# Accounting for Inequality:
# A Proposed Revision of the Human Development Index

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**Abstract**

The Human Development Index (HDI) is a country-level measure of social welfare based on national values for average life expectancy, rates of adult literacy and school enrollment, and gross domestic product (GDP) per capita. Since HDI is based entirely on national averages it can provide only limited information about distribution within countries. The distribution of access to key resources is an important determinant of the effect of health, education and income on both individual well-being and on the aggregate well-being of a population as a whole. This paper makes a case for the importance of inequality to measuring social welfare; presents an original alternative to HDI that includes the distribution of health, education, and income in each country; and reports the results of this inequality-adjusted HDI for 46 countries.



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**Accounting for Inequality: A Proposed Revision of the Human Development Index**

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Inequalities in health, education, and income – key components of human development – matter deeply to social welfare. The poorest fifth of the world's population receives less than two percent of the world's total income – while the richest fifth receives more than 80 percent (UNDP 1992). In developing countries, almost 60 percent of all births take place with no health professional in attendance. In one-third of all countries, 20 percent of the population or more lacks even the most basic literacy (UNDP 2005). Yet the best-known measures of social well-being either ignore distributional inequalities altogether or at best account for only some of their effects.

Per capita income, the most common measure of well-being, is a simple average. Its main alternative, the United Nations Development Program's (UNDP) Human Development Index (HDI), is likewise based on national averages, albeit for a wider set of welfare indicators. The practice of identifying averages with national well-being ignores potential social-welfare tradeoffs between increasing averages and decreasing differences in distribution. For example, as the rich get richer, average income may increase, but income inequality simultaneously may increase so sharply that the incomes of the poor decline, arguably resulting in a decrease in social welfare. More generally, measures based solely on national averages record unambiguous changes in social welfare in circumstances made ambiguous by changes in inequality.

The UNDP has done path-breaking work in disseminating HDI as an alternative to per capita income – hitherto the hegemonic measure of social welfare – and in bringing quantitative measures of human development to scholars, development professionals, policy-makers, and the general public in its annual *Human Development Reports,* the first of which was published in 1990. HDI measures social welfare by combining average measures of health, education, and the natural logarithm of per capita national income (embodying the assumption that as income increases its marginal impact on welfare grows smaller). To calculate HDI, health, education, and income components are each transformed into index values ranging from 0 to 1, and the three indices are then averaged together.

The rationale for HDI is that average health and education are not simple functions of average income per capita. There are two reasons for this. First, health and education have a substantial public goods component; they are not private goods, distributed entirely according to income. Second, if the privately obtainable components of health and education are concave in income – that is, the marginal provision of health and education diminishes as income rises – then countries with the same average income but different income distributions will have different levels of average health and education. For the latter reason, HDI's inclusion of average health and education goes some way toward capturing the effects of income inequality on social welfare. But it fails to account for other welfare-relevant effects of income inequality, as well as for welfare-relevant effects of inequalities in the distribution of health and education outcomes. For example, inequalities in all three components of HDI may have corrosive effects on social well-being through their association with decreasing social cohesion, increasing violence, or increasing environmental degradation.[1] Moreover, there is evidence that many, if not all, people put some intrinsic value on equality as an end in itself (Sen 1992).

In this essay I argue that it is both desirable and feasible to reformulate the Human Development Index to push the boundaries of social-welfare measurement beyond national averages. The paper begins with a summary and critique of the UNDP's own efforts to measure inequality in its *Human Development Reports*. Next, I explore the impacts of inequality on social welfare in greater detail. I then propose a new "Inequality-adjusted HDI," providing a detailed explanation of the necessary data and methodology, and discussing the theoretical underpinnings of this methodology. Finally, I calculate this new measure for 46 countries, and compare the results to the current HDI.

## Inequality in the *Human Development Reports*

Early *Human Development Reports* (HDRs) explicitly recognized distribution's importance to human development:

> *Presenting average figures for each country disguises many important disparities – between urban and rural areas, between rich and poor, between male and female, as well as between ethnic groups and different regions. The HDI should try to reflect how people really live. (UNDP 1992: 21)*

Lack of data was cited as the only reason for leaving measures of inequality out of HDI (UNDP 1990:12).

Today, somewhat better data are available. And where data are not yet adequate to the task, the UNDP's demand for distributional data could help to improve the supply. The *HDRs* have the capacity to shift not only practices for data collection but also the development discourse itself. Yet in recent years the UNDP appears to have retreated from its earlier stance. "The purpose of HDI is to provide a *summary measure, not a comprehensive measure*, of human development," the director of the Human Development Report office stated in 2001 (Fakuda-Parr 2001: 247, original emphasis). "It measures *average achievement* and does not reflect disparities and deprivation…Though disparities are a major concern in human development analysis, HDI is a measure of national average and does not integrate inequality."

The *HDRs* not only present HDI, but also contain a narrative report on human development-related themes that vary from year to year. Over the years, the *HDR*s' narratives and its statistical appendices have contained a number of different measures of poverty and inequality. Of these, only measures of absolute poverty and measures of gender inequality have achieved a permanent place in the *HDR*s. Others have appeared in only one or a few *HDR*s, or as limited examples; for example, disaggregations of HDI for subnational groups often have been reported but only by means of examples for one or two countries.

[1] On social cohesion, see Thurow (1971); on violence, see Birdsall (2004); on environmental degradation, see Boyce (2002).

*Poverty*

In *HDR 1996*, the UNDP introduced the Capability Poverty Measure (CPM), a composite measure of three basic capabilities: being well-nourished and healthy (the proportion of underweight children under the age of five); capability for healthy reproduction (the proportion of births unattended by a trained health professional); and education (female illiteracy). The CPM was designed to place particular emphasis on the deprivation of women because of their importance to the human development of families and society (UNDP 1996: 27).

The following year, the CPM was replaced by the Human Poverty Index (HPI), which measured: longevity (the percentage of people expected to die before age 40); knowledge (adult illiteracy); and a living standards (the percentage of people with access to health services, the percentage of people with access to safe drinking water, and the percentage of underweight children less than five years of age). The UNDP (1997: 20) explained the need for HPI stating that, while HDI uses a perspective in which everyone's well-being counts – rich and poor – HPI focuses only on the least well-off.

In *HDR 1998*, the UNDP (1998: 15) renamed HPI – it is now called HPI-1 and is earmarked exclusively for the measurement of poverty in developing countries – and added HPI-2 as a measure of poverty in industrialized countries "because human deprivation varies with the social and economic condition of a community." HPI-2 incorporates different measures of longevity (the percentage of people expected to die before age 60); knowledge (a higher standard of literacy than that used in HPI-1) and living standards (the percentage of people with disposable incomes of less than 50 percent of the median); and adds a measure of social inclusion (the proportion of long-term unemployment).

*Income inequality*

Most *HDR*s have reported some measure of income inequality, usually the Gini coefficient, or income shares by quintile (see Figure 1 below). Early *HDR*s also included an "income-distribution-sensitive HDI" that used each country's Gini coefficient (G) for income to adjust HDI's income component using a formula discussed in detail below. This measure was first mentioned (although without reference to its formula) in *HDR 1990.* It was included with more detail and results for a small sample of countries in *HDR*s 1991 through 1994, but since then it has not been reported.

*Disaggregating HDI*

Different dimensions of inequality can be distinguished in terms of how a population is disaggregated. Frances Stewart (2002: 2) notes that most analyses of poverty and inequality focus on the individual: they are, "concerned with the numbers of individuals in poverty in the world as a whole, not with who they are, or where they live." In a discussion of the origins of violent conflict, Stewart (2002: 3) goes on to distinguish between "vertical" and "horizontal" dimensions of inequality:

> *It is my hypothesis that an important factor that differentiates the violent from the peaceful [countries] is the existence of severe inequalities between culturally defined groups, which I shall define as horizontal inequalities to differentiate them from the normal definition of*

**Figure 1: History of Changes to *HDR*'s Inequality Measures**

| Year | Income Disparities | Gender Disparities |
|---|---|---|
| 1990 | • Discussion in text with sample of HDI's sensitivity to income distribution<br>• Quintile ratios and Gini in tables | • Technical note table on female and male HDI<br>• Both female and male HDIs use GDP per capita for income measure |
| 1991 | • Table in text of income-distribution-sensitive HDI<br>• Quintile ratios and Gini in tables | • Table in text of Gender-Sensitive HDI using estimated income<br>• 1 gender table |
| 1993 | | • 2 gender tables |
| 1994 | • Annex table of income-distribution-sensitive HDI<br>• Quintile ratios in tables | • Annex table of Gender-Disparity-Adjusted HDI |
| 1995 | • Quintile ratios in tables only | • Tables in text on GDI and GEM<br>• 7 Annex tables on gender<br>• Table in text on burden of work time |
| 1996 | | • Tables in text on GDI and GEM<br>• GDI and GEM are Tables 2 and 3<br>• 2 other gender tables |
| 1999 | • Historical income distribution in text<br>• Quintile ratios in tables | • Bardhan and Klasen income method introduced for GDI and GEM<br>• GDI and GEM are Tables 2 and 3<br>• 4 other gender tables |
| 2000 | • Quintile ratios in tables only | |
| 2001 | • Gini table in text<br>• Quintile ratios, Gini in tables | • GDI and GEM are Tables 21 and 22 or higher<br>• 4 other gender tables |
| 2002 | • Quintile ratios and Gini in tables only | |

*Note: GDI = Gender-related Development Index; GEM = Gender Empowerment Measure*

> *inequality which lines individuals or households up vertically and measures inequality over the range of individuals – I define the latter type of inequality as vertical inequality. Horizontal inequalities are multidimensional – with political, economic, and social elements (as indeed are vertical inequalities, but they are rarely measured in a multidimensional way). It is my contention that horizontal inequalities affect individual well-being and social stability in a serious way, and one that is different from the consequences of vertical inequality.*

Comparative HDIs calculated for specific regions or racial/ethnic groups within countries can and have been used to depict horizontal inequalities. A table in *HDR 1993* (UNDP 1993: 18), for example, disaggregated the United States' HDI by race and gender: U.S. whites had a higher HDI than Japan (the country ranking first in HDI that year), while U.S. blacks had an HDI near that of Trinidad and Tobago (HDI rank 31), and U.S. Latinos had an HDI near that of Estonia (HDI rank 34).[2]

*Gender disparities*

Disaggregation by gender is the only type of horizontal inequality for which comparable data have been reported regularly in the *HDR*s for a large set of countries. In fact, the UNDP has included some measure of female development or gender inequality in all sixteen *HDR*s (see

[2] See also Stanton (2006), chapter 4.

Figure 1 above). Female- and Male-HDIs (that is, HDIs constructed as if a single gender were the entire population) were reported in a technical note to the first *HDR,* with GDP per capita used for both genders' incomes because of a lack of gendered income data. *HDR 1991* expanded coverage of gender inequality, stating that, "Of the many inequalities in human development, the most striking is that along gender lines." (UNDP 1991: 92)

Both *HDR 1991* and *HDR 1992* weighted the regular HDI by the ratio of Female- to Male-HDI for a small subset of countries, and presented the results as the "Gender-Sensitive HDI." The Female- and Male-HDIs again were calculated using gendered data for life expectancy and literacy, and wage ratios and labor force participation rates by gender were used to construct gendered estimates of income. In 1993 and 1994, the UNDP switched to a very closely related "Gender-Disparity-Adjusted HDI," which did not use Female- and Male-HDIs as an intermediary step, instead, adjusting HDI by a gender disparity factor calculated as the average of the female-to-male ratios of life expectancy, educational attainment, and income (UNDP 1994: 97).

This approach was further refined to create the Gender-related Development Index (GDI) first presented in 1995, the year of the United Nations' Fourth World Conference on Women, held in Beijing. GDI is a measure of human development that takes into account the extent of gender inequality in each country (for details, see Stanton 2006, chapter 5). GDI is the only cross-country index related to gender disparities in human development that has been calculated consistently over a number of years. Also since 1995, the *HDRs* have reported a Gender Empowerment Measure (GEM), which measures gender inequality in political, professional, and economic participation.

