum_{k=1}^{K} \lambda_k L_k \\ &= \sum_{k=1}^{K} \lambda_k \ln\left(\frac{p_k}{q_k - 1}\right) + \sum_{k=1}^{K} \lambda_k \left[\psi(q_k) - \psi(p_k)\right] \end{aligned} \quad (23)$$

Inequality between countries is given by $L_B = L - L_W$. Subtracting (23) from (19), and using the result $p_k / (q_k - 1) = \mu_k / b_k$, yields

$$L_B = \ln(\mu) - \sum_{k=1}^{K} \lambda_k \ln(\mu_k)$$

An equivalent and more familiar way of writing L_B is in terms of population and income shares. After a little algebra we obtain

$$L_B = \sum_{k=1}^{K} \lambda_k \ln\left(\frac{\lambda_k}{s_k}\right) \quad (24)$$

3. DESCRIPTION OF DATA AND SOURCES

3.1 Data sources

Global income distributions are estimated for the years 1993 and 2000. The data on country income distributions used for this estimation are from two main sources: the World Bank and the World Institute for Development Economics Research (WIDER).

The World Bank has long been a major provider of income-distribution data for the purpose of cross-country research. Recent work by Milanovic (2002) who examined global income distributions for 1988 and 1993 is based on a set of cross-country data that he compiled for the World Bank. Data are available for more than 100 countries for the years 1988 and 1993. For each country, the data are in the form of mean incomes for a number of income classes. The WIDER database version used in this paper is known as "UNU/WIDER World Income Inequality Database Version 2.0b, May 2007" or WIID2b. It is an "update of the Deininger & Squire database from the World Bank, with new estimates from the Luxembourg Income Study and Transmonee, and other new sources as they have become available."[1] Data from WIID2b are available for more than 150 countries or areas with a time span from before 1960 to 2005. However, the data available for the majority of countries are between 1985 and 2000.[2] The data are in the form of income (expenditure) and population shares for a number of income classes. In the current paper, to facilitate comparison of our results with those of Milanovic, the data we use for 1993 are from the World Bank and we extend the results to examine the global income distribution for 2000 using the data from WIID2b. Both sources of data provide information for each country on class mean incomes (or expenditures) in local currency or income shares for a number of income classes, ranging from as low as 5 and up to 20. For each income class the population share is known.

Ideally distribution data should refer either to income or expenditure of persons or households. In the World Bank data set for 1993, there is a mix of per capita income and per capita expenditure. The WIID2b data set provides data from a

---

[1] http://www.wider.unu.edu/research/Database/en_GB/wiid/

[2] As this paper was nearing completion, data for 2005 for many countries became available. However, the coverage of countries is still much less than that used for this paper.

variety of sources/surveys for some countries and for some years. There is a mix of per capita income and per capita expenditure for individual, family or household units. Our preference was to use per capita household income. If this was not available we chose per capita household expenditure. These differences could influence the estimates of the parameters of the respective "income" distributions.

To derive regional/global income distributions, nominal per capita income for each country needs to be adjusted for differences in prices across countries, and, to make temporal welfare comparisons, further adjustments are necessary for movements in prices over time. To describe how such adjustments were made, consider first the country data obtained from the World Bank for 1993. Let $\bar{x}_i$ = class mean income (or expenditure) in local currency, and c_i = population share for the *i*-th income class. Based on these data we calculate the income share for each income class as $g_i = \bar{x}_i c_i \big/ \sum \bar{x}_j c_j$. For the year 2000, the data from WIID2b are already in the form of income shares, g_i and population shares, c_i. To adjust for purchasing power parity (over countries and time) we obtain data on real per capita income from the Penn World Tables, PWT 6.1[3], These tables have data on real per capita incomes for over 150 countries spanning a 50-year period. PWT 6.1 also provides data on the population size of each of the countries. For each country and for a given year, let $\bar{y}$ be the real per capita income adjusted for differences in prices across countries and over time and let S be population size. For each income group in a given country the real class mean income for income class *i*, $\bar{y}_i$, is derived as total income in the *i*-th group, $g_i \bar{y} S$, divided by total population in the *i*-th group, $c_i S$. That is,

[3] http://pwt.econ.upenn.edu/php_site/pwt_index.php

$\bar{y}_i = g_i\,\bar{y}/c_i$. The values $\bar{y}_i$ and c_i are those used for the estimation described in Section 2.2.

3.2 Coverage

We began with as many countries as possible, but found that for some countries with only 5 income classes the estimations were unstable producing estimated means not consistent with those reported by PWT6.1 and estimated Gini coefficients not consistent with those reported by WIID2b. These cases were dropped from the analysis, leaving a total of 91 countries for both 1993 and 2000. The countries covered according to geographical groupings are as follows.

Western Europe, North America and Oceania (WENAO) (22 countries)

Australia, Austria, Belgium, Canada, Cyprus, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Luxembourg, Netherlands, Norway, New Zealand, Portugal, Sweden, United Kingdom, United States, Turkey.

Latin America and Caribbean (18 countries)

Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Honduras, Jamaica, Mexico, Panama, Venezuela, Ecuador, Peru, Argentina, El Salvador, Guyana, Nicaragua, Uruguay.

Eastern Europe (17 countries)

Armenia, Bulgaria, Slovak Republic, Hungary, Romania, Belarus, Estonia, Kazakhstan, Krygyz Republic, Latvia, Lithuania, Moldova, Russia, Ukraine, Uzbekistan, Slovenia, Albania.

Asia (18 countries)

Bangladesh, China, Hong Kong, India, Indonesia, Japan, Jordan, Korea South, Pakistan, Philippines, Taiwan, Thailand, Iran, Laos, Nepal, SriLanka, Vietnam, Yemen.

Africa (16 countries)

Algeria, Egypt, Ghana, Madagascar, Morocco, Nigeria, Tunisia, Uganda, Zambia, Burkina Faso, Ethiopia, Gambia, Kenya, Mauritania, South Africa, Zimbabwe.

The percentage coverage for each continent and for the two years is reported in Table 1. For both years, we cover nearly 90% of the world population. In terms of continents, it can be seen that we cover more than 90% of the total population for Asia, Latin America and Caribbean and WENAO. The percentage coverage is less for Eastern Europe and Africa. In particular the coverage for the African continent is only about 60% for both years.

The country coverage in this paper is compared to that of Milanovic (2002) in Table A1. He covers 86 countries in total, with, in some cases, rural and urban considered separately and counted as two countries. In our study the data were not separated into rural and urban components. As the table shows, there are some minor differences in coverage, but most countries are common.

Sala-i-Martin (2002a, 2002b) investigates global income distributions between 1970 and 1998. He covers 125 countries and classifies them into three groups, A, B and C, according to the level of data. Group A includes countries that have some data on country income shares by quintiles over time. Group B includes countries that have only one observation between 1970 and 1998 and Group C includes countries for which there is no data on income shares. He uses income shares for each country in group A to estimate a kernel density for each country and each year. For his treatment of countries in Groups B and C see Sala-i-Martin (2002a). Our study covers most of the countries in Group A and some in Group B. Most of the countries in Eastern Europe that are covered in our study are not covered in Sala-i-Martin's study.

4. EMPIRICAL ANALYSIS

Our presentation and discussion of the results begins in Section 4.1 with consideration of the estimated country-specific income distributions for eight countries as examples. Parameter estimation and goodness-of-fit for each of these countries are discussed in Subsection 4.1.1. An analysis of the country income distributions and changes in inequality are given in Subsection 4.1.2. Some brief remarks about mean income and inequality in all countries are made in Subsection 4.1.3. Section 4.2 is devoted to an analysis of levels and trends of regional income distributions and related inequality. The global distributions in 1993 and 2000 are discussed in Section 4.3.

4.1 Country-specific income distributions and inequality

While country-specific information was obtained for all 91 countries, a detailed presentation of this information for all cases requires an excessive amount of space. To illustrate the range of information that can be provided, we chose to focus on eight countries selected as examples. They are India, China, USA, Brazil, Egypt, Kenya, Mexico and Russia. These eight countries were selected from different continents and because of their different sizes and level of development. Less detailed information on the remaining countries is provided in the Appendix.

4.1.1 *Parameter estimates and goodness of fit*

Table 2 displays the estimated parameters of the beta distributions for the example countries. They are obtained using the procedure described in Section 2.1. The estimated parameters provide meaningful income distributions, all of which are skewed and uni-modal. However, the very large values of p and relatively small values of b for India appear out of place. As found in Chotikapanich *et al* (2007), the parameters b and p were highly correlated and alternative pairs of (b, p) close to the convergence point led to virtually identical income distributions. Also, the best data available for India are in quintile shares. To estimate the parameters of the distribution based on only five data points may result in the estimation being unstable. However, even with only five data points our estimation produces a reasonable goodness of fit when actual and estimated income shares are compared.

Goodness-of-fit was assessed by comparing the observed income shares

$$g_i = \frac{c_i \, \bar{y}_i}{\sum_{j=1}^{N} c_j \, \bar{y}_j} = \frac{c_i \, \bar{x}_i}{\sum_{j=1}^{N} c_j \, \bar{x}_j}$$

with the expected income shares derived from the estimated distributions. To find the expected shares we began with the population shares c_i and corresponding cumulative proportions

$$\pi_i = \sum_{j=1}^{i} c_j$$

and then found class limits a_i (not necessarily the same as the previously-estimated class limits) such that

$$B_{a_i/(\hat{b}+a_i)}\left(\hat{p}, \hat{q}\right) = \pi_i$$

Corresponding cumulative income shares were found from the first moment distribution function

$$\hat{\eta}_i \;=\; B_{a_i/(\hat{b}+a_i)}\left(\hat{p}+1, \hat{q}-1\right)$$

The estimated income shares are given by

$$\hat{g}_i = \hat{\eta}_i - \hat{\eta}_{i-1}$$

A comparison of the estimated and observed income shares appears in Table 3 for 1993 and Table 4 for 2000. The actual (observed) and estimated (expected) income shares are remarkably similar for the selected countries in both years. In most cases the differences are in the third decimal place. This outcome is very encouraging given that the parameters of the distributions have been estimated from limited data, and given that the class limits a_i implied by the estimated parameters, not the a_i giving the "best fit", were used to compute the expected income proportions. When there is a discrepancy between the actual and estimated shares, it tends to occur in the right tail of the distribution. The worst fit is Russia in 2000. There are many examples of very good fits; two such examples are Egypt in 1993 and India in 2000.

4.1.2 *Analysis of income distributions of example countries*

Figure 1 shows the plots of the income density functions for 1993 and 2000 for the example countries. In each year the results are reported in two graphs because of the vast differences in the locations of the density functions for the poorest country (Kenya) and the richest country (USA). The left panels display the 4 poorest countries and the right panels the 4 richest countries. The density functions are consistent with general expectations. The locations of the distributions in terms of the mode and the mean are ordered according to the real per capita incomes of these countries. Also, the spreads of the distributions reveal the wide disparities in incomes across countries. To show how the distributions for each country have changed over time, in Figure 2 the country-specific density functions for 1993 and 2000 are presented on separate graphs. Most of the eight countries exhibit noticeable shifts to the right. Egypt and Russia are exceptions. In Egypt modal income has fallen, but the far right tail is fatter, suggesting an increase in the proportion of rich. In Russia modal income has declined and the right tail is thinner suggesting a more general decline in incomes.

Also informative are the distribution functions and Lorenz curves for each country in each of the two years. Graphs of these functions were created using equations (2) and (7). Figures 3a and 3b show the distribution functions for the selected eight countries in the study. In both years the USA clearly dominates all other countries in terms of first-order stochastic dominance. The distribution functions of the other countries all cross implying that they cannot be separated on the basis of this criterion. However, in 1993 Brazil, Mexico and Russia have functions that are noticeably further to the right than those of the remaining countries. In 2000 China and Egypt are more clearly differentiated from Kenya and India who are the poorest two countries.

The Lorenz curves graphed in Figures 4a and 4b clearly show inequality to be least in India, although the gap between India and the remaining countries has narrowed in 2000. An examination of the Gini coefficients in Table 2 reveals that this narrowing of the gap is largely attributable to increasing inequality in India and declining inequality in China. In 1993 inequality is greatest in Brazil and Kenya, and in 2000 Brazil stands out as the country with greatest inequality. Further inequality comparisons can be made using the parameter restrictions for Lorenz dominance given in Section 2.1. These restrictions can be used to assess intertemporal dominance for each country or cross-country dominance at a particular point in time. Kenya is the only country whose 2000 income distribution Lorenz dominates its 1993 income distribution. On the other hand, the distributions in 1993 Lorenz dominate the corresponding 2000 distributions for India, Egypt, and Mexico. The necessary and sufficient condition is not satisfied for China, USA, Brazil and Russia. Using the parameter inequalities to assess Lorenz dominance across countries for given time period, and using the notation $>_L$ to denote Lorenz dominance, we have India $>_L$ Egypt $>_L$ China $>_L$ Mexico in 1993 and in 2000, India $>_L$ Kenya and China $>_L$ Egypt $>_L$ Mexico $>_L$ Brazil. These dominance properties can also be observed in Figure 4.

4.1.3 *Mean incomes and inequality in all countries*

Estimated mean income, the Gini coefficient and the Theil coefficient were computed for all countries using the expressions in equations (3), (4) and (6), respectively. These quantities appear in Tables A2 through A6. Some brief comments on the results in these tables follow.

Using mean per capita income as the metric, the poorest countries in Africa (see Table A2) were Ethiopia, Madagascar, Uganda, Nigeria and Zambia with Madagascar, Nigeria and Zambia experiencing a decline in real income over the seven years from 1993 to 2000. Ten of the 17 African countries experienced an increase in inequality. Some of these increases were dramatic. South Africa and Kenya were the only countries with a noticeable decline in inequality.

In Asia (Table A3) mean incomes increased in all countries. Yemen, Lao, Nepal and Bangladesh were the poorest countries. Inequality declined most in China, Hong Kong, Indonesia, Nepal and Yemen; there were large increases in inequality in

India, Japan, Korea, Lao, Sri Lanka and Thailand. In 2000 inequality was greatest in Thailand, and the Philippines.

The poorest Eastern Europe countries (Table A4) were Armenia and Moldova, but, overall, the living standards were greater than in Africa and Asia. Bulgaria, Moldova, Russia and Ukraine had mean incomes that declined over the 7 year period. There were noticeable increases in inequality in Armenia, Bulgaria, Hungary, the Kyrgyz Republic, Latvia and Uzbekistan; inequality declined in Ukraine and the Slovak Republic.

All Latin American and Caribbean countries (Table A5) enjoyed growth in mean income with the exception of Ecuador, Jamaica, Nicaragua, and Venezuela. With a couple of minor exceptions (Dominican Republic, Guyana and Honduras) inequality increased in all countries. Inequality is relatively high in the countries in this region with the smallest Gini and Theil coefficients for 2000 being 0.44 and 0.34, respectively.

Finally, considering the WENAO group of countries (Table A6) we note that mean incomes increased throughout. In 64% of the cases this increase in income was accompanied by an increase in inequality. In 2000 Australia exhibited the highest level of inequality with Gini and Theil coefficients of 0.45 and 0.39, respectively.

4.2 Regional Distributions and Inequality

In this Section we compare income distributions and inequality for the five regions: Western Europe, North America and Oceania (WENAO), Latin America and Caribbean (LAC), Eastern Europe (EE), Asia, and Africa, for the years 1993 and 2003. The global income distribution is also considered. The regional and global density functions are obtained as weighted averages of the density functions for each country in the region and in the world. Inequality is measured using the Gini and Theil coefficients. These coefficients and their decompositions are computed from the expressions in Sections 2.3 and 2.4.

4.2.1 *Regional density and distribution functions*

Figures 5 and 6 display plots for regional and global density functions for 1993 and 2000, respectively. All regional distributions in both years are unimodal. Note that, although the country-specific beta-2 distributions must be unimodal, a regional or global mixture of them will not necessarily be unimodal. In both years, the regions can be ordered according to the location of their density functions, from poorest to richest, as Africa, Asia, LAC, EE and WENAO. Africa and Asia have highly skewed distributions reflecting a high concentration of poverty. Relative to other distributions, that of WENAO is almost flat. The global income distribution is located approximately between the distributions of Asia and LAC. The relatively high incomes in WENAO and EE are offset by the large populations in Asian countries such as India and China.

The regional and global distribution functions are presented in Figures 7 and 8 for years 1993 and 200, respectively. When assessing first order stochastic dominance visually, it is often difficult to know whether some distributions cross as they approach zero or one. However, with that qualification, the following first order dominance relationships are suggested by Figures 7 and 8.

1993: $\{\text{WENAO}\} >_{FSD} \{\text{EE, LAC}\} >_{FSD} \{\text{Asia}\} >_{FSD} \{\text{Africa}\}$

2000: $\{\text{WENAO}\} >_{FSD} \{\text{EE, LAC, Asia}\} >_{FSD} \{\text{Africa}\}$

Using the criterion of first order stochastic dominance WENAO is clearly the richest and Africa is clearly the poorest region, in both years. The greatest improvement was achieved by Asia who was dominated by all regions except Africa in 1993, but only by WENAO in 2000.

4.2.2 *Trends in regional density functions*

The changes in the regional density functions from 1993 ro 2000 are illustrated separately for each region in Figure 9. The density functions for Asia, Eastern Europe and WENAO move to the right while that for LAC does not exhibit any change. The income distribution for Africa moves slightly to the left.

4.2.3 *Regional income inequality*

Information on regional and global inequality, the decomposition of this inequality, and the changes from 1993 to 2000 are provided in Table 5. Inequality is measured by the Gini coefficient and the Theil index. In both years, and irrespective of the measure used, the region with the greatest inequality is Africa. Moreover, inequality in Africa increased from 1993 to 2000. A large part of this inequality is attributable to inequality between countries, although the precise relative importance of between-country inequality depends on whether it is measured using the Gini coefficient or the Theil index. The Theil index suggests within-country inequality and between-country inequality contribute approximately equally to African inequality. However, using the Gini coefficient, between-country inequality, and the interaction term from overlapping of distributions, contribute over 90% of total African inequality.

After Africa, Asia and LAC are the regions with the next highest level of inequality. There was a decline in inequality in Asia from 1993 to 2000, but an increase in inequality in LAC for the same period. In terms of decomposition of the inequality, the contributions of the within and between components for Asia are similar to those for Africa; the Theil index suggests the within and between components contribute approximately equally to total inequality whereas decomposition of the Gini coefficient reveals a greater contribution from between-inequality and the interaction term. In the LAC region Theil's index suggests inequality is largely attributable to within-country inequality. Decomposition of the Gini coefficient shows the majority of the inequality coming from the interaction term; it is the overlapping of the country distributions that has the major impact, although within and between inequality are also strong components.