*Non-income inequalities*

With the exception gender disparities, the inequality measures sporadically reported in the *HDR* have been been restricted exclusively to the income distribution, and none have been incorporated into the HDI itself. Sudhir Anand and Amartya Sen (2000: 97), the authors of the current specification of HDI's income component, have advocated adjustment of HDI not only for income inequality but also for health or education inequality: "Sensitivity to inequality in achievements requires that we adjust all three components of the HDI for inequality."[3]

Life expectancy – like health in general – is not distributed equally within nations. Hicks (1997: 1289) notes that, "[T]here is significant life-span inequality, ranging from infants who die at birth or before age one, to persons who die at ages over 100 years." Similarly, there is abundant evidence that literacy and school enrollment are not distributed equally within nations.[4]

The first *HDR* stated that all three average measures of human development "conceal wide disparities in the overall population," but that compared to income inequality, the "inequality possible in respect to life expectancy and literacy is much more limited: a person can be literate only once, and human life is finite." (UNDP 1990: 12) The argument that health and education inequalities are quantitatively more limited than income inequality is correct (as demonstrated

[3] See also Chowdhury 1991, Sagar and Najam 1998, and Chatterjee 2005.
[4] Indeed, any rate of literacy or school enrollment less than 100 percent indicates an unequal distribution of educational resources where some have received the benefits of education while others have not.

below), although the replacement of binary variables, like literacy and school enrollment, with continuous variables, like years of schooling, allows for the detection of more inequality.

In *Inequality Reexamined*, Sen (1992: 28, original emphasis) nevertheless argues that unequal distributions of health and education also have important impacts on human well-being: "The extent of real inequality of opportunities that people face cannot be readily deduced from the magnitude of inequality of *incomes*, since what we can or cannot do, can or cannot achieve, does not depend just on our incomes but also on the variety of physical and social characteristics that affect our lives and make us what we are." To some extent, the distributions of health and education outcomes reflect private expenditures, and hence the distribution of income.[5] Publicly provided goods and services may be unequally distributed as well, because access to them is politically driven and affected by discrimination on the basis of race, ethnicity, religion, or gender. Because inequalities in the distribution of health and education have negative effects on human well-being, and are not simply a function of income inequality, they too should enter into measures of social welfare.

**Why Inequality Matters for Social Welfare**

HDI, the UNDP's measure of social welfare, is an important alternative to per capita national income because it includes non-income dimensions of welfare, and because to a limited extent it creates a more distribution-sensitive measure. This section explains what HDI does and does not achieve, and why the UNDP should go further in incorporating welfare-relevant aspects of distribution into HDI.

The most commonly used proxy for social welfare is per capita income ($\overline{Y}$), usually measured as a country's Gross Domestic Product (GDP) divided by its population (N):

$$(1)\ \overline{Y}_i = \frac{\mathrm{GDP_i}}{\mathrm{N_i}}$$

where the subscript i refers to the country. Per capita national income has often been criticized as a measure of aggregate well-being for its lack of information regarding non-monetary aspects of welfare.[6] A further limitation is its lack of distributional information: in two countries with identical GDP per capita but very different distributions of income, it is easy to imagine very different income impacts on aggregate well-being.

HDI is derived from three component indices: health (H-Index) as proxied by average life expectancy; education (E-Index) as proxied by a weighted average of literacy and school

[5] Even when the provision of health and education is public, access to them can be affected by the distribution of purchasing power. For example, travel to even a free health clinic may be constrained by lack of income, or children's need to work to support themselves or their families may constrain their effective access to education.
[6] See Ackerman *et al.* (1997) and UNDP (1990) among many others.

enrollment rates; and income per capita (Y-Index), using the natural logarithm in order to account for the diminishing marginal utility of income.[7]

The concept of diminishing returns in the fulfillment of human needs, was expressed by Alfred Marshall (1890, Book 3, Chapter 3) more than a century ago:

> *There is an endless variety of wants, but there is a limit to each separate want. This familiar and fundamental tendency of human nature may be stated in the law of satiable wants or of diminishing utility thus: The total utility of a thing to anyone (that is, the total pleasure or other benefit it yields him) increases with every increase in his stock of it, but not as fast as his stock increases. If his stock of it increases at a uniform rate the benefit derived from it increases at a diminishing rate. In other words, the additional benefit which a person derives from a given increase of his stock of a thing, diminishes with every increase in the stock that he already has.*

HDI's use of the logarithmic transform of per capita income to adjust for diminishing returns to income seems, at first glance, to be motivated by Marshall's principle of satiable wants. Yet the utilitarians and early marginalists like Marshall did not discuss diminishing returns to the *aggregate* per capita income of a country, which is what HDI currently takes into account. Rather, they posited diminishing marginal returns to *individual* income. In the same way, in modern neoclassical theory, diminishing marginal returns are applied to individual income, not aggregate income; indeed, neoclassical theory has no concept of aggregate social welfare beyond the notion of Pareto improvement.[8] To account for diminishing marginal returns to income, we therefore need to use a concave transform of income (such as natural logarithms) at the level of *individual* incomes, a point to which I return below.

In calculating HDI, the UNDP first normalizes life expectancy, education, and the natural log of income for conversion into indices, and then combines the three indices in a simple average. The normalization formula causes index values (called the X-Index in Equation 2 below, to generalize across the three) to range from 0 to 1, by comparing each country's indicator value ($\overline{X}_i$, the average value of variable X in the ith country) to a stylized range of indicator values among all countries:

$$(2)\ \text{X-Index}_i = \frac{\overline{X}_i - \text{minimum X value}}{\text{maximum X value} - \text{minimum X value}}$$

In the current HDI formula, the stylized range for average life expectancy values ($LE_i$) is 25 to 85 years; for literacy and enrollment rates ($LIT_i$ and $ENR_i$) it is 0 to 100 percent; and for GDP per capita ($Y_i$) it is the natural log of $100 to the natural log of $40,000.

The formula for HDI is as follows:

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[7] According the UNDP (2005: 341), "Income is adjusted because achieving a respectable level of human development does not require unlimited income. Accordingly, the logarithm of income is used." Using slightly different language, the first *HDR* explained the use of logarithms this way: "[Since] there are diminishing returns in the conversion of income into the fulfillment of human needs, the adjusted GDP per capita figures have been transformed into their logarithms." (UNDP 1990: 13)

[8] A Pareto improvement occurs when some individual is made better off without making anyone worse off.

$$\text{(3a) H-Index}_i = \frac{LE_i - 25 \text{ years}}{85 \text{ years} - 25 \text{ years}}$$

$$\text{(3b) LIT-Index}_i = \frac{LIT_i - 0\%}{100\% - 0\%}$$

$$\text{(3c) ENR-Index}_i = \frac{ENR_i - 0\%}{100\% - 0\%}$$

$$\text{(3d) E-Index}_i = 2/3(\text{LIT-Index}_i) + 1/3(\text{ENR-Index}_i)$$

$$\text{(3e) Y-Index}_i = \frac{\ln(Y_i) - \ln(\$100)}{\ln(\$40{,}000) - \ln(\$100)}$$

$$\text{(3f) HDI}_i = 1/3(\text{H-Index}_i) + 1/3(\text{E-Index}_i) + 1/3(\text{Y-Index}_i)$$

The inclusion of non-income dimensions is important for two reasons: first, because health and education are in part publicly provided goods, which are not distributed according to income; and second, because insofare as they are privately purchases, health and education – like utility – are concave in income. As a result of the latter, HDI to some extent captures the welfare effects of income inequality.

*Income Inequality's Aggregation Effect*

Income inequality has been shown to be correlated negatively with the average level of health in a society. Daniels, Kennedy, and Kawachi (2000: 3) summarize this relationship:[9]

> *We now know…that countries with a greater degree of socioeconomic inequality show greater inequality in health status; also, that middle-income groups in relatively unequal societies have worse health than comparable, or even poorer, groups in more equal societies. Inequality, in short, seems to be bad for our health.*

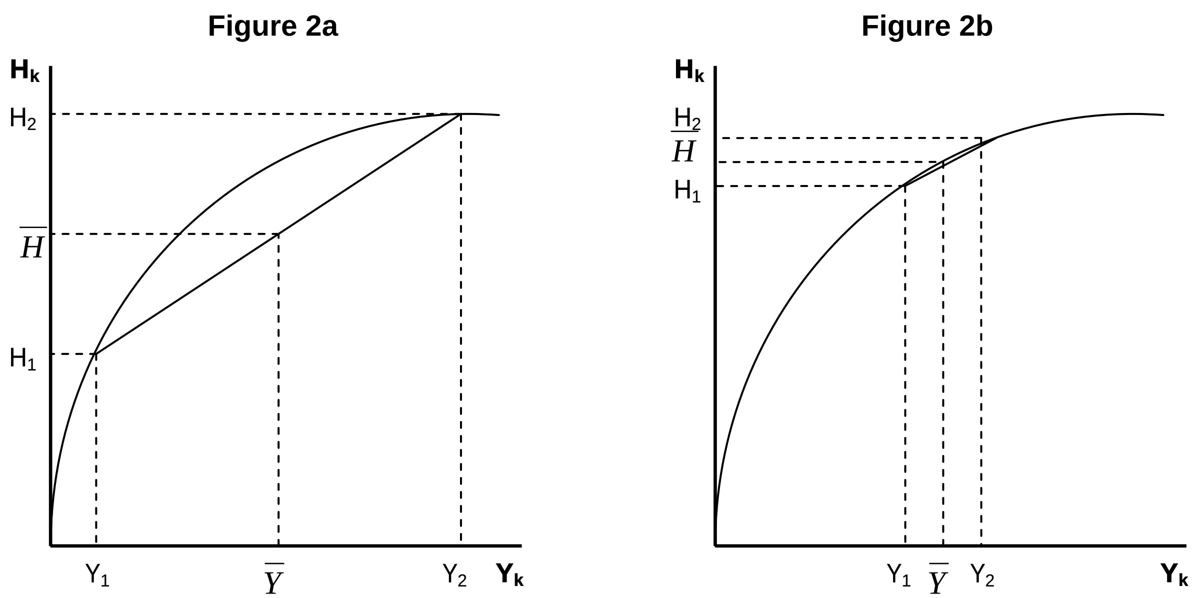
In part, this is because the relationship between individual health and individual income is concave – that is, increases to income improve health but at a diminishing rate. For example, Michael Marmot's "Whitehall" studies of British civil servants have found a strong inverse relationship between social class and mortality from diseases: workers with the lowest status jobs had twice the mortality rate of those with the highest status jobs, a disparity attributed to differences in the psychosocial work environment (Marmot and Smith 1991; Marmot and Bosma 1997).

If health is concave in income, then a redistribution of income would change the average level of health. Figures 2a and 2b illustrate this effect. Individual income ($Y_k$) maps into increasing individual health ($H_k$), where subscript k denotes the individual with diminishing returns. The frequency distribution along the horizontal axes cause different average levels of health, depending on how individual incomes are spread out. In the population of two individuals

[9] See also Kawachi and Kennedy (2002).

depicted here, the incomes of Person 1 and Person 2 ($Y_1$ and $Y_2$) are much closer together in Figure 2b than in Figure 2a, although average income ($\overline{Y}$) is the same.

**Figures 2a and 2b: The Aggregation Effect of Income Distribution**




Average health ($\overline{H}$) is higher in Figure 2b, where income is more equally distributed. This is can be described as an "aggregation effect": $\overline{H} = H(\overline{Y})$ only if $Y_k = \overline{Y}$ for all k (Heerink *et al.* 2001; Boyce 2006).[10] If two countries have identical average income but different income distributions, the country with greater income inequality will have lower average health – and therefore a lower HDI.

The same logic applies to education. The relationship between individual income and individual education is concave: As individual income increases so too do education levels, but at a decreasing rate (Tilak 2002; Hicks 1997; Noorbakhsh 1998). As a result, average education is higher when income is more equally distributed.