The other two regions, EE and WENAO, have lower levels of inequality, and inequality that has changed little from 1993 to 2000. Decomposition of the Theil index shows that most of the inequality comes from inequality within countries. However, using the Gini coefficient decomposition, we find that between-country inequality and the interaction term are also strong components.

Summarizing the inequality decomposition results, we find that, relative to other regions, inequality in Asia and Africa is largely attributable to inequality between countries, with a small degree of overlap of country distributions, reflecting that these regions contain both very rich and very poor countries. In all other regions inequality between countries is much smaller and the contributions of within-country and overlapping inequality are relatively large.

4.3 Global Income Distribution

4.3.1 *Global density functions for 1993 and 2000*

In Figures 5 and 6 the global density functions for 1993 and 2000 are graphed alongside the regional density functions. They are graphed again in Figure 10 alongside each other. Relative to 1993, the global income distribution for 2000 has moved to the right, reflecting a general increase in income. From Table 5 we observe that global mean income has increased from $6357 to $7477. Also, the density function is 2000 has developed a second mode in its left tail. The apparent reason for this extra mode is the relatively poor nature of Africa whose mean income increased only modestly in 2000. In Figure 6 the mode corresponds to the spike in the regional density function for Africa.

4.3.2 *Trends in global income distributions and income inequality*

Table 5 presents measures of global income inequality for 1993 and 2000 alongside those for regional income inequality. Global inequality, as measured by Gini coefficient, decreases slightly from 0.6479 in 1993 to 0.6401 in 2000. This decline can also be observed from Figure 11 where the Lorenz curves for the two years are graphed. Although the Gini coefficient has declined, the Lorenz curves cross, and so the distribution in 2000 does not Lorenz dominate that in 1993. In Table 5, the Theil index declines from 0.8130 in 1993 to 0.7949 in 2000 again suggesting a slight decrease in global inequality. The decompositions of both measures indicate that inequality between countries is the major contributor to the total inequality. Hence, policies directed towards reducing global inequality should give priority to catching up between countries.

Table 6 presents the global income distributions for the two years in terms of the cumulative percentages of persons and incomes. The poorest 50% of the population earn 9.5% and 10.3% of total income in 1993 and 2000, respectively. The richest 10% of the population earn approximately 50% of the total income. The population in the top of the distribution earns a slightly greater proportion of the income in 2000.

Some interesting links between the characteristics of inequality at the global and regional levels can be found in Table 5. At the global level, inequality decreases from a Gini coefficient value of 0.6479 in 1993 to 0.6401 in 2000. At the regional level, the only region in which inequality decreases is Asia. Inequality in Africa and LAC increases significantly, and in WENAO and EE, only slightly. Global inequality decreases when inequality in Asia decreases because, for the countries considered in this study, the Asian population makes up 61.62% of the global population in 1993 and 62.07% in 2000. If we look further into income inequality in Asia we find the major contribution to total inequality is from inequality between countries. However, there is some evidence that the percentage contribution of inequality between countries in Asia decreases between 1993 and 2000 suggesting catch-up and convergence between countries. Table 7 examines global inequality further, looking at the effect of excluding the most heavily populated countries, China and India, from the analysis. In this table we recalculate global inequality by leaving out first China and then India separately, and then both at the same time. It is found that without China global inequality increases and without India global inequality decreases slightly. Without both China and India, global inequality increases. Since the populations of China and India contribute nearly half of global population, we can conclude that the biggest impact on the reduction of global inequality between the two years is from the fast growth in China that results in it catching-up with the rest of the world.

5 SUMMARY AND CONCLUSIONS

The welfare of our global society depends heavily on the global income distribution – on the location of that distribution and on the extent of inequality that it displays. It is important, therefore, to have a set of tools for estimating this distribution and for measuring its degree of inequality. Using country-specific data in the form of population and income shares we have shown how to (a) estimate beta-2 income distributions for each country, (b), compute the Gini and Theil inequality measures from the estimated income distributions, (c) combine the country-specific income distributions into regional and global income distributions, (d) compute Gini and Theil inequality measures for the resulting mixture distribution, and (e) decompose the Gini and Theil measures into between and within-country inequality.

We find a high but declining degree of inequality at the global level. This decline in global inequality is largely attributable to strong growth in China, as well as a decline in inequality in China. In all regions other than Asia, inequality increased, although the increases in the WEANO and EE regions were slight. In Africa and LAC there were increases in total inequality, within-country inequality and between-country inequality. When China is omitted, inequality increases in Asia, and globally. For global inequality to decline further, growth in incomes in Africa and in the poorer countries in Asia, and in Latin America and the Caribbean, are likely to have the biggest impact. Our finding that growth in China is the main contributor to a decline in global inequality is consistent with the conclusion of Sala-i-Martin (2002a) who examined data for the period 1970-1998. On the other hand, using data for 1988 and 1993, Milanovic (2002) found increasing global inequality which was largely attributable to a growth in inequality between rural and urban China. Our results suggest that this trend has been reversed.

REFERENCES

Bandourian, R., McDonald, J. B., and Turley, R. S. (2003), “Income Distributions: An Inter-temporal Comparison Over Countries," Estadistica, 55, 135-152.

Chotikapanich, D., Valenzuela, M. R., and Rao, D. S. P. (1997), “Global and Regional Inequality in the Distribution of Income: Estimation with Limited/Incomplete Data," *Empirical Economics*, 20, 533-546.

Chotikapanich, D., and Prasada Rao, D. S. P. (1998), “Inequality in Asia 1975-1990: A Decomposition Analysis," *The Asia Pacific Journal of Economics and Business*, 2, 63-78.

Chotikapanich, D., W.E. Griffiths, and D.S.P. Rao (2007), “Estimating and Combining National Income Distributions using Limited Data”, *Journal of Business and Economic Statistics*, 25, 97-109.

Creedy, J., and Martin, V. L. (eds.) (1997), *Nonlinear Economic Models: Cross-sectional, Time Series and Neural Network Applications*, Cheltenham: Edward Elgar.

Dagum, C (1997), “A New Approach to the Decomposition of the Gini Income Inequality Ratio”, *Empirical Economics*, 22, 515-531.

Firebaugh G. (1999), “Empirics of World Inequality,” *American Journal of Sociology*, 104, 1597-1630.

Griffiths, W. (2008), “On Dagum’s Decomposition of the Gini Coefficient”, Working Paper, Department of Economics, University of Melbourne.

Kleiber, C (1999), “On the Lorenz order within parametric families of income distributions”, *Sankhya* B61, 514-517.

Kleiber, C. and Kotz, S. (2003), *Statistical Size Distributions in Economics and Actuarial Sciences*, New York: John Wiley and Sons.

Lambert, P.J. and Aronson, T.R. (1993), “Inequality Decomposition Analysis and the Gini Coefficient Revisited”, *The Economic Journal*, 103, 1221-1227.

McDonald, J. B. (1984), “Some Generalized Functions of the Size Distribution of Income,” *Econometrica*, 52, 647-663.

McDonald, J. B. and Ransom, M. R. (1979), “Functional Forms, Estimation Techniques and the Distribution of Income," *Econometrica*, 47, 1513 – 1525.

McDonald, J. B. and Xu, Y. J. (1995), “A Generalization of the Beta Distribution with Applications," *Journal of Econometrics* 66, 133-152. Errata 69 (1995), 427-428.

Melchior, A., K. Telle and H. Wiig (2000), "Globalisation and Inequality: World Income Distribution and Living Standards, 1960-1988", Report 6B, Oslo, Norway.

Milanovic, B. (2002), “True World Income Distribution, 1988 and 1993: First Calculations based on Household Surveys Alone," *The Economic Journal*, 112, 51-92.

Milanovic, B and S. Yitzhaki (2001), “Decomposing World Income Distribution: Does the World have a Middle Class?,” World Bank Development Research Working Paper.

Sala-i-Martin, X. (2002a), “The Disturbing “Rise” Of Global Income Inequality," NBER Working Paper No. 8904: 1-75.

Sala-i-Martin, X. (2002b), “The World Distribution of Income (Estimated from Individual Country Distributions)," NBER Working Paper No. 8905: 1-68.

Schulz, T. Paul (1998).”Inequality in the Distribution of Personal Income in the World: How it is changing and why?”, *Journal of Population Economics*, 11:307-44.

Silber, J (1989), “Factor Components, Population Subgroups and the Computation of the Gini Index of Inequality”, *The Review of Economics and Statistics*, 71,1, 107-115.

Theil, H. (1979), “World Income Inequality and its Components,” *Economics Letters,* 2, 99-102.

Theil, H. (1989), “The Development of International Inequality, 1960 – 1985," *Journal of Econometrics*, 42, 145-155.

Theil, H. (1996), *Studies in Global Econometrics,* Kluwer Academic Publishers, The Netherlands.

Wilfling, B. (1996), “Lorenz Ordering of Generalized Beta-II Income Distributions," *Journal of Econometrics*, 71, 381-388.

Table 1 Regional and World Population (in millions)

	Population		Population included in the study			
	1993	2000	1993	%	2000	%
Africa	672	813	417	62.1	482	59.3
Asia	3,206	3,628	3,006	93.8	3,302	91.0
Eastern Europe	411	365	322	78.3	317	86.9
Latin America and Caribbean	462	523	424	91.8	473	90.4
WENAO	755	758	710	94.0	746	98.4
World	5,506	6,087	4,878	88.6	5,320	87.4

Notes: 1993 population figures are from Milanovic (2002). The 2000 figures are based on a report by the Population Section at the United Nations at http://esa.un.org/unpp/

Table 2: Estimated Coefficients from Beta Distributions

	1993	2000		1993	2000
India			Egypt		
b	0.1802	2.0531	*b*	471.35	1165.81
p	29923.17	2571.69	*p*	15.4063	3.8923
q	3.9277	3.1879	*q*	3.0786	2.0864
mean	1770.71	2407.29	*mean*	3492.07	4160.55
Gini	0.3159	0.3604	*Gini*	0.3923	0.5432
China			Kenya		
b	1260.25	1474.86	*b*	208.66	91.51
p	4.3622	5.6155	*p*	4.4013	18.8845
q	2.9544	3.5293	*q*	1.7355	2.3919
mean	2455.17	3747.50	*mean*	1240.68	1242.96
Gini	0.4522	0.4039	*Gini*	0.6018	0.4538
USA			Mexico		
b	181432.60	60879.06	*b*	2089.20	2741.33
p	2.0009	2.6443	*p*	4.0059	3.3497
q	14.0315	5.7531	*q*	2.1187	2.0433
mean	26927.54	33835.94	*mean*	7480.08	8830.25
Gini	0.4022	0.4093	*Gini*	0.5373	0.5588
Brazil			Russia		
b	4606.08	2516.05	*b*	69017.02	10672.19
p	1.5108	2.4007	*p*	1.9712	2.6457
q	2.1061	1.8474	*q*	16.6886	4.4816
mean	6265.93	7104.14	*mean*	8665.62	8126.81
Gini	0.6111	0.6105	*Gini*	0.4001	0.4322

Table 3: Income Shares 1993

Egypt		Kenya		China		India	
actual	estimated	actual	estimated	actual	estimated	actual	estimated
0.027	0.027	0.012	0.011	0.019	0.018	0.088	0.087
0.040	0.039	0.015	0.019	0.031	0.031	0.125	0.125
0.049	0.049	0.028	0.026	0.039	0.041	0.162	0.163
0.057	0.058	0.036	0.034	0.049	0.051	0.214	0.219
0.067	0.068	0.045	0.043	0.060	0.062	0.411	0.406
0.080	0.080	0.057	0.055	0.076	0.076		
0.097	0.096	0.071	0.071	0.096	0.093		
0.117	0.118	0.093	0.096	0.125	0.119		
0.155	0.155	0.139	0.145	0.169	0.162		
0.310	0.309	0.503	0.501	0.337	0.347		

Russia		Brazil		Mexico		USA	
actual	estimated	actual	estimated	actual	estimated	actual	estimated
0.015	0.015	0.005	0.005	0.013	0.013	0.015	0.015
0.032	0.031	0.015	0.014	0.023	0.023	0.033	0.031
0.046	0.045	0.024	0.023	0.032	0.032	0.046	0.045
0.059	0.058	0.034	0.033	0.041	0.041	0.059	0.058
0.073	0.073	0.044	0.044	0.051	0.051	0.073	0.072
0.088	0.089	0.057	0.058	0.064	0.064	0.088	0.088
0.106	0.108	0.073	0.076	0.081	0.082	0.105	0.108
0.132	0.134	0.100	0.105	0.107	0.108	0.129	0.133
0.173	0.172	0.154	0.158	0.155	0.157	0.167	0.172
0.277	0.275	0.494	0.484	0.431	0.429	0.285	0.277

Table 4: Income Shares 2000

Egypt		Kenya		China		India	
actual	estimated	actual	estimated	actual	estimated	actual	estimated
0.012	0.013	0.023	0.023	0.024	0.023	0.032	0.032
0.024	0.023	0.033	0.033	0.035	0.036	0.044	0.044
0.033	0.031	0.040	0.042	0.046	0.047	0.053	0.053
0.042	0.040	0.050	0.051	0.057	0.057	0.061	0.062
0.052	0.051	0.060	0.060	0.069	0.068	0.071	0.071
0.063	0.063	0.070	0.073	0.082	0.081	0.082	0.082
0.078	0.081	0.100	0.089	0.099	0.098	0.097	0.097
0.101	0.107	0.112	0.112	0.123	0.121	0.118	0.117
0.146	0.156	0.151	0.154	0.162	0.160	0.154	0.152
0.448	0.435	0.361	0.364	0.304	0.308	0.289	0.290

Russia		Brazil		Mexico		USA	
actual	estimated	actual	estimated	actual	estimated	actual	estimated
0.014	0.016	0.008	0.008	0.011	0.012	0.018	0.018
0.034	0.030	0.016	0.016	0.021	0.021	0.035	0.033
0.046	0.042	0.024	0.024	0.030	0.029	0.048	0.045
0.058	0.054	0.032	0.032	0.039	0.038	0.060	0.057
0.069	0.067	0.042	0.042	0.049	0.049	0.073	0.070
0.083	0.082	0.052	0.055	0.063	0.062	0.087	0.085
0.097	0.100	0.070	0.072	0.079	0.079	0.103	0.103
0.118	0.126	0.098	0.100	0.104	0.106	0.125	0.128
0.154	0.168	0.157	0.152	0.155	0.156	0.161	0.168
0.326	0.315	0.500	0.498	0.448	0.448	0.290	0.294

Note: All shares are decile shares with the exception of India and Brazil in 1993 where the population proportions were not equal for each class. Brazil has ten classes and India has five classes.

Table 5: Global and Regional Income Inequality

		Global		Asia		WENAO		Africa		EE		LAC	
	# countries	**91**		**18**		**22**		**16**		**17**		**18**	
1993	Pop (%)	4878408000	100.00	3005884000	61.62	709695000	14.55	416951800	8.55	322098800	6.60	423778400	8.69
	mean	**6357.48**		**3377.76**		**21017.56**		**2308.07**		**7060.67**		**6391.54**	
	Gini	0.6479	100.00	0.5755	100.00	0.3918	100.00	0.6136	100.00	0.4311	100.00	0.5454	100.00
	Within	0.0215	3.32	0.0713	12.39	0.0798	20.37	0.0458	7.46	0.1193	27.67	0.1174	21.52
	Between	0.5405	83.42	0.3965	68.90	0.1456	37.16	0.4514	73.57	0.1540	35.72	0.1527	27.99
	interaction	0.0859	13.26	0.1077	18.71	0.1664	42.47	0.1164	18.97	0.1578	36.60	0.2753	50.48
	Theil	0.8130	100.00	0.5466	100.00	0.3006	100.00	0.7324	100.00	0.3324	100.00	0.6088	100.00
	Within	0.2879	35.41	0.2536	46.40	0.2398	79.77	0.3578	48.85	0.2657	79.93	0.5599	91.97
	Between	0.5251	64.59	0.2930	53.60	0.0608	20.23	0.3746	51.15	0.0667	20.07	0.0489	8.01
2000	Pop (%)	5319485000	100.00	3302017000	62.07	746004100	14.02	482216000	9.07	316743000	5.95	472505600	8.88
	mean	**7477.37**		**4293.86**		**25365.26**		**2439.35**		**6701.96**		**7144.25**	
	Gini	0.6401	100.00	0.5373	100.00	0.4063	100.00	0.6545	100.00	0.4373	100.00	0.5966	100.00
	Within	0.0239	3.73	0.0761	14.16	0.0846	20.83	0.0482	7.36	0.1211	27.68	0.1201	20.13
	Between	0.5247	81.97	0.3576	66.55	0.1681	41.37	0.4727	72.22	0.1774	40.56	0.1585	26.57
	interaction	0.0915	14.29	0.1036	19.28	0.1536	37.80	0.1336	20.41	0.1388	31.74	0.3180	53.30
	Theil	0.7949	100.00	0.4903	100.00	0.3060	100.00	0.9039	100.00	0.3638	100.00	0.6612	100.00
	Within	0.3022	38.02	0.2491	50.81	0.2297	75.07	0.4859	53.76	0.2957	81.28	0.6090	92.11
	Between	0.4927	61.98	0.2412	49.19	0.0763	24.93	0.4180	46.24	0.0681	18.73	0.0522	7.90

Table 6: Global income distribution

Cum % pop	Cum % income	
	1993	2000
Bottom		
10	0.8	0.7
20	2.1	2.2
50	9.5	10.3
75	24.0	25.0
85	38.1	38.1
Top		
10	50.0	50.9
5	33.1	34.7
1	11.4	12.5

Note: These values are computed from the estimated global distribution functions.