A ranking of countries by HDI differs from a ranking by $\overline{Y}$, therefore, in part because average life expectancy and education register the effects of income distribution, as well as because of the existence of publicly provided goods and other non-income determinants of health and education. While these effects make HDI a better measure of social welfare than $\overline{Y}$, three additional ways in which inequality can affect well-being are missing from HDI:

- The aggregation effects of inequality in *health and education* on individual welfare (as opposed to the aggregation effects of inequality in income on health and education);

[10] A more familiar example of the aggregation effect concerns the diminishing marginal utility of income: aggregate utility (social welfare) is maximized when income is equally distributed.

- Shifts in the curves relating individual welfare to individual income, health, and education, due to the effects of inequality of other welfare-relevant variables that are not accounted for in HDI; and

- Inequality's intrinsic effect as a disamenity.

Each omitted effect is described in more detail below.

*Aggregation Effects of Health and Education Inequalities*

Individual welfare can be assumed to exhibit diminishing returns to both life expectancy and educational attainments.[11] Each additional year of life adds to our individual welfare, but it adds less than the previous year; thus, a four year-old who has succeeded this year in living to the age of five, arguably has gained more in welfare than a 74 year-old who has succeeding in living to the age of 75. Thus, according to Srinivasan (1994: 240):

> *The components of HDI, namely, life expectancy and educational attainment, are 'functionings' in the Sen sense but their relative values need not be the same across individuals, countries, and socioeconomic groups. Besides, the 'intrinsic' value of a single 'functioning,' namely, ability to live a healthy life, is not captured by its linear deprivation measure in HDI, since a unit decrease in the deprivation in life expectancy at an initial life expectancy of, say, 40 years is not commensurate with the same unit decrease at 60 years.*

Interdependencies among individuals also have relevance. If loved ones, and society as a whole, feel greater loss upon the death of a child than the death of an elderly person, this reinforces the concavity at the level of the individual.

Similarly, and perhaps less controversially, each extra year of schooling adds to our individual welfare, but it adds less than the previous year. For example, the completion of a year of primary school – and the acquisition of basic literacy – arguably has a greater impact on any individual's welfare than the completion of an additional year of advanced graduate studies. Noorbakhsh (1997: 519) makes a similar argument: "[T]he early 'units' of educational attainments to a country should be of much higher value than the last ones. In the context of policy-making in a country with 30% adult literacy, improvements in literacy are of far greater urgency than the same for a country with 90% adult literacy."

If individual welfare is concave with respect to both health and education, then for any given average level of health or education, a more equal distribution of these results in higher average well-being. In the simple two-person examples of Figures 3a and 3b (where $w_k$ is individual welfare), as health becomes more equally distributed ($H_1$ and $H_2$ converge on $\overline{H}$), average welfare ($\overline{w}$) increases; again, because the relationship between the two variables is concave, $\overline{w}$ = $w(\overline{H})$ only if $H_k$ = $\overline{H}$ for all k. Implicitly modeling individual welfare as linear in both health and education, HDI omits the aggregation effects of health inequality and education inequality.

[11] For discussions, see Sen 1981, Kelley 1991, Srinivasan 1994, Noorbakhsh 1998, Cahill 2002, and Deaton 2003.

**Figures 3a and 3b: Aggregation Effect of Health and Education Inequality**

**Figure 3a**

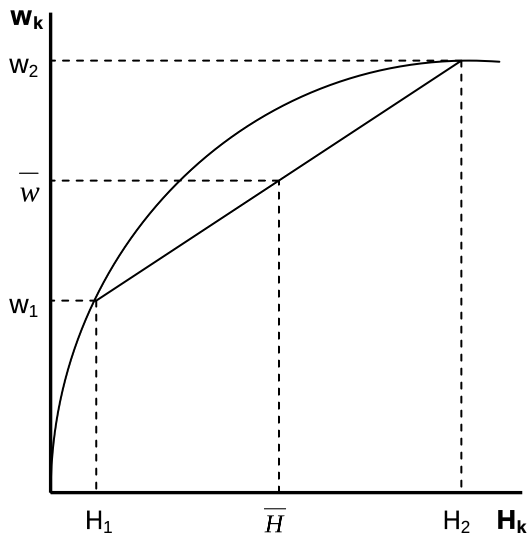
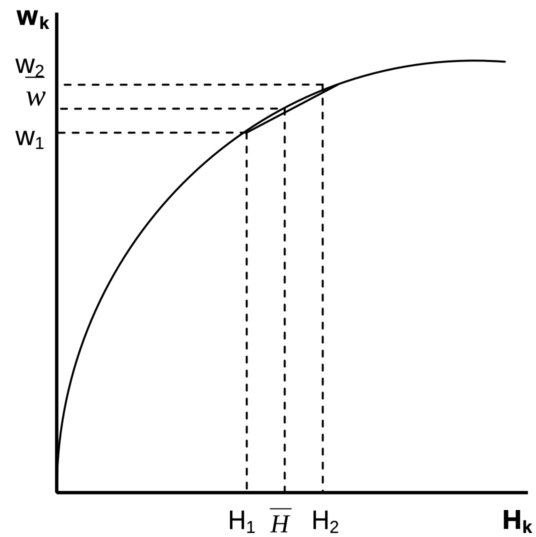



**Figure 3b**




*Shift Effects*

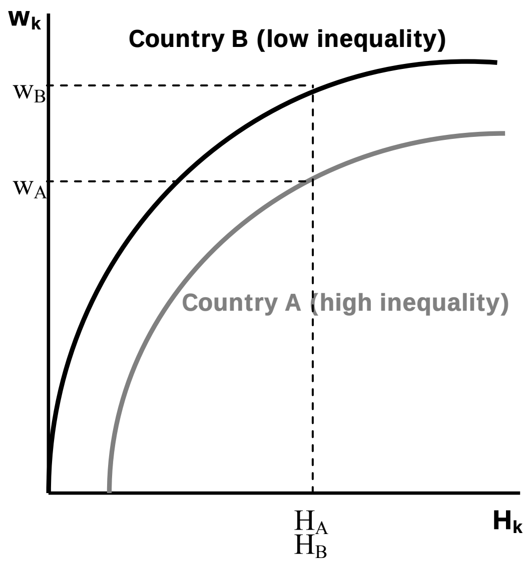
In addition to these aggregation effects, inequalities in health, education, and income further impact social welfare through what can be called "shift effects": changes in the position of the curve relating individual welfare to these variables (as opposed to changes in the frequency distribution along the horizontal axis) (Boyce 2006). Figure 4 depicts a shift effect: individual welfare ($w_k$) is a concave function of individual health in both countries A and B, but country A has a more unequal distribution of health than country B. Two individuals with the same level of health ($H_A$ and $H_B$) will have different levels of individual welfare ($w_A$ and $w_B$) depending on their country, for either or both of two reasons: 1) instrumental shift effects, and 2) intrinsic shift effects.

Instrumental Shift Effects

"Instrumental effects" refer to inequality's impact on social welfare by way of some other variable, regardless of whether or not inequality is seen as bad in and of itself (Ray 1998: 170). Inequalities in health, education, or income that have an adverse impact on some other welfare-relevant variable(s) absent from HDI would cause a negative shift effect – a decrease in everyone's welfare – an effect that is omitted from HDI as currently constructed.

An unequal distribution of health, for example, may affect the existence and distribution of public goods that are created through community labor, as in the case where communities disproportionately impacted by HIV/AIDS lack sufficient adults to care for children, either publicly or privately. Similarly, the distribution of educational attainment – and not just the average level of education – may have a profound impact on the distribution of power in society, and in turn on outcomes related to public goods, like electoral participation or environmental quality. A society with a broad distribution of education, in contrast to a society with large educational disparities, may have an enhanced ability to engage in collective action, take part in political processes, and resist misuses of power that erode public goods.

**Figure 4: Inequality's Shift Effect**




To cite another example, income inequality, and the unequal distribution of power with which it is correlated, can negatively impact environmental quality. There are winners as well as losers in every instance of environmental degradation. Boyce (2002: 34-38) posits a power-weighted social decision rule: when those who are hurt by environmental degradation are less powerful than those that benefit from it, the environmental damage will exceed the "social optimum," on the other hand, when the victims of environmental degradation are more powerful than the beneficiaries, environmental degradation will be sub-optimal. Boyce argues that these two possibilities do not balance each other out: "The power-weighted social decision rule yields an unambiguous prediction: the greater the inequality of power, the greater the extent and social cost of environmental degradation."

Boyce offers three explanations for this result. First, power correlates positively with wealth, and hence with the ownership of productive assets; since industry causes many environmentally degrading activities, the wealthy and powerful who own industrial capital more often tend to be winners. The rich also benefit more as consumers, insofar as firms pass along cost savings from cost externalization to consumers; since the rich consume more than the poor, they will reap a greater share of the resulting increases to consumer surplus. Second, too little environmental degradation can be easily "corrected," but too much cannot; shifts over time in the balance of power will not be able to correct irreversible damage. Finally, rising marginal costs of environmental degradation mean that higher levels of degradation have a greater welfare impact per unit degradation than lower levels.

Income inequality can also undermine political processes, disrupt social and civic life, exacerbate crime, and ignite civil conflicts (Birdsall 2004). Thurow (1971: 327) warns that, "Preventing crime and creating social or political stability may depend on preserving a narrow distribution of income or a distribution of income that does not have a lower tail." Similarly, Sen (1973) mentions inequality's negative effects on social cohesion, especially where the perception of inequity is strong. Environmental quality and social cohesion again are important components of social welfare, but both are omitted from HDI. The impacts of inequality on such variables have negative instrumental shift effects that are likewise omitted from HDI.

Intrinsic Shift Effects

Inequality's intrinsic impacts on social welfare can also cause shifts in the curves relating individual income, health, and education to individual welfare. Ray (1998: 169) refers to "philosophical and ethical grounds for aversion to inequality," or the negative weight that society places on inequality.[12] In this same vein, Thurow (1971) describes income inequality as a "public bad" and suggests that income redistribution is necessary to achieve a Pareto optimal state if one or more of the following contributes to an individual's welfare: the income of others; the process of giving gifts and charity; or the income distribution itself. [13] In the latter case:

> *Each individual in society faces the same income distribution. No one can be deprived of the benefits flowing from any particular income distribution. My consumption of whatever benefits occur is not rival with your consumption. In short, the income distribution meets all of the tests of a pure public good. (Thurow 1971: 327)*

Inequality of health, education, or income thus may enter into individual welfare functions because of what may be a universal intrinsic value placed on equity. According to Sen (1992: 130), "[A]ll the major ethical theories of social organization tend to demand equality in some space – a space that has some basic importance in that theory." In his earlier work on this topic, *Economic Inequality*, Sen (1973) describes inequality as a departure from an "appropriate" distribution, where the appropriate distribution could be based on what a person needs or deserves. Intrinsic preferences for equality would cause negative shift effects, or a decrease in everyone's welfare.

HDI, as currently constructed, thus misses a number of ways in which inequalities affect social welfare: the aggregation effects of inequalities of income, health, and education (apart from the aggregation effects of income inequality on health and education themselves); the instrumental shift effects of inequalities of income, health, and education (again, apart from those of income inequality on education and life expectancy), such as impacts on the provision of social services, participation in public life, environmental quality, and social cohesion; and the intrinsic shift effects arising from preferences for greater equality.

The Inequality-adjusted HDI (IHDI), which I propose below, accounts for these missing components of social welfare with four important adjustments. First, social welfare is modeled as concave in all three components of HDI, not just per capita income, to reflect diminishing returns. Second, the role for concavity is extended beyond the average measure for the relevant indicators in order to better account for the aggregation effects of inequality. Third, binary education variables are replaced with continuous variables, which better depict inequality. Fourth, social welfare is further adjusted to account for shift effects due to instrumental and intrinsic impacts of inequality on social welfare.

[12] The term "aversion to inequality" is also used by the UNDP (1995) to explain its rationale for the Gender-related Development Index.
[13] See also Birdsall (2004: 297-8).