Table 7: Global Income Inequality

		Global		Global without China		Global without India		Global without China and India	
	# countries	**91**		**90**		**90**		**89**	
	Pop (%)	4878408000	100.00	3700006000	75.84	3980208000	81.59	2801806000	57.43
1993	**mean**	**6357.48**		**7600.32**		**7392.56**		**9469.17**	
	Gini	0.6479	100.00	0.6385	100.00	0.6365	100.00	0.6041	100.00
	Within	0.0215	3.32	0.0165	2.58	0.0240	3.77	0.0170	2.82
	Between	0.5405	83.42	0.5396	84.51	0.5215	81.93	0.4866	80.54
	interaction	0.0859	13.26	0.0824	12.91	0.0911	14.31	0.1005	16.64
	Theil	0.8130	100.00	0.8347	100.00	0.8225	100.00	0.8035	100.00
	Within	0.2879	35.41	0.2668	31.96	0.3165	38.48	0.3007	37.42
	Between	0.5251	64.59	0.5679	68.03	0.5060	61.52	0.5028	62.58
	Pop (%)	5319485000	100.00	4060664000	76.34	4303562000	80.90	3044741000	57.24
2000	**mean**	**7477.37**		**8633.65**		**8674.24**		**10711.16**	
	Gini	0.6401	100.00	0.6548	100.00	0.6349	100.00	0.6365	100.00
	Within	0.0239	3.73	0.0187	2.85	0.0259	4.08	0.0177	2.79
	Between	0.5247	81.97	0.5488	83.81	0.5113	80.54	0.5132	80.63
	interaction	0.0915	14.29	0.0874	13.34	0.0977	15.39	0.1056	16.59
	Theil	0.7949	100.00	0.8852	100.00	0.8135	100.00	0.8995	100.01
	Within	0.3022	38.02	0.3102	35.04	0.3236	39.78	0.3432	38.15
	Between	0.4927	61.98	0.5750	64.96	0.4899	60.22	0.5563	61.85

Figure 1 Density functions for selected countries

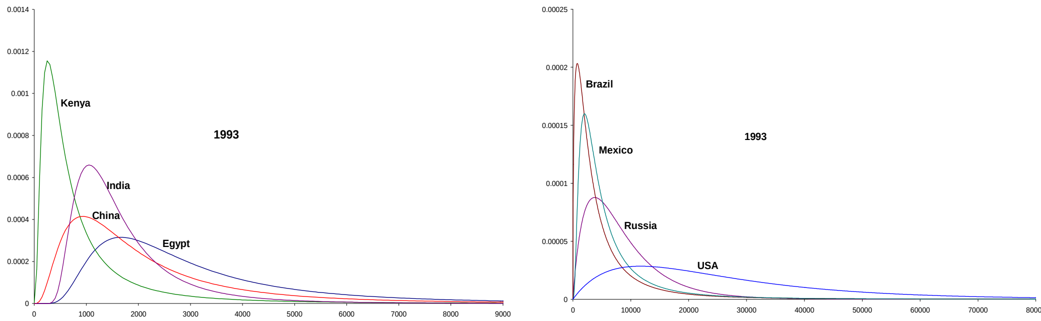


Figure 1a 1993 Density functions for selected countries

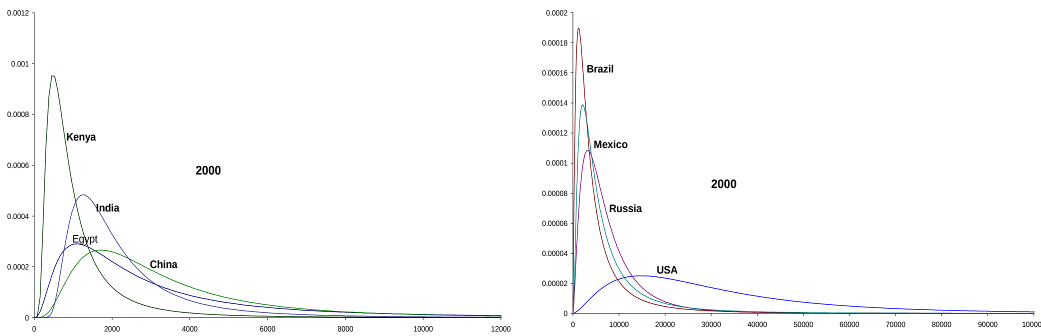


Figure 1b: 2000 Density functions for selected countries

Figure 2: Temporal changes in country-specific density functions

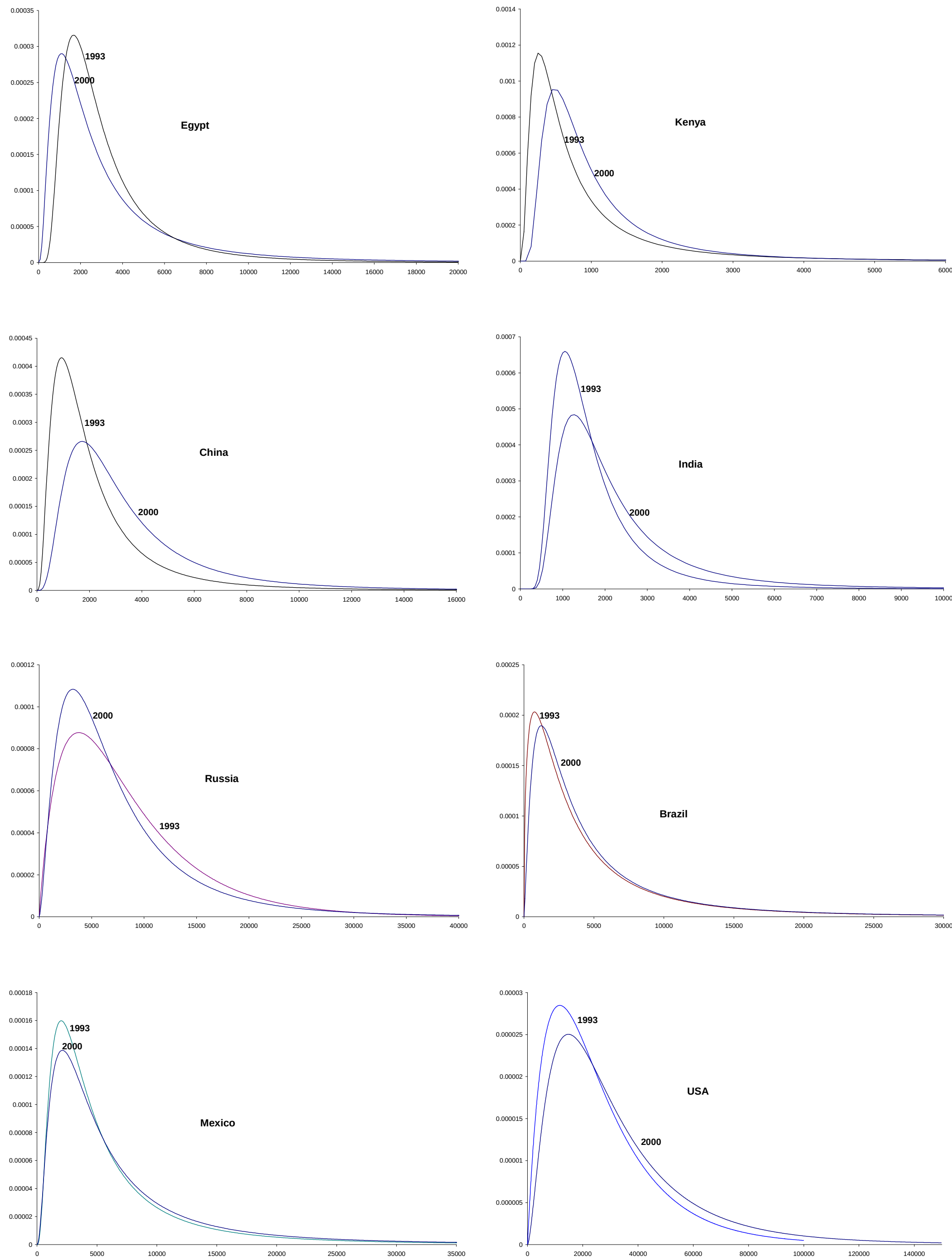


Figure 3: Distribution functions for selected countries

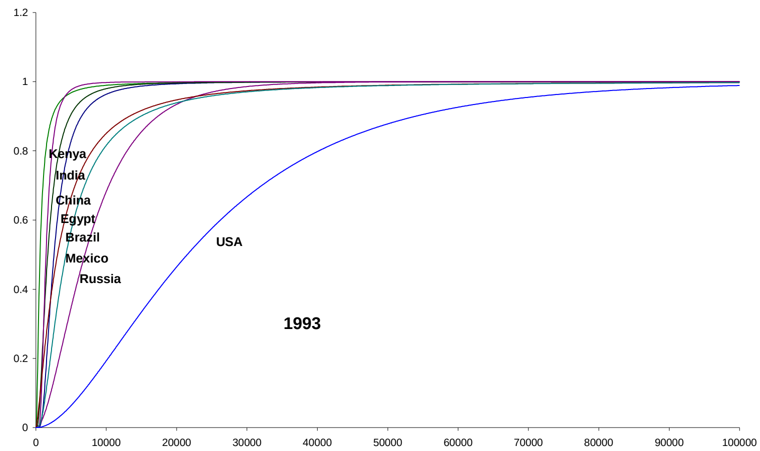


Figure 3a: 1993 Distribution functions

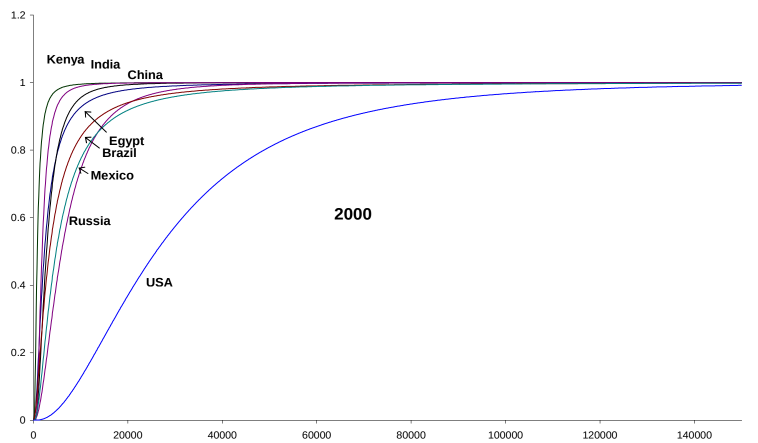


Figure 3b: 2000 Distribution functions

Figure 4: Lorenz curves for selected countries.

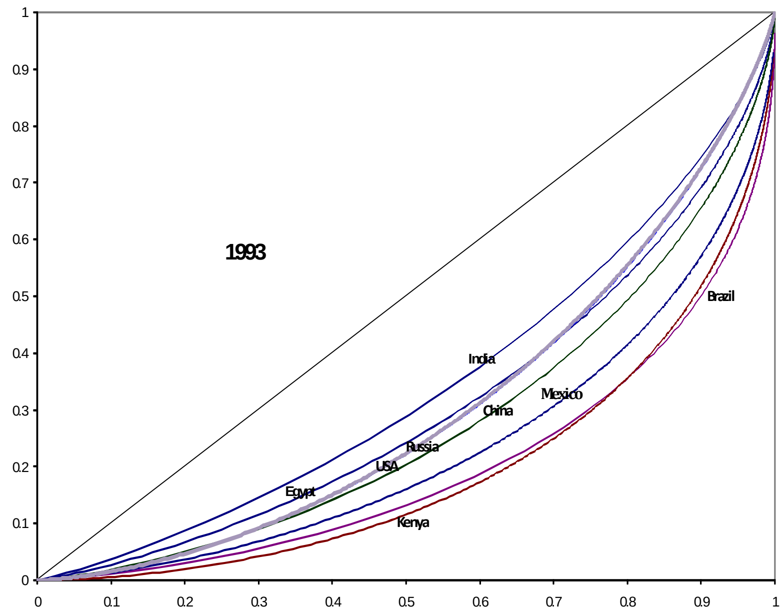


Figure 4a: 1993 Lorenz curves

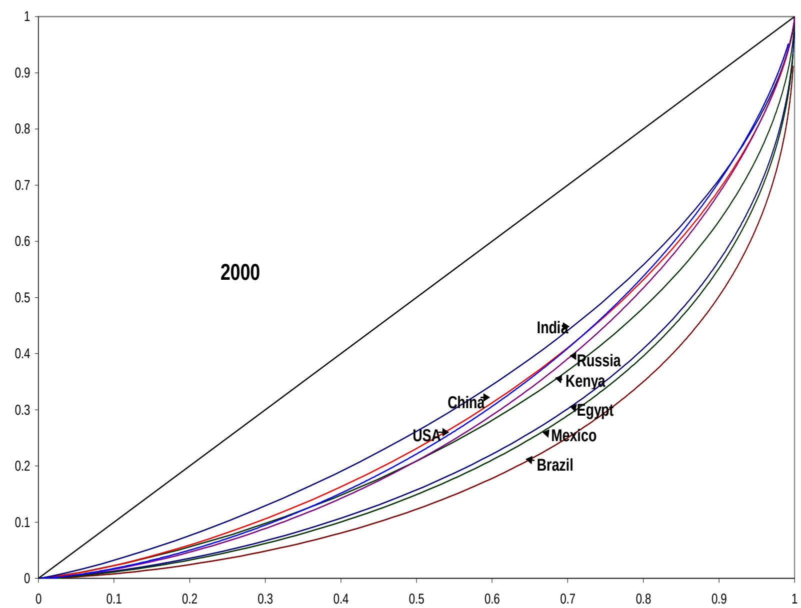


Figure 4b: 2000 Lorenz curves

Figure 5: 1993 Regional and global density functions

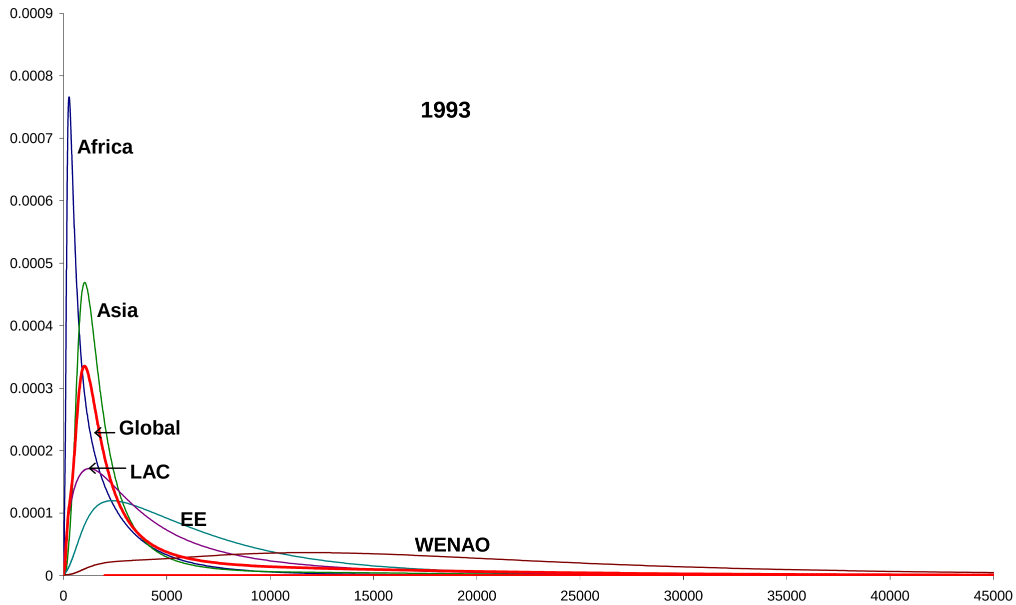


Figure 6: 2000 Regional and global density functions

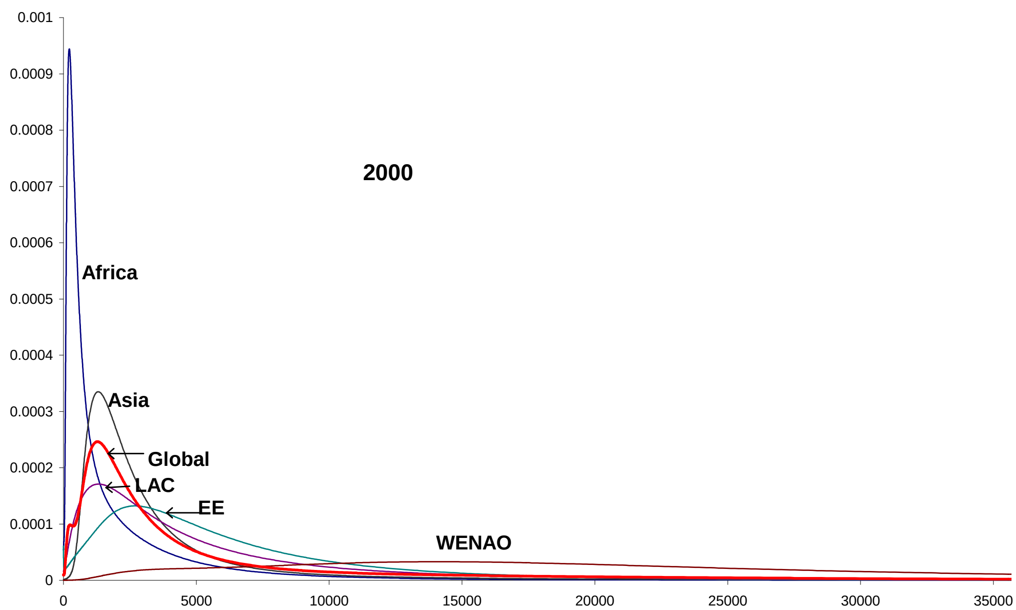


Figure 7: 1993 Regional and global distribution functions

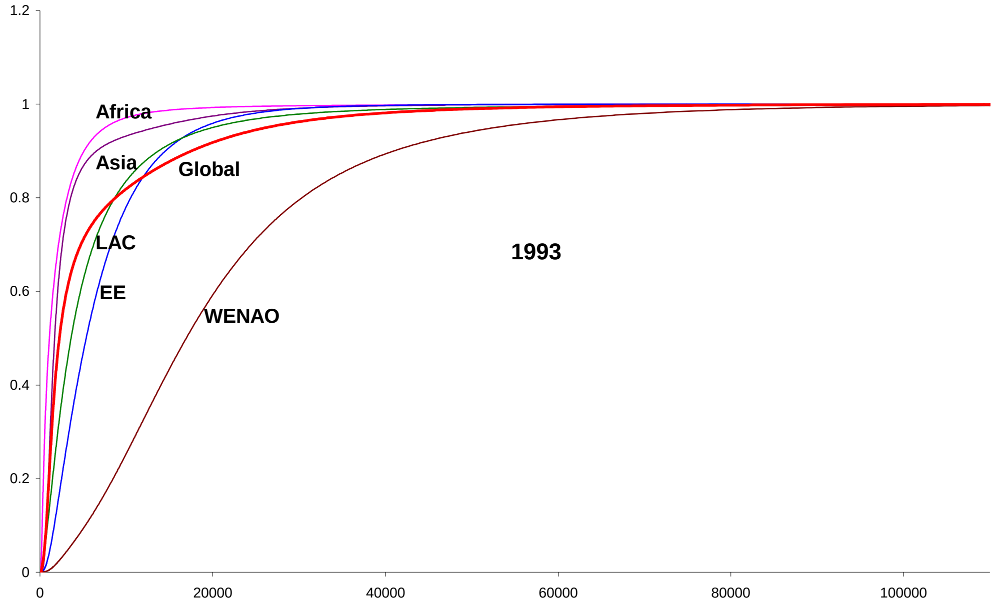


Figure 8: 2000 Regional and global distribution functions

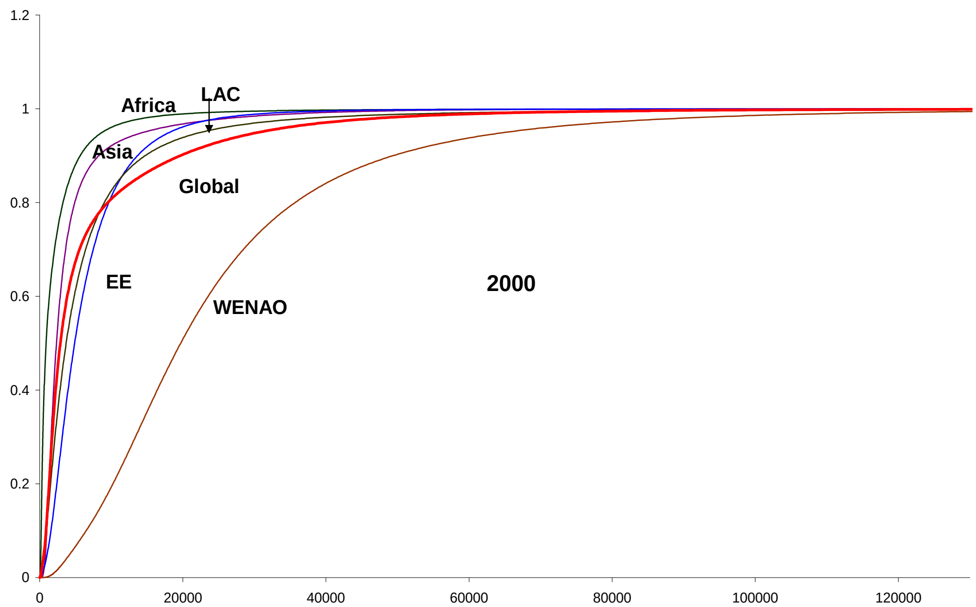


Figure 9: A comparison of regional density functions in 1993 and 2000

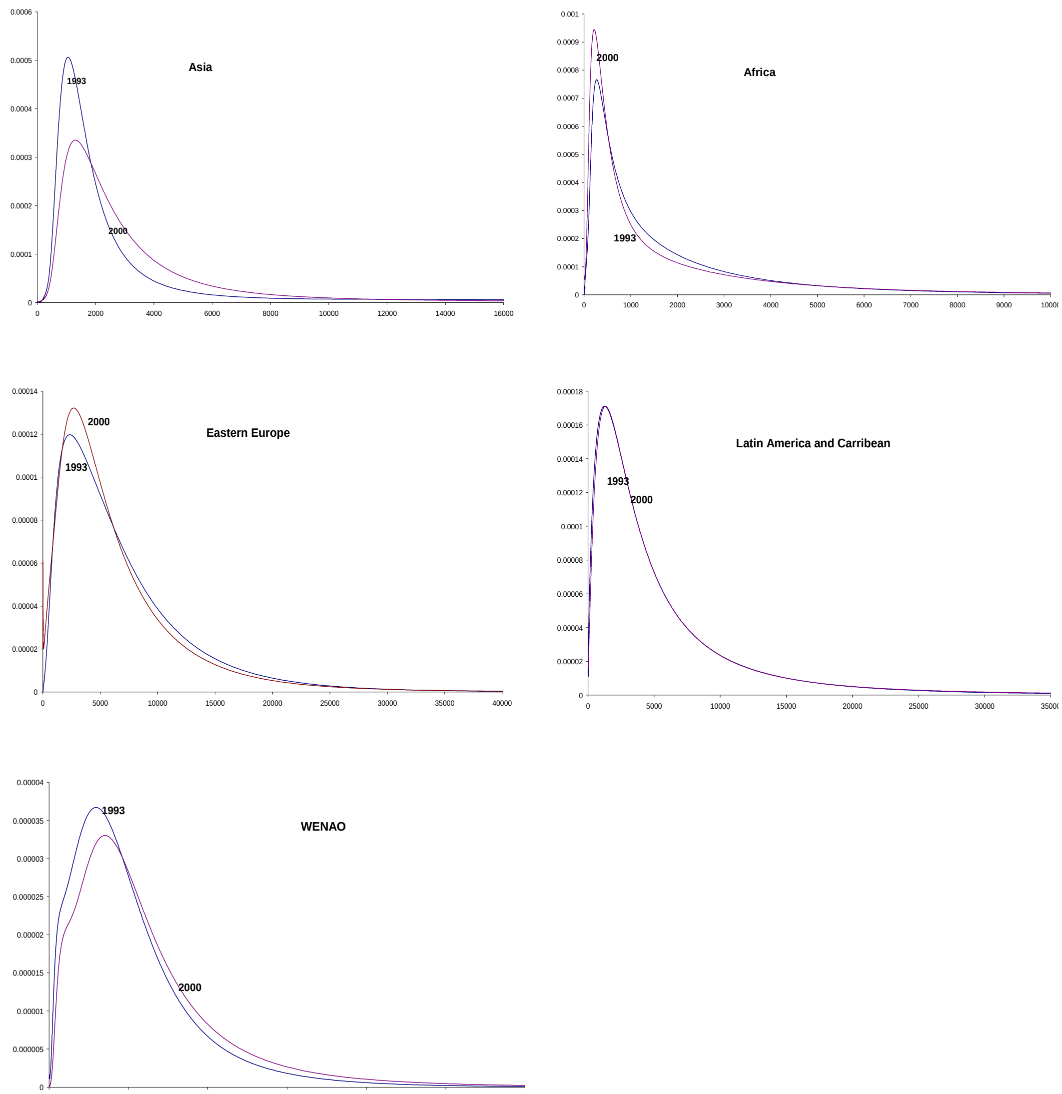


Figure 10: Global density functions

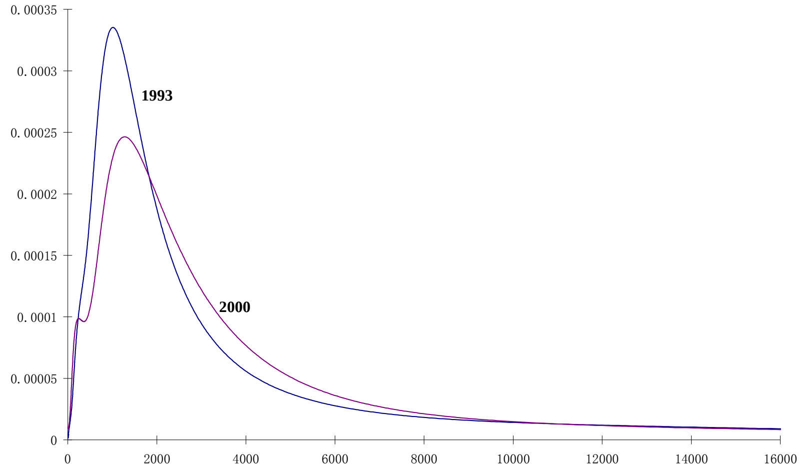
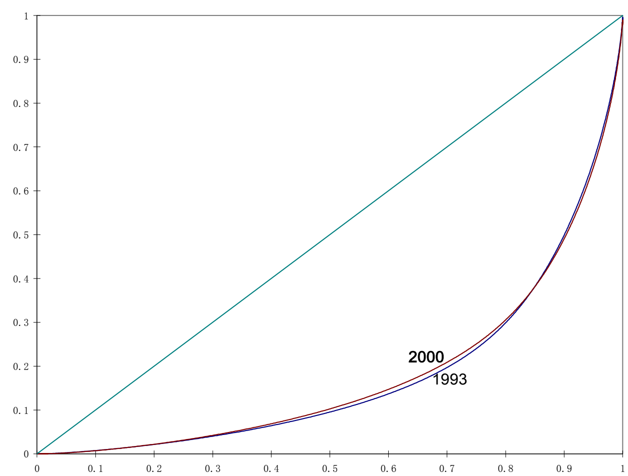


Figure 11: Global Lorenz curves



APPENDIX TABLES

Table A1: A Comparison of Country Coverage with that in Milanovic (2002)

	Countries common to both studies	Milanovic only	This paper only
Western Europe, North America and Oceania			