**Constructing the IHDI: Data**

Construction of the IHDI requires distributional data for health, education, and income for two purposes: 1) to model welfare with respect to each of these components as a concave function, so as to capture aggregation effects; and 2) to construct measures of the inequality for each country for all three of these components, so as to capture shift effects. (A detailed description and analysis of the data used is presented in Appendix A.) The measures of inequality used for the latter purpose in this paper are Gini coefficients. When calculating a Gini, the indicator values for each individual (or each group) in a given country are first ordered from lowest to highest; then cumulative shares of the population are compared to cumulative shares of the country's aggregate value of that indicator.[14]

In the case of educational attainment, for example, a country's population can be ordered from the individual(s) with the lowest education (no schooling whatsoever) to the individual(s) with the highest education (say 20 or more years of schooling). If each cumulative percentile of the population had exactly the same cumulative share of total years of schooling – so that the first 10 percent of the population had 10 percent of the total years of schooling, the first 20 percent of population had 20 percent, and so on – the country would exhibit perfect equality in schooling, and the Education Gini for the country would be zero. If on the other hand, only one person in the country had any schooling at all, and all others had none whatsoever, the country would exhibit perfect inequality and its Education Gini would be 1. All countries fall somewhere in between these hypothetical extremes: for example, the first 10 percent of the population might have only 1 or 2 percent of the total years of schooling. The Lorenz curve, from which the Gini coefficient can be derived, represents perfect equality as a 45-degree line emanating from the origin. The more inequality, the greater the divergence of the Lorenz curves from the 45-degree line (as shown in Appendix Figures A2, A4, and A6).[15]

Distributional data on health are available for 81 countries; on education for 110 countries; and on income for 113 countries. Altogether, data for at least one of the three components are available for 149 countries, but all three measures are available for only 46 countries. The proposed IHDI is calculated below only for these 46 countries, a sample that does not include any of the least developed countries.[16]

In general terms, Health Ginis are relatively low, falling primarily between 0.1 and 0.2, a result consistent with the UNDP's prediction that intrinsic limits of a lifespan result in a more equal distribution of life years than of income, on which there is no such limit.[17] Health Ginis are not perfectly correlated with average life expectancy, but there is an observable trend in that lower

[14] For details, see Ray (1998: 188).

[15] For a discussion of the Gini coefficient's attributes as a measure of inequality see Ray (1998) and Hicks (1997). Hicks also makes a compelling case for the appropriateness of constructing Gini coefficients for health and education.

[16] Of these 46 countries, Egypt has the lowest HDI rank, 119 out 177, and no country is among those classified as "low human development" by the UNDP (2005).

[17] Although, if countries with high levels of infant mortality were included in the sample, the average Health Gini would be much higher.

average life expectancies are associated with higher Health Ginis. The distribution of Education Ginis is more dispersed than that of Health Ginis. Lower average years of schooling are associated with higher Education Ginis, but there is a substantial spread in the observations indicating that average years of schooling do not fully reflect differences in educational inequality. Income Ginis have no strong relationship to per capita income. (See Appendix Figures A1, A3, and A5.)

*Correlations*

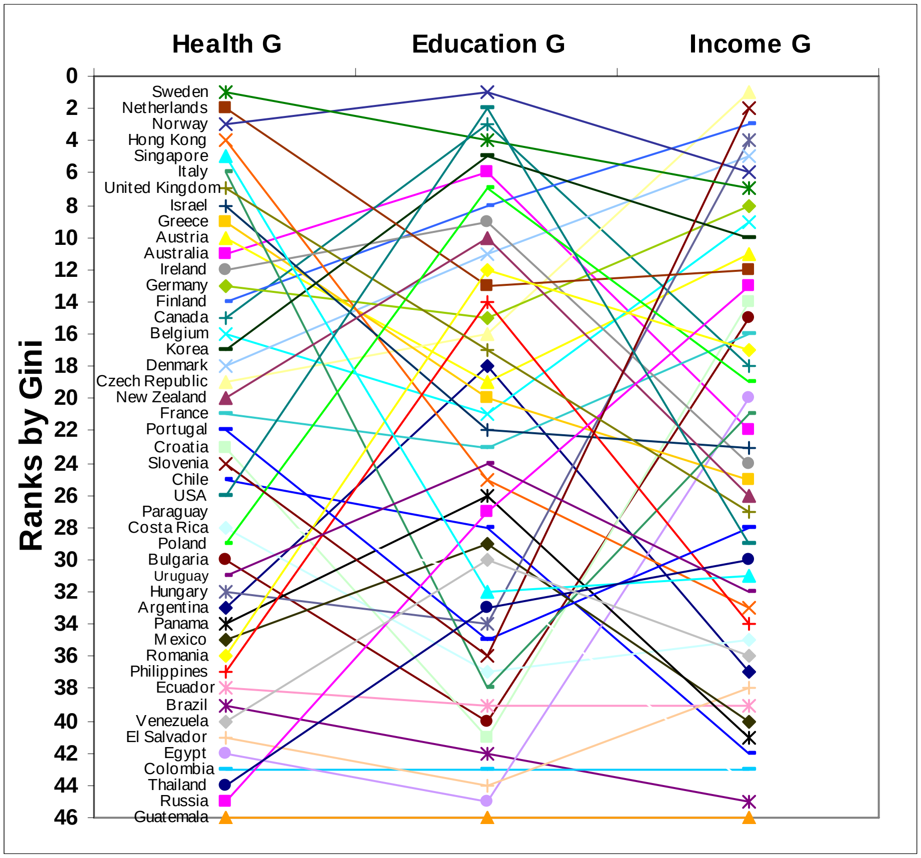
Table 1 presents a correlation matrix for the three Gini coefficients and average levels of life expectancy, educational attainment, and income. The pairwise correlations between the Health, Education, and Income Ginis range from 0.50 to 0.62. Income inequality, therefore, is not a satisfactory proxy for health and education inequalities. The negative correlation between Gini coefficients and the corresponding indicator's average value is strongest between the Health Gini and average life expectancy, 0.91, and weakest between the Income Gini and per capita income, 0.60. The use of all three inequality measures can be justified by the very different ranges of the Ginis and the imperfect inter-country correlations among them. By averaging these three Ginis to form a "Human Development Gini" (as proposed below), we can obtain a useful summary measure. For example, very high income inequality could be tempered by taking into account the extent to which public provision of health and education means that these are not distributed as unequally as income.

**Table 1: Correlation Matrix for IHDI Gini Coefficients and Average Indicator Values (2003)**

| | $G^H$ | $G^E$ | $G^Y$ | Average LE | Average EA | Average Y |
|---|---|---|---|---|---|---|
| $G^H$ | 1.000 | | | | | |
| $G^E$ | 0.623 | 1.000 | | | | |
| $G^Y$ | 0.550 | 0.502 | 1.000 | | | |
| Average LE | -0.914 | -0.573 | -0.391 | 1.000 | | |
| Average EA | -0.561 | -0.885 | -0.630 | 0.512 | 1.000 | |
| Average Y | -0.779 | -0.669 | -0.596 | 0.783 | 0.658 | 1.000 |

Figure 5 below depicts the within-country correlations of the Health, Education, and Income Gini ranks, showing that, with a few exception like Guatemala, there is little correlation of the three Ginis within each country. Because the data presented here come from separate data sets, there is no way to empirically establish the extent to which the income-poor are also the health-poor and the education-poor. It is my hypothesis, however, that these inequalities are cumulative. Marmot (2005: 101) presents evidence from several countries that adult mortality rates vary inversely with education levels. Similarly, Tilak (2002: 198) demonstrates an inverse relationship between education levels and income poverty: "Poverty of education is a principal factor responsible for income poverty; and income poverty, in turn, does not allow the people to overcome poverty of education."

**Figure 5: Correlation between Health, Education, and Income Gini Ranks**




*Source: Author's calculations using data from the current study.*

## Constructing the IHDI: Methodology

Early *HDRs*, as noted above, reported results for an Income-Distribution-Adjusted HDI (HDI$^{A*}$). This measure used the Gini coefficient for income to penalize HDI values for the extent of income inequality in each country: [18]

$$\text{(4a) H-Index}_i = \frac{\text{LE}_i - 25 \text{ years}}{85 \text{ years} - 25 \text{ years}}$$

$$\text{(4b) E-Index}_i = \quad 2/3(\text{LIT-Index}_i) + 1/3(\text{ENR-Index}_i)$$

$$\text{(4c) Y-Index}^{A*}{}_i = \frac{[(1 - G_i^{Y})*\ln(Y_i)] - \ln(\$100)}{\ln(\$40{,}000) - \ln(\$100)}$$

[18] Since the HDI's technique for adjusting GDP per capita for diminishing returns has changed over time, the formula presented here combines the *HDR 1990* adjustment for income distribution and the current income index.

$$\text{(4d) } HDI^{A^*}_i = 1/3(H\text{-}Index_i) + 1/3(E\text{-}Index_i) + 1/3(Y\text{-}Index^{A^*}_i)$$

In calculating $HDI^{A*}$, the life expectancy and education indices thus remained unchanged, but the income index ($Y\text{-}Index^{A*}$) was adjusted for income inequality: before employing the normalization formula, the natural log of income was multiplied by 1 minus the Gini coefficient for income ($G^Y$). Since Ginis range from 0 (perfectly equality) to 1 (perfect inequality), the greater the extent of income inequality the greater the reduction to the income component of $HDI^{A*}$, and the lower $HDI^{A*}$ itself. *HDRs* 1990 through 1994 contained $HDI^{A*}$ results for a sample of countries.

Hicks (1997) proposed an Inequality-Adjusted HDI ($HDI^{B*}$) that made adjustments for distribution in all three component indices. In addition to the more commonly available Gini coefficient for income ($G^Y$), Hicks constructed Ginis for health ($G^H$) and education ($G^E$) using data for age at death and educational attainment respectively.[19] In $HDI^{B*}$, the component indices were identical to those used in HDI with one exception: the three Ginis were used to penalize their respective index values for the extent of inequality in that particular component.[20] Hicks' method of introducing the Ginis into his adjusted HDI differed from the UNDP method described above, being inserted into the component indices after normalization rather than beforehand: [21]

$$\text{(5) } HDI^{B*}_i = 1/3[(1 - G^H_i) * H\text{-}Index_i] + 1/3[(1 - G^E_i) * E\text{-}Index_i] + 1/3[(1 - G^Y_i) * Y\text{-}Index_i]$$

In HDI, each of the three component indices account, on average, for about one-third of the value of HDI – that is, the three components are very nearly equally balanced. The placement of the adjustments for inequality (1 – G) outside of the normalization formulae in Hicks' $HDI^{B*}$ has the unfortunate side-effect of upsetting this balance. Using data from the current study, Table 2 compares the average weight of each component in the values of HDI and Hicks' $HDI^{B*}$.[22]

[19] Income distribution data by quintile for Hicks' study was taken from the World Bank, education data from a study by Ahuja and Filmer (1995) that broke educational attainment into six categories, and longevity data from the UN Demographic Yearbook's age at death (Hicks 1997).

[20] Foster *et al*. (2005) have also presented a distribution-adjusted HDI using distributional data for Mexican states. The authors point out that Gini coefficients, while excellent measures of inequality in many other ways, are "sub-group inconsistent" (that is, it is theoretically possible for the income, for example, of one group to worsen while that of all other groups remains the same and for the Gini coefficient to fail to reflect the greater inequality). Foster *et al.* instead propose the use of a version Atkinson's welfare measure for each of HDI's component indices: $W(x) = (\Sigma^n_{k=1} x_k^{1-\varepsilon})^{1/1-\varepsilon}$. While Atkinson's welfare measure is superior in this one respect, it is much less transparent than Hicks' measure or the IHDI proposed here; for example, it would be extremely difficult to isolate the impact of inequality on social welfare in Atkinson's or to describe its implicit social welfare function. Foster also argues that Hicks' measure is problematic because it is unknown whether its three types of inequality are cumulative or off-setting, but this would seem to be a problem of data not formula. Without consistent groups across the three measures, Atkinson's welfare measure suffers from the same failing.

[21] The formula for Hick's Inequality-Adjusted HDI as presented here has been updated for consistency with the current HDI formula.

[22] Despite HDI's simple formula, the average share of HDI taken up by the components is not equal to one-third each because the three indices differ in their average values and standard deviations, as shown below. The original endpoints (stylized maxima and minima) chosen to normalize each index resulted in very nearly balanced shares.

**Table 2: Average Component Shares in HDI and Hicks' HDI$^{B*}$ (2003)**

| | H | E | Y |
|---|---|---|---|
| **HDI** | 32.7% | 35.6% | 31.7% |
| **Hicks' HDI$^{B*}$** | 39.1% | 34.4% | 26.5% |

*Source: Author's calculations using data from the current study.*

The current study proposes a new Inequality-Adjusted HDI (IHDI) that differs from HDI not only in the inclusion of Ginis for health, education, and income – which are introduced with out changing the balance among the three HDI components – but also in an adjustment to each component to reflect diminishing returns. To do the latter, the indicators for life expectancy, education, and income are first transformed (before incorporation in the index normalization formulas) into social welfare (W) using the distributional data discussed above:

$$\text{(6a)}\ W^H_i = \sum^n_{k=1} [a^H_{ik} * \ln(LY_{ik})]$$

$$\text{(6b)}\ W^E_i = \sum^n_{k=1} [a^E_{ik} * \ln(EA_{ik})]$$

$$\text{(6c)}\ W^Y_i = \sum^n_{k=1} [a^Y_{ik} * \ln(Y_{ik})]$$

where LY is life-years, and EA is educational attainment. The social welfare functions for life expectancy ($W^H$), education ($W^E$), and income ($W^Y$) are the weighted average (using the set of weights $a_{ik}$) of the natural log of the values of that component for k individuals in the ith country. The use of natural logs results in individual welfare functions that are concave with respect to the logged variable.

IHDI uses the average of the natural log of individual values, whereas HDI uses the natural log of an average value (in the case of the income component). Taking the natural log of $\overline{Y}$ was a way for the UNDP to make the HDI less sensitive to income differences between countries then it otherwise would have been. This provided an incomplete solution to the diminishing marginal utility of income, in that it only addresses differences between national averages and not differences within countries. Taking the average of the natural logs adjusts individual welfare for

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But as data have changed while endpoints have remained the same (making it possible to compare HDI across years), the component shares have drifted slightly from this balance:

**Descriptive Statistics for HDI (2003)**

| | H | E | Y |
|---|---|---|---|
| **average** | 0.845 | 0.920 | 0.826 |
| **standard deviation** | 0.065 | 0.081 | 0.122 |

*Source: Author's calculations using data from the current study.*

diminishing returns to health, education, and income, and thereby allows the average to reflect the associated aggregation effects.[23]

The weights ($a_{ik}$) can take different values summarized by the following general case:

$$(7)\ a_{ik} = \frac{(1/share_{ik})^{\alpha}}{\Sigma^{n}_{k=1}\ (1/share_{ik})^{\alpha}}$$

where "$share_{ik}$" is the kth individual's percentage share of the total value of that indicator summed across all individuals; that is, when $\alpha = 1$ the weights are the inverse of each person's share of the total indicator value for that country. The higher the $\alpha$, the greater the weight placed on the well-being of the least well-off group, making this weighting system analogous to the Foster-Greer-Thorbecke class of poverty measures, in which $\alpha = 2$ is the most commonly used value (1984).[24]

When $\alpha = 0$, the weights the ith country are equal to one divided by that country's population ($N_i$) for all k individuals; each person gets the same weight. This weighting system, when combined with taking the natural log of the indicator, is analogous to the system of "equal weights" described by Ahluwalia and Chenery (1974). The result of the equal weighting system is that a given percentage change in any individual's indicator value (life-years, educational attainment, or income) has the same effect on social welfare, regardless of the individual's indicator level. For example, a one percentage change in the richest individual's income has exactly the same impact on IHDI as a one percentage change in the poorest individual's income.

When $\alpha = 1$, the weights are the inverse of the individual's share of the total indicator value for that country; the smaller the individual's share of the indicator, the greater that individual's weight in social welfare. At higher values for $\alpha$, the individual with the smallest share of the indicator would take on greater and greater importance in the social welfare function. This weighting system corresponds to Ahluwalia and Chenery's "poverty weights." As $\alpha$ approaches infinity, the weighting system approaches a Rawlsian concept of social welfare in which only the well-being of the least well-off member of society is considered in the social welfare function.[25]

For simplicity, weights such that $\alpha = 0$ will be used in the calculations that follow. The social welfare functions with respect to health, education, and income, therefore, can be restated as:

$$(6a^*)\ W^{H}_{i} = \Sigma^{n}_{k=1}\ [1/N_i * \ln(LE_{ik})]$$

[23] Correcting for aggregation effects by taking the average of the natural log of income also means that when comparing between countries, the diminishing marginal utility has already been taken into account.
[24] This rule does not follow, however, for $\alpha$ values between 0 and 1; for those values, higher $\alpha$ values put less value on the well-being of the least well-off.
[25] Regardless of the weighting scheme chosen, since the data used in this study are for groups and not individuals a small adjustment is necessary. For each group, the individual indicator value is the group's average indicator value; the product of the weight and the logged indicator for each "individual" is then multiplied by the number of group members before it is aggregated into social welfare.

$$(6b^*)\ W^E_i = \Sigma^n_{k=1} [1/N_i * \ln(EA_{ik})]$$

$$(6c^*)\ W^Y_i = \Sigma^n_{k=1} [1/N_i * \ln(Y_{ik})]$$

The social welfare functions with respect to life expectancy ($W^H$), education ($W^E$), and income ($W^Y$) are then normalized using the same type of formula employed in HDI:

$$(8a)\ \text{H-Index}^*_i = \frac{W^H_i - \text{minimum value}}{\text{maximum value} - \text{minimum value}}$$

$$(8b)\ \text{E-Index}^*_i = \frac{W^E_i - \text{minimum value}}{\text{maximum value} - \text{minimum value}}$$

$$(8c)\ \text{Y-Index}^*_i = \frac{W^Y_i - \text{minimum value}}{\text{maximum value} - \text{minimum value}}$$

In calculating IHDI, each stylized maximum value was assumed to be a little bit more than the actual maximum, and each stylized minimum value was assumed to be a little bit less than the actual minimum. This buffer around the actual maximum and minimum was included to increase the likelihood that IHDIs calculated for different years could use the same end points and would therefore be comparable. The specific buffer for each indicator's endpoints was chosen to improve the balance of the three component indices in terms of their shares of IHDI.[26] Descriptive statistics of the component indicators, including their average component shares of IHDI, are shown in Table 3.

**Table 3: Descriptive Statistics for IHDI (2003)**

| | H | E | Y |
|---|---|---|---|
| **average** | 0.564 | 0.604 | 0.599 |
| **standard deviation** | 0.097 | 0.196 | 0.217 |
| **component share of IHDI** | 33.3% | 33.5% | 33.1% |

*Source: Author's calculations using data from the current study.*

IHDI is one minus the average of the Ginis for health ($G^H$), education ($G^E$), and income ($G^Y$), multiplied by the average of the adjusted health, education, and income indices:

$$(9)\ \text{IHDI}_i = [1 - (1/3G^H_i + 1/3G^E_i + 1/3G^Y_i)] * (1/3\text{H-Index}^*_i + 1/3\text{E-Index}^*_i + 1/3\text{Y-Index}^*_i)$$

Denoting the average of the three Ginis as HD-Gini, and the average of the three components as HD-Index$^*$:

[26] For health, the range was set at five percent less than the maximum and five percent more than the minimum; for education, six percent less than the maximum and five percent more than the minimum; and for income, four percent less than the maximum and ten percent more than the minimum

$$(10)\ \text{HD-Gini} = 1/3G^{H}_{i} + 1/3G^{E}_{i} + 1/3G^{Y}_{i}$$

$$(11)\ \text{HD-Index}^{*} = 1/3\text{H-Index}^{*}_{i} + 1/3\text{E-Index}^{*}_{i} + 1/3\text{Y-Index}^{*}_{i}$$

$$(12)\ \text{IHDI} = (1 - \text{HD-Gini}) * \text{HD-Index}^{*}$$

This method of including the three Ginis maintains the balance between the component indices. On average, the elasticity of IHDI with respect to the HD-Index is 0.98 (a one percent change in the HD-Index causes a 0.98 percent change in IHDI), while the elasticity of IHDI the with respect to HD-Gini is negative 0.34 percent.

In sum, modeling social welfare as the weighted average of the natural log of indicator values adjusts HDI for the aggregation effects of inequality. Weighting the average of the component indices by the average of the Gini coefficients adjusts for shifts in the social welfare function due to inequality's instrumental and intrinsic effects on human well-being.

## IHDI Results

Among the 46 countries in the sample, Norway ranks first by the IHDI and Guatemala ranks last (Appendix Table B reports IHDI, with comparisons to HDI and Hicks' $HDI^{B*}$, for all 46 countries). The inequality adjustments in IHDI yield significant differences from HDI in terms of countries' rankings (for examples, see Table 4).

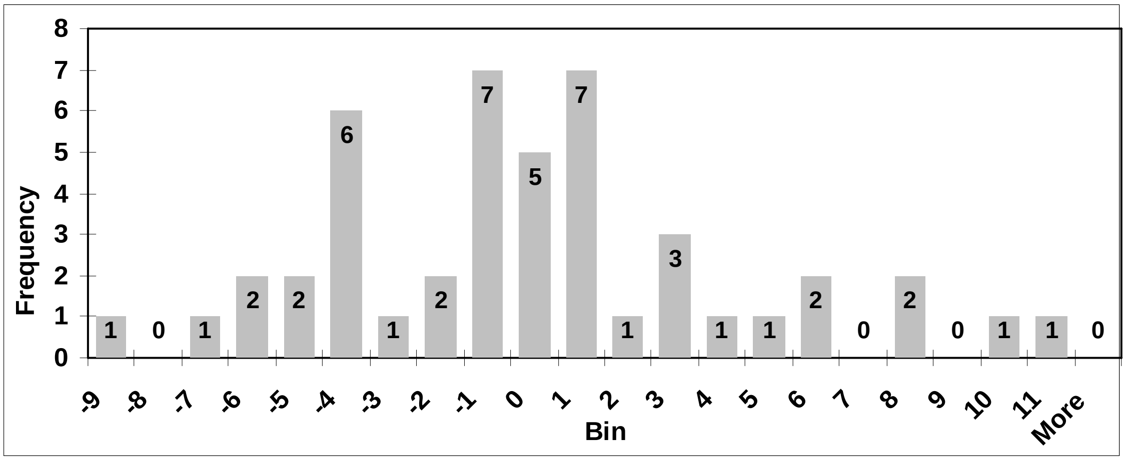
**Table 4: IHDI Results with comparisons to HDI (2003), selected countries**

| Country | IHDI | IHDI rank | HDI | HDI rank | HDI rank less IHDI rank |
|---|---|---|---|---|---|
| Norway | 0.682 | 1 | 0.963 | 1 | 0 |
| Korea | 0.568 | 12 | 0.901 | 23 | 11 |
| Brazil | 0.229 | 43 | 0.792 | 37 | -6 |
| Guatemala | 0.098 | 46 | 0.663 | 45 | -1 |

*Source: Author's calculations using data from the current study.*

Figure 6 presents a histogram of all rank changes from HDI to IHDI; five countries kept the same rank, 22 had worse ranks by IHDI, and the remaining 19 had better ranks. The average (absolute value) change in rank was 3.3, which is quite large considering that these are rank changes among only 46 countries.

**Figure 6: Histogram of Rank Changes, HDI Rank minus IHDR Rank (2003)**




## Conclusions

The Inequality-adjusted Human Development Index (IHDI) incorporates several new elements that make HDI more sensitive to inequality. First, social welfare functions with respect to health, education, and income are modeled as the average of the natural logs of these variables, as opposed to the average of the variables or (in the case of income) the natural log of the average. This method captures the aggregation effects of inequality. Moving from binary classifications for literacy and school enrollment to the continuous variable of educational attainment makes it easier to identify inequality in education.