	Australia, Austria, Belgium, Canada, Cyprus, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Luxembourg, Netherlands, Norway, New Zealand, Portugal, Sweden, United Kingdom, United States	Switzerland	Turkey
Latin America and Caribbean			
	Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Honduras, Jamaica, Mexico, Panama, Venezuela, Ecuador, Peru	Argentina (u), El Salvador (u), Paraguay, Uruguay (u),	Argentina, El Salvador, Guyana, Nicaragua, Uruguay
Eastern Europe			
	Armenia, Bulgaria, Slovak Republic, Hungary, Romania, Belarus, Estonia, Kazakhstan, Krygyz Republic, Latvia, Lithuania, Moldova, Russia, Ukraine, Uzbekistan, Slovenia	Czech Republic, East Germany, Georgia, Poland, Turkmenistan, Yugoslavia	Albania
Asia			
	Bangladesh, China, Hong Kong, India, Indonesia, Japan, Jordan, Korea South, Pakistan, Philippines, Taiwan, Thailand	Malaysia	Iran, Laos, Nepal, SriLanka, Vietnam, Yemen
Africa			
	Algeria, Egypt, Ghana, Madagascar, Morocco, Nigeria, Tunisia, Uganda, Zambia	Ivory Coast, Lesotho, Senegal	Burkina Faso, Ethiopia, Gambia, Kenya, Mauritania, South Africa, Zimbabwe

Note: (u) = urban only.

Table A2: Inequality and Mean Income for African Countries

Africa		**1993**			**2000**	
	mean	Gini	Theil	mean	Gini	Theil
Algeria	4731.25	0.3536	0.2096	4904.10	0.3541	0.2092
Burkina Faso	882.02	0.4783	0.3841	1572.15	0.7707	1.3474
Egypt	3492.07	0.3923	0.2543	4160.55	0.5432	0.5271
Ethiopia	499.26	0.3908	0.2502	641.87	0.5249	0.4702
Gambia	1133.32	0.4772	0.4019	1206.51	0.5067	0.4573
Ghana	1219.46	0.3379	0.1858	1348.72	0.5065	0.5108
Kenya	1240.68	0.6018	0.6588	1242.96	0.4538	0.3451
Madagascar	843.15	0.4597	0.3605	840.60	0.4372	0.3288
Mauritania	1226.55	0.3896	0.2576	1309.25	0.3897	0.2556
Morocco	3430.94	0.3973	0.2601	3701.33	0.3913	0.2544
Nigeria	905.68	0.4499	0.3824	705.96	0.5038	0.4397
South Africa	7039.39	0.5944	0.6472	7547.66	0.5534	0.5592
Tunisia	5182.50	0.3207	0.1775	6758.67	0.3995	0.2691
Uganda	736.63	0.3905	0.2528	944.31	0.5448	0.5305
Zambia	915.95	0.5271	0.5280	868.49	0.6689	0.9175
Zimbabwa	2591.90	0.5340	0.4989	2651.04	0.7338	1.2789

Table A3: Inequality and Mean Income for Asian Countries

Asia		**1993**			**2000**	
	mean	Gini	Theil	mean	Gini	Theil
Bangladesh	1389.83	0.2833	0.1292	1681.796	0.3140	0.1590
China	2455.17	0.4522	0.3541	3747.496	0.4039	0.2764
Hongkong	24254.69	0.5169	0.4611	26643.767	0.4342	0.3648
India	1770.71	0.3159	0.1611	2407.290	0.3604	0.2115
Indonesia	3364.33	0.4175	0.2875	3585.800	0.3342	0.1809
Iran	4600.82	0.4330	0.3197	5994.831	0.4055	0.2962
Japan	21963.13	0.2483	0.0984	24646.088	0.3463	0.2123
Jordan	3422.25	0.3503	0.2101	3847.339	0.3625	0.2140
Korea	11693.55	0.3171	0.1726	15970.896	0.3853	0.2890
Laos	1315.76	0.2954	0.1403	1326.854	0.3702	0.2235
Nepal	1077.11	0.4490	0.3354	1418.099	0.3734	0.2276
Pakistan	1819.84	0.2818	0.1275	1970.909	0.2995	0.1444
Philippines	2887.12	0.4297	0.3084	3417.752	0.4944	0.4261
Srilanka	2805.29	0.4484	0.3401	3398.088	0.6288	0.7346
Taiwan	13210.41	0.2996	0.1452	17041.437	0.3122	0.1586
Thailand	5833.14	0.4707	0.3720	6852.145	0.5842	0.7054
Vietnam	1316.19	0.3358	0.1830	1812.052	0.3734	0.2277
Yemen	891.79	0.3581	0.2265	949.371	0.2278	0.0874

Table A4: Inequality and Mean Income for Eastern Europe Countries

Eastern Europe		**1993**			**2000**	
	mean	Gini	Theil	mean	Gini	Theil
Albania	2436.36	0.2913	0.1387	3337.71	0.2860	0.1331
Armenia	2235.08	0.4437	0.3333	2785.31	0.5636	0.6124
Belarus	6655.34	0.2873	0.1377	8340.62	0.2843	0.1298
Bulgaria	6360.86	0.3439	0.2014	5964.28	0.5098	0.4567
Estonia	7035.95	0.3941	0.2593	9588.98	0.3661	0.2253
Hungary	8403.13	0.2272	0.0835	9936.11	0.3019	0.1506
Kazakhstan	5899.63	0.3107	0.1588	7374.87	0.3119	0.1606
Kyrgyz Rep.	2842.21	0.4370	0.3584	2964.30	0.6222	1.0705
Latvia	5750.14	0.2858	0.1411	7564.51	0.3476	0.2043
Lithuania	6678.29	0.3769	0.2443	7240.21	0.3309	0.1807
Moldova	2391.05	0.3700	0.2352	2079.95	0.4048	0.2865
Romania	4111.27	0.3284	0.1815	4278.84	0.2950	0.1420
Russia	8665.62	0.4001	0.3063	8126.81	0.4322	0.3372
Slovak Rep.	8677.31	0.3263	0.1942	11331.19	0.2612	0.1176
Slovenia	11668.53	0.2383	0.0964	15047.21	0.2394	0.0952
Ukraine	7107.58	0.4385	0.3466	4610.41	0.3447	0.1987
Uzbekistan	2616.40	0.3304	0.1819	3202.90	0.4807	0.4435

Table A5: Inequality and Mean Income for Latin American and Caribbean Countries

Latin America		**1993**			**2000**	
and Caribbean	mean	Gini	Theil	mean	Gini	Theil
Argentina	10492.14	0.3911	0.2996	10934.64	0.5197	0.5148
Bolivia	2506.59	0.5200	0.4718	2714.16	0.6338	0.9220
Brazil	6265.93	0.6111	0.7533	7104.14	0.6105	0.7063
Chile	7541.61	0.5730	0.5924	10040.95	0.6018	0.6666
Colombia	5074.12	0.4922	0.4451	5401.59	0.5779	0.6480
Costa Rica	5231.93	0.4553	0.3769	5885.22	0.5017	0.4603
Dominican Rep	3392.34	0.4818	0.4115	5256.48	0.4749	0.3878
Ecuador	3833.08	0.4167	0.2946	3477.69	0.5624	0.5827
El Salvador	3879.31	0.5191	0.5127	4465.65	0.5397	0.5821
Guyana	2230.66	0.5078	0.4473	3600.45	0.4487	0.3733
Honduras	2158.27	0.5649	0.6000	2186.25	0.5279	0.5253
Jamaica	3756.75	0.3803	0.2454	3721.49	0.5416	0.5746
Mexico	7480.08	0.5373	0.5139	8830.25	0.5588	0.5657
Nicaragua	1910.11	0.5198	0.4714	1755.42	0.5499	0.5419
Panama	5591.62	0.5732	0.8337	6068.36	0.5793	0.6675
Peru	3777.76	0.4948	0.4843	4660.78	0.5143	0.4642
Uruguay(urb)	8477.48	0.4350	0.3346	9596.50	0.4446	0.3459
Venezuela	7337.99	0.4293	0.3164	6413.45	0.4582	0.3811

Table A6: Inequality and Mean Income for Western Europe, North American and Oceania Countries

WENAO	**1993**			**2000**		
	mean	Gini	Theil	mean	Gini	Theil
Australia	21075.66	0.3663	0.2553	25620.10	0.4450	0.3873
Austria	19780.95	0.5249	0.6662	23673.58	0.2923	0.1420
Belgium	20293.65	0.2515	0.1062	23567.31	0.3228	0.1683
Canada	21588.42	0.3168	0.1726	26858.73	0.3246	0.1806
Cyprus	13500.22	0.3042	0.1542	18515.97	0.3415	0.2134
Denmark	21914.38	0.2545	0.1111	26624.15	0.3918	0.2840
Finland	17536.28	0.2304	0.0859	23767.71	0.2707	0.1186
France	19445.49	0.2550	0.1116	22076.93	0.2822	0.1291
Germany, West	20707.46	0.3009	0.1508	22767.79	0.2474	0.0994
Greece	11971.28	0.3270	0.1789	14794.98	0.3202	0.1728
Ireland	14919.96	0.3005	0.1540	26556.80	0.3101	0.1662
Israel	14832.56	0.3550	0.2113	16945.53	0.3700	0.2329
Italy	19562.26	0.3120	0.1653	21698.51	0.3584	0.2272
Luxembourg	31472.12	0.2695	0.1176	44112.99	0.3067	0.1564
Netherlands	19739.43	0.3202	0.1753	24711.01	0.2542	0.1051
New Zealand	17032.30	0.3790	0.2557	18486.76	0.4186	0.3561
Norway	20915.50	0.2524	0.1029	27021.24	0.3645	0.2326
Portugal	12878.39	0.3563	0.2093	16128.67	0.3504	0.2029
Sweden	19686.00	0.2555	0.1118	23609.76	0.2730	0.1221
Turkey	6239.02	0.4615	0.3657	6806.63	0.3954	0.2641
U.K.	18319.31	0.3618	0.2237	22147.86	0.3471	0.1996
USA	26927.54	0.4022	0.3082	33835.94	0.4093	0.3028