Second, IHDI introduces the possibility of varying the weights on individuals in calculating social welfare, via a parameter adjustment to reflect the degree of emphasis on equality. The higher the parameter α, the greater the weight placed on the well-being of the least well-off. This option is important for two reasons:

- The relationship between the component variables (health, education, and income) and individual welfare may be even more concave than the logarithmic transformation specifies. Does an extra $100 for someone with an annual income of $100 really make the same contribution to social welfare as extra $1 million to someone with an annual income of $1 million? Assigning values of 1 or higher to α would (in effect) increase the degree of concavity in individual welfare functions.

- If inequality is indeed considered bad for social welfare, then a social planner attempting to maximize social welfare would choose higher values for α with the goal of prioritizing increases to the well-being of the least well-off and reducing inequality.

Third, Gini coefficients are used to adjust the resulting composite indices – in a way that maintains balance among the components – to take into account further instrumental and intrinsic costs of inequality beyond the aggregation effect.

GDP per capita and HDI are commonly used as measures of social welfare to indicate which countries' policies have been the most effective in providing the best quality of life. When social welfare is measured without reference to inequality, these rankings incorporate conceptual flaws. HDI thus ranks some countries, like Korea, too unfavorably, and others, like Brazil, too favorably.

By the same token, when distributional inequalities are omitted from HDI, progress in improving social welfare may be overlooked – as may certain kinds of deterioration of social welfare. IHDI can both provide a better ranking of countries at any given time and better illuminate changes in social welfare overtime. While the data necessary to calculate IHDI are not yet available for the full set of countries covered in the *HDR*s, this essay provides a roadmap to a more robust measure of social welfare for use in international and inter-temporal comparisons.

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## Appendix A: Data

The distributional data for health, education, and income used in this study are described an analyzed below.

*Health*

The health data come from the World Health Organization's Mortality Database, "Table 1: Number of registered deaths, by cause, sex, and age." These data provide the number of deaths in a given year for each of ten age groups and the total number of individuals in each group: (1) under 1 year; (2) 1 to 4 years; (3) 5 to 14 years; (4) 15 to 24 years; (5) 25 to 34 years; (6) 35 to 44 years; (7) 45 to 54 years; (8) 55 to 64 years; (9) 65 to 74 years; and (10) 75 years or more. The ratio of the number of deaths in a given year to the total number of individuals is the death rate for each group. In order to have distributional data for health outcomes for a large set of countries it is necessary to use data for the years 1996 to 2003; for each country, I use only data for the most recent year available.

In order to calculate the distribution of life-years in each country, I created a simple computer model of a cohort of 100,000 people all born in the same year. The death rate for the under 1 year-olds was applied to this cohort to determine the number of deaths in the first year; the second round begins with a cohort size equal to 100,000 less those who died in the first year. On average, for all 81 countries for which data are available, approximately 1 percent of the cohort died before reaching their first birthday, but this ranges from 0.2 percent in Singapore to 4 percent in Mongolia.

This same procedure was repeated for each of 99 years (using the death rates from the corresponding age group), and in the 100$^{th}$ year all of the remaining members of the cohort were assumed to die. The number of life-years for each individual is the age to which they live (for those who die before reaching age one, this is assumed to be 0.5 years); the number of life-years for each of the 101 groups created by the computer model is the age to which that group lives multiplied by the number of individuals in that group. The total number of life years for an entire country is the sum of the 101 groups' life years.[27]

The Gini coefficient for health was calculated using each group's cumulative share of the population and each group's cumulative share of total life years. Among the sample of 46 countries, Sweden had the lowest Health Gini, 0.096, indicating the most equal distribution of lifespans; Guatemala had the highest, 0.174, indicating the least equal distribution; and Croatia (along with Slovenia) has the median Health Gini, 0.112. Figure A1 below is a scatterplot of Health Ginis versus average life expectancies. Figure A2, shows Lorenz curves for Sweden, Guatemala, and Croatia. Years of data, death rates, and Health Ginis for all 46 countries are reported in Table A1.

[27] For the purposes of this paper, I relied only on the World Health Organization's age specific mortality data, but in principle it would be possible to construct data for most countries using census data on birthrates and the age structure of the population, making these data available for a larger set of countries.

*Education*

In calculating IHDI, the binary classifications used to measure education in HDI (literacy and school enrollment) are replaced with a continuous variable, educational attainment measured as years of schooling.[28] The data for education come from two sources. The percentage of the population in each country that has reached a given level of education (but no higher), and the average years of schooling come from the World Bank, EdStats, Thematic Data, "Education Attainment in the Adult Population" (also called the Barro-Lee Data Set) for 2000. This source reports seven levels of achievement: (1) no schooling; (2) some primary school; (3) completed primary school; (4) some secondary school; (5) completed secondary school; (6) some tertiary school; and (7) completed tertiary school. Data on the duration of primary and secondary school come from the World Bank, EdStats, Global Country Data, "Duration of Education Primary and Secondary" for 2000.

These data provide the share of each country's population in the seven groups described above and the average number of years of schooling for three of the groups – no schooling, completed primary, and completed secondary. In order to estimate the average number of years of schooling by country for the four remaining groups, the following assumptions were made:

1) The duration of tertiary school is four years in every country.

2) The average years of schooling for each country is equal to the sum of the average years of schooling in each of its seven groups weighted by that group's share of the population.

3) Since the duration of schooling for those students who began but did not complete the primary, secondary, or tertiary levels is unknown, I assume that, within each country, the ratio of "some" years of schooling to "completed" years of schooling is equal for the primary, secondary, and tertiary levels, and thus solve for a single ratio of "some" to "completed" for each country.[29]

The Gini coefficient for education was calculated using the cumulative share of each country's population in each of seven groups and the cumulative share of each group's total years of schooling. Among the 46 countries in the sample, Norway had the lowest Education Gini, 0.115, indicating the most equal distribution of schooling; Guatemala had the highest, 0.527, indicating the least equal distribution; and France (together with Uruguay) has the median Education Gini, 0.271. Figure A3 is a scatterplot of Education Ginis versus average years of schooling. Figure A4 shows Lorenz curves for Norway, Guatemala, and France. Cumulative shares of the population,

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[28] By dropping literacy, IHDI misses adult literacy programs and other forms of informal education. If this loss of information were perceived as a serious limitation it would be possible to develop survey methodology to produce data on educational attainment regardless of formal or informal schooling.

[29] For four countries – Bulgaria, Hungary, India, and Russia – the ratio described above was greater than one, indicating that the reported average years of schooling for those four countries was not a weighted mean of average years of schooling for that group, that is, that some error occurred in the World Banks' reporting of these data. Only increasing the assumed duration of tertiary school to ten to 14 years made the value of "some" equal to or less than "completed" in these countries. For these four countries the ratio of "some" to "completed" was instead assumed to be the average ratio for the other 106 countries, 0.71.

cumulative total years of schooling, and Education Ginis for all 46 countries are presented in Table A2.

*Income*

The income data come from the World Bank's World Development Indicators 2006, "Table 2.8: Distribution of income or consumption." These data provide the share of income in a given year for each of seven groups ranked by income, starting from the decile with the least income; the percentiles in each group are: (1) 0 to 10; (2) 10 to 20; (3) 20 to 40; (4) 40 to 60; (5) 60 to 80; (6) 80 to 90; and (7) 90 to 100. In order to have distributional data for income shares for a large set of countries it was necessary to use data for 1994 to 2003; for each country, again only the data for the most recent year available were used.[30]

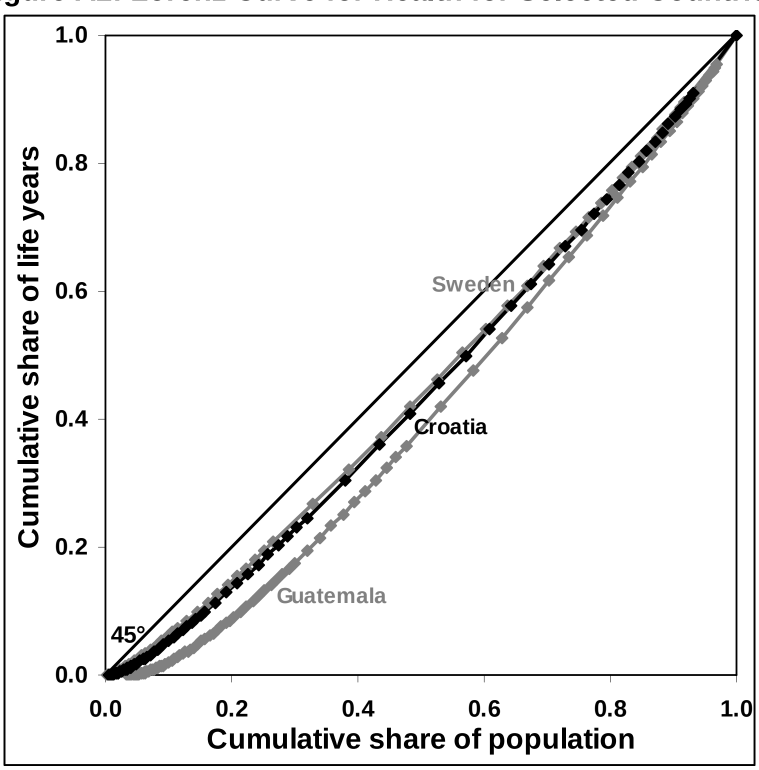
Among the 46 countries in the sample, Czech Republic had the lowest Income Gini, 0.244, indicating the most equal distribution of income; (once again) Guatemala had the highest, 0.572, indicating the least equal distribution; and Israel (together with Ireland) had the median Income Gini, 0.341. Figure A5 below is a scatterplot of Income Ginis versus PPP-adjusted GDP per capita. Figure A6 presents Lorenz curves for Czech Republic, Guatemala, and Israel. Years of data, cumulative shares of the population, cumulative shares of income, and Income Ginis for all 46 countries can be found in Table A3.

[30] The individual values of income used to calculate IHDI combine this information with purchasing-power-parity (PPP) adjusted GDP per capita for 2003 from HDI 2005.

**Figure A1: Health Gini Coefficient versus Life Expectancy**

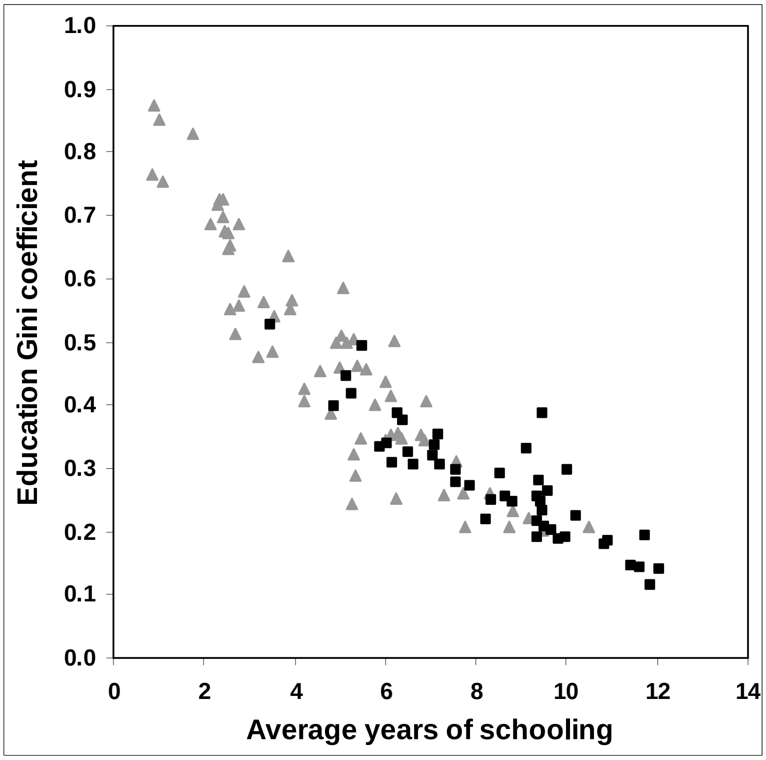

*Note: Black squares indicate one of the 46 coinciding countries; gray triangles indicates one of the countries not in that sample.*

**Figure A2: Lorenz Curve for Health for Selected Countries**



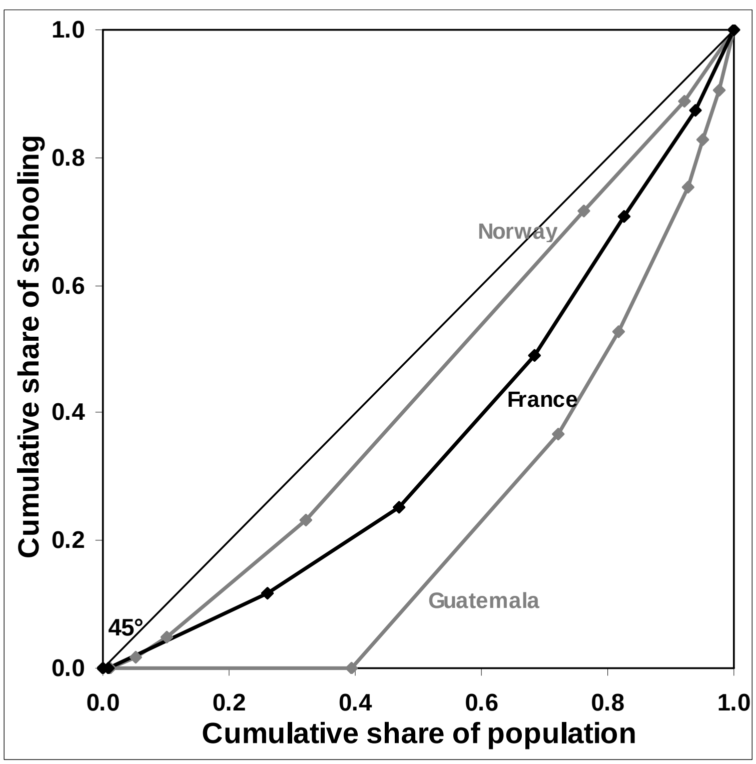
*Source: Author's calculations using data from the current study.*

**Figure A3: Education Gini Coefficient versus Average Years of Schooling (2000)**



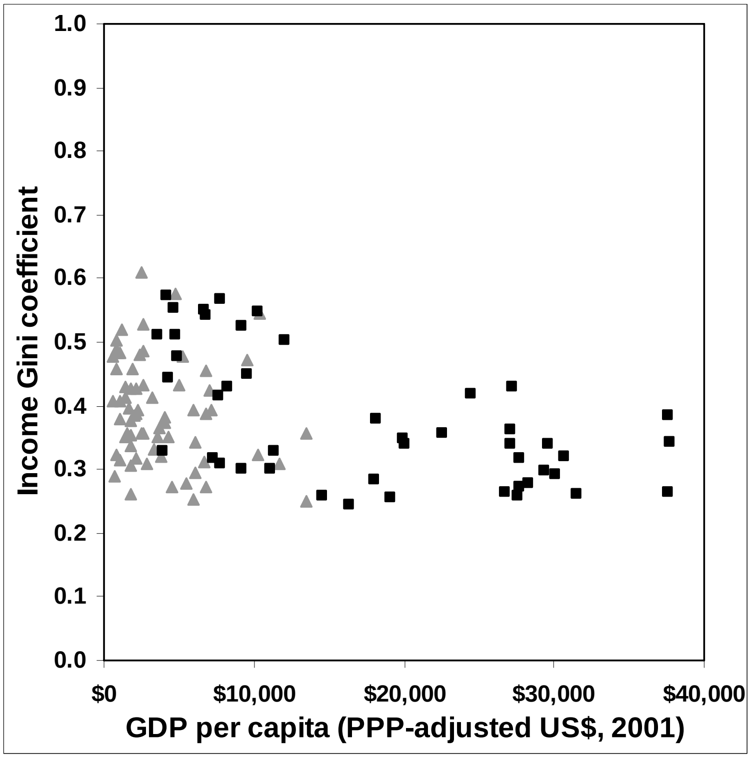

*Note: Black squares indicate one of the 46 coinciding countries; gray triangles indicates one of the countries not in that sample.*

**Figure A4: Lorenz Curves for Education for Selected Countries (2000)**



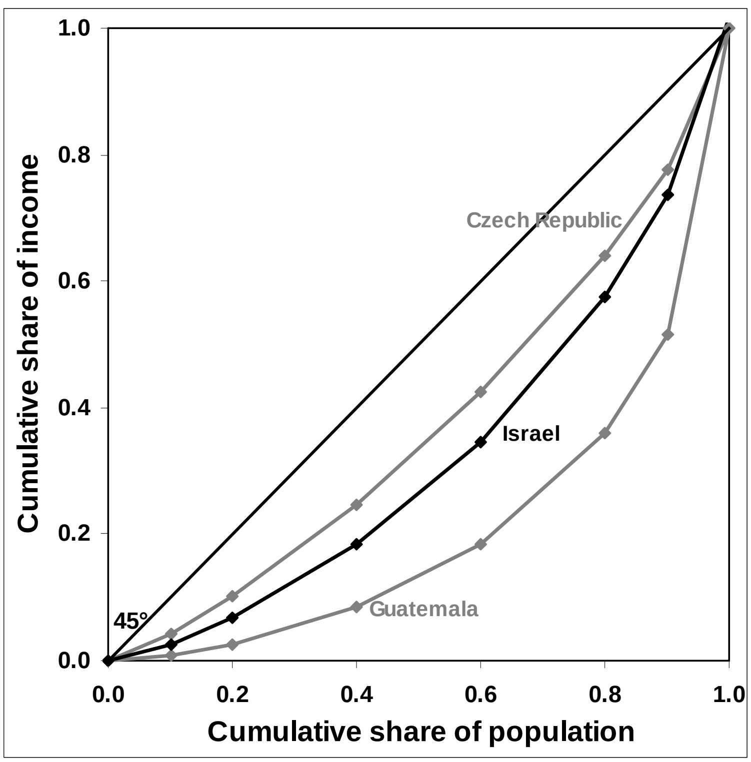
*Source: Author's calculations using data from the current study.*

**Figure A5: Income Gini Coefficient versus GDP per capita**




*Note: Black squares indicate one of the 46 coinciding countries; gray triangles indicates one of the countries not in that sample.*

**Figure A6: Lorenz Curves for Income for Selected Countries**



*Source: Author's calculations using data from the current study.*

## Table A1: Distributional Data for Life Years

| | | | Group death rate | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Country | Data year | | Under 1 | 1 to 4 | 5 to 14 | 15 to 24 | 25 to 34 | 35 to 44 | 45 to 54 | 55 to 64 | 65 to 74 | 75+ | | Health Gini coefficient |
| Argentina | 2001 | | 0.016 | 0.001 | 0.000 | 0.001 | 0.001 | 0.002 | 0.005 | 0.012 | 0.027 | 0.090 | | 0.128 |
| Australia | 2001 | | 0.005 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.002 | 0.006 | 0.018 | 0.070 | | 0.104 |
| Austria | 2002 | | 0.004 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.004 | 0.008 | 0.020 | 0.081 | | 0.104 |
| Belgium | 1997 | | 0.006 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.004 | 0.009 | 0.023 | 0.092 | | 0.107 |
| Brazil | 2000 | | 0.019 | 0.001 | 0.000 | 0.001 | 0.002 | 0.003 | 0.006 | 0.013 | 0.029 | 0.094 | | 0.142 |
| Bulgaria | 2002 | | 0.013 | 0.001 | 0.000 | 0.001 | 0.001 | 0.003 | 0.007 | 0.015 | 0.035 | 0.111 | | 0.124 |
| Canada | 2000 | | 0.005 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.003 | 0.008 | 0.020 | 0.073 | | 0.105 |
| Chile | 2001 | | 0.008 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.004 | 0.010 | 0.025 | 0.083 | | 0.115 |
| Colombia | 1999 | | 0.016 | 0.001 | 0.000 | 0.002 | 0.002 | 0.003 | 0.004 | 0.010 | 0.025 | 0.069 | | 0.145 |
| Costa Rica | 2002 | | 0.010 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.003 | 0.008 | 0.019 | 0.067 | | 0.118 |
| Croatia | 2002 | | 0.007 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.005 | 0.012 | 0.031 | 0.098 | | 0.112 |
| Czech Republic | 2002 | | 0.004 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.005 | 0.012 | 0.029 | 0.097 | | 0.108 |
| Denmark | 1999 | | 0.004 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.004 | 0.011 | 0.029 | 0.091 | | 0.108 |
| Ecuador | 2000 | | 0.019 | 0.002 | 0.001 | 0.001 | 0.002 | 0.003 | 0.005 | 0.009 | 0.021 | 0.084 | | 0.141 |
| Egypt | 2000 | | 0.026 | 0.002 | 0.001 | 0.001 | 0.001 | 0.002 | 0.007 | 0.017 | 0.039 | 0.109 | | 0.144 |
| El Salvador | 1999 | | 0.011 | 0.001 | 0.000 | 0.002 | 0.002 | 0.004 | 0.006 | 0.011 | 0.022 | 0.080 | | 0.143 |
| Finland | 2002 | | 0.003 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.004 | 0.008 | 0.020 | 0.084 | | 0.105 |
| France | 2000 | | 0.005 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.004 | 0.008 | 0.018 | 0.076 | | 0.110 |
| Germany | 2001 | | 0.004 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.004 | 0.009 | 0.021 | 0.082 | | 0.104 |
| Greece | 2001 | | 0.005 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.003 | 0.007 | 0.019 | 0.081 | | 0.103 |
| Guatemala | 1999 | | 0.034 | 0.004 | 0.001 | 0.002 | 0.003 | 0.005 | 0.008 | 0.013 | 0.029 | 0.107 | | 0.174 |
| Hong Kong | 2000 | | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.007 | 0.019 | 0.062 | | 0.100 |
| Hungary | 2002 | | 0.007 | 0.000 | 0.000 | 0.001 | 0.001 | 0.003 | 0.009 | 0.016 | 0.034 | 0.098 | | 0.126 |
| Ireland | 2001 | | 0.006 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.003 | 0.008 | 0.025 | 0.094 | | 0.104 |
| Israel | 1999 | | 0.006 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.003 | 0.008 | 0.022 | 0.083 | | 0.103 |
| Italy | 2001 | | 0.005 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.003 | 0.007 | 0.018 | 0.075 | | 0.102 |
| Korea | 2002 | | 0.005 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.004 | 0.009 | 0.023 | 0.086 | | 0.108 |
| Mexico | 2001 | | 0.016 | 0.001 | 0.000 | 0.001 | 0.001 | 0.002 | 0.005 | 0.011 | 0.025 | 0.080 | | 0.133 |
| Netherlands | 2003 | | 0.005 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.003 | 0.008 | 0.021 | 0.088 | | 0.099 |
| New Zealand | 2000 | | 0.006 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.003 | 0.008 | 0.021 | 0.075 | | 0.110 |
| Norway | 2001 | | 0.004 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.003 | 0.007 | 0.020 | 0.086 | | 0.100 |
| Panama | 2000 | | 0.016 | 0.001 | 0.000 | 0.001 | 0.001 | 0.002 | 0.003 | 0.008 | 0.018 | 0.069 | | 0.130 |
| Paraguay | 2000 | | 0.011 | 0.001 | 0.000 | 0.001 | 0.001 | 0.002 | 0.004 | 0.010 | 0.025 | 0.094 | | 0.117 |
| Philippines | 1998 | | 0.014 | 0.002 | 0.001 | 0.001 | 0.002 | 0.004 | 0.007 | 0.015 | 0.033 | 0.120 | | 0.138 |
| Poland | 2002 | | 0.007 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.006 | 0.013 | 0.029 | 0.089 | | 0.121 |
| Portugal | 2002 | | 0.005 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.004 | 0.008 | 0.021 | 0.088 | | 0.111 |
| Romania | 2002 | | 0.017 | 0.001 | 0.000 | 0.001 | 0.001 | 0.003 | 0.008 | 0.017 | 0.036 | 0.109 | | 0.135 |
| Russia | 2002 | | 0.014 | 0.001 | 0.000 | 0.002 | 0.004 | 0.008 | 0.014 | 0.027 | 0.048 | 0.111 | | 0.167 |
| Singapore | 2001 | | 0.002 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.003 | 0.008 | 0.022 | 0.072 | | 0.102 |
| Slovenia | 2002 | | 0.004 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.005 | 0.011 | 0.025 | 0.083 | | 0.112 |
| Sweden | 2001 | | 0.004 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.003 | 0.007 | 0.019 | 0.084 | | 0.096 |
| Thailand | 2000 | | 0.005 | 0.001 | 0.001 | 0.002 | 0.004 | 0.005 | 0.006 | 0.013 | 0.028 | 0.097 | | 0.145 |
| United Kingdom | 2002 | | 0.005 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.003 | 0.008 | 0.022 | 0.088 | | 0.103 |
| Uruguay | 2000 | | 0.013 | 0.001 | 0.000 | 0.001 | 0.001 | 0.002 | 0.005 | 0.012 | 0.026 | 0.085 | | 0.126 |
| USA | 2000 | | 0.007 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.004 | 0.010 | 0.024 | 0.082 | | 0.117 |
| Venezuela | 2000 | | 0.017 | 0.001 | 0.000 | 0.002 | 0.002 | 0.003 | 0.005 | 0.010 | 0.024 | 0.078 | | 0.142 |

## Table A2: Distributional Data for Years of Schooling (2000)

| | Cumulative Pop Share | | | | | | | Cumulative share of value | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Country | No schooling | Some primary | Complete primary | Some secondary | Complete secondary | Some tertiary | Complete tertiary | No schooling | Some primary | Complete primary | Some secondary | Complete secondary | Some tertiary | Complete tertiary | Education Gini coefficient |
| Argentina | 0.04 | 0.21 | 0.49 | 0.70 | 0.80 | 0.92 | 1.00 | 0.00 | 0.10 | 0.29 | 0.53 | 0.67 | 0.86 | 1.00 | 0.248 |
| Australia | 0.02 | 0.10 | 0.20 | 0.50 | 0.68 | 0.85 | 1.00 | 0.00 | 0.04 | 0.10 | 0.36 | 0.57 | 0.76 | 1.00 | 0.184 |
| Austria | 0.03 | 0.14 | 0.28 | 0.64 | 0.85 | 0.95 | 1.00 | 0.00 | 0.04 | 0.11 | 0.47 | 0.77 | 0.90 | 1.00 | 0.249 |
| Belgium | 0.06 | 0.24 | 0.41 | 0.68 | 0.79 | 0.87 | 1.00 | 0.00 | 0.11 | 0.21 | 0.52 | 0.66 | 0.78 | 1.00 | 0.256 |
| Brazil | 0.16 | 0.66 | 0.78 | 0.88 | 0.93 | 0.96 | 1.00 | 0.00 | 0.37 | 0.47 | 0.68 | 0.78 | 0.89 | 1.00 | 0.397 |
| Bulgaria | 0.06 | 0.17 | 0.44 | 0.69 | 0.82 | 0.88 | 1.00 | 0.00 | 0.04 | 0.17 | 0.41 | 0.58 | 0.68 | 1.00 | 0.385 |
| Canada | 0.01 | 0.05 | 0.16 | 0.33 | 0.46 | 0.90 | 1.00 | 0.00 | 0.02 | 0.07 | 0.22 | 0.35 | 0.86 | 1.00 | 0.144 |
| Chile | 0.07 | 0.42 | 0.51 | 0.74 | 0.86 | 0.93 | 1.00 | 0.00 | 0.20 | 0.28 | 0.55 | 0.73 | 0.85 | 1.00 | 0.297 |
| Colombia | 0.20 | 0.54 | 0.63 | 0.82 | 0.90 | 0.96 | 1.00 | 0.00 | 0.22 | 0.31 | 0.60 | 0.77 | 0.87 | 1.00 | 0.418 |
| Costa Rica | 0.10 | 0.54 | 0.66 | 0.78 | 0.82 | 0.91 | 1.00 | 0.00 | 0.29 | 0.42 | 0.55 | 0.63 | 0.79 | 1.00 | 0.339 |
| Croatia | 0.11 | 0.36 | 0.51 | 0.77 | 0.91 | 0.94 | 1.00 | 0.00 | 0.10 | 0.20 | 0.53 | 0.79 | 0.85 | 1.00 | 0.387 |
| Czech Republic | 0.02 | 0.20 | 0.30 | 0.69 | 0.90 | 0.93 | 1.00 | 0.00 | 0.07 | 0.13 | 0.55 | 0.83 | 0.88 | 1.00 | 0.233 |
| Denmark | 0.00 | 0.16 | 0.36 | 0.44 | 0.81 | 0.92 | 1.00 | 0.00 | 0.07 | 0.20 | 0.27 | 0.74 | 0.86 | 1.00 | 0.201 |
| Ecuador | 0.15 | 0.48 | 0.61 | 0.78 | 0.85 | 0.92 | 1.00 | 0.00 | 0.21 | 0.33 | 0.55 | 0.68 | 0.81 | 1.00 | 0.375 |
| Egypt | 0.36 | 0.50 | 0.57 | 0.80 | 0.91 | 0.96 | 1.00 | 0.00 | 0.10 | 0.17 | 0.56 | 0.77 | 0.88 | 1.00 | 0.492 |
| El Salvador | 0.28 | 0.66 | 0.77 | 0.88 | 0.90 | 0.96 | 1.00 | 0.00 | 0.35 | 0.48 | 0.69 | 0.73 | 0.89 | 1.00 | 0.447 |
| Finland | 0.00 | 0.14 | 0.30 | 0.44 | 0.78 | 0.91 | 1.00 | 0.00 | 0.06 | 0.16 | 0.28 | 0.69 | 0.86 | 1.00 | 0.190 |
| France | 0.01 | 0.26 | 0.47 | 0.68 | 0.83 | 0.94 | 1.00 | 0.00 | 0.12 | 0.25 | 0.49 | 0.71 | 0.87 | 1.00 | 0.271 |
| Germany | 0.04 | 0.13 | 0.23 | 0.60 | 0.84 | 0.92 | 1.00 | 0.00 | 0.03 | 0.07 | 0.46 | 0.76 | 0.87 | 1.00 | 0.223 |
| Greece | 0.05 | 0.15 | 0.47 | 0.60 | 0.86 | 0.91 | 1.00 | 0.00 | 0.05 | 0.27 | 0.40 | 0.77 | 0.83 | 1.00 | 0.254 |
| Guatemala | 0.40 | 0.72 | 0.82 | 0.93 | 0.95 | 0.98 | 1.00 | 0.00 | 0.37 | 0.53 | 0.75 | 0.83 | 0.91 | 1.00 | 0.527 |
| Hong Kong | 0.11 | 0.23 | 0.37 | 0.56 | 0.87 | 0.94 | 1.00 | 0.00 | 0.06 | 0.15 | 0.35 | 0.79 | 0.89 | 1.00 | 0.279 |
| Hungary | 0.02 | 0.27 | 0.46 | 0.75 | 0.88 | 0.90 | 1.00 | 0.00 | 0.10 | 0.20 | 0.53 | 0.75 | 0.78 | 1.00 | 0.332 |
| Ireland | 0.04 | 0.14 | 0.28 | 0.62 | 0.79 | 0.92 | 1.00 | 0.00 | 0.06 | 0.17 | 0.47 | 0.71 | 0.85 | 1.00 | 0.192 |
| Israel | 0.11 | 0.24 | 0.31 | 0.57 | 0.73 | 0.90 | 1.00 | 0.00 | 0.07 | 0.11 | 0.39 | 0.59 | 0.83 | 1.00 | 0.264 |
| Italy | 0.12 | 0.31 | 0.47 | 0.74 | 0.86 | 0.95 | 1.00 | 0.00 | 0.09 | 0.20 | 0.52 | 0.74 | 0.88 | 1.00 | 0.352 |
| Korea | 0.07 | 0.07 | 0.18 | 0.32 | 0.74 | 0.88 | 1.00 | 0.00 | 0.00 | 0.07 | 0.19 | 0.65 | 0.82 | 1.00 | 0.180 |
| Mexico | 0.10 | 0.34 | 0.52 | 0.74 | 0.89 | 0.96 | 1.00 | 0.00 | 0.14 | 0.29 | 0.54 | 0.81 | 0.90 | 1.00 | 0.304 |
| Netherlands | 0.04 | 0.15 | 0.29 | 0.65 | 0.78 | 0.91 | 1.00 | 0.00 | 0.06 | 0.15 | 0.51 | 0.68 | 0.84 | 1.00 | 0.215 |
| New Zealand | 0.00 | 0.13 | 0.28 | 0.47 | 0.59 | 0.86 | 1.00 | 0.00 | 0.06 | 0.14 | 0.32 | 0.45 | 0.80 | 1.00 | 0.195 |
| Norway | 0.01 | 0.05 | 0.10 | 0.32 | 0.76 | 0.92 | 1.00 | 0.00 | 0.02 | 0.05 | 0.23 | 0.72 | 0.89 | 1.00 | 0.115 |
| Panama | 0.09 | 0.27 | 0.45 | 0.61 | 0.81 | 0.90 | 1.00 | 0.00 | 0.10 | 0.23 | 0.40 | 0.68 | 0.81 | 1.00 | 0.292 |
| Paraguay | 0.06 | 0.48 | 0.68 | 0.81 | 0.92 | 0.96 | 1.00 | 0.00 | 0.26 | 0.45 | 0.60 | 0.83 | 0.88 | 1.00 | 0.309 |
| Philippines | 0.03 | 0.20 | 0.36 | 0.54 | 0.77 | 0.88 | 1.00 | 0.00 | 0.09 | 0.21 | 0.38 | 0.65 | 0.80 | 1.00 | 0.219 |
| Poland | 0.02 | 0.06 | 0.36 | 0.72 | 0.90 | 0.94 | 1.00 | 0.00 | 0.03 | 0.21 | 0.62 | 0.84 | 0.90 | 1.00 | 0.186 |
| Portugal | 0.12 | 0.38 | 0.61 | 0.78 | 0.86 | 0.96 | 1.00 | 0.00 | 0.15 | 0.38 | 0.57 | 0.74 | 0.89 | 1.00 | 0.332 |
| Romania | 0.04 | 0.17 | 0.25 | 0.69 | 0.93 | 0.95 | 1.00 | 0.00 | 0.05 | 0.08 | 0.58 | 0.88 | 0.92 | 1.00 | 0.206 |
| Russia | 0.01 | 0.12 | 0.33 | 0.66 | 0.84 | 0.89 | 1.00 | 0.00 | 0.03 | 0.12 | 0.46 | 0.70 | 0.77 | 1.00 | 0.296 |
| Singapore | 0.16 | 0.32 | 0.55 | 0.80 | 0.90 | 0.96 | 1.00 | 0.00 | 0.12 | 0.31 | 0.65 | 0.80 | 0.92 | 1.00 | 0.319 |
| Slovenia | 0.02 | 0.29 | 0.45 | 0.73 | 0.87 | 0.91 | 1.00 | 0.00 | 0.10 | 0.19 | 0.50 | 0.74 | 0.81 | 1.00 | 0.335 |
| Sweden | 0.02 | 0.10 | 0.17 | 0.34 | 0.78 | 0.89 | 1.00 | 0.00 | 0.04 | 0.07 | 0.24 | 0.71 | 0.85 | 1.00 | 0.146 |
| Thailand | 0.13 | 0.47 | 0.74 | 0.85 | 0.89 | 0.93 | 1.00 | 0.00 | 0.26 | 0.51 | 0.67 | 0.75 | 0.83 | 1.00 | 0.326 |
| United Kingdom | 0.03 | 0.22 | 0.39 | 0.69 | 0.80 | 0.91 | 1.00 | 0.00 | 0.10 | 0.20 | 0.54 | 0.69 | 0.84 | 1.00 | 0.246 |
| Uruguay | 0.05 | 0.39 | 0.50 | 0.77 | 0.85 | 0.93 | 1.00 | 0.00 | 0.20 | 0.28 | 0.60 | 0.73 | 0.85 | 1.00 | 0.278 |
| USA | 0.01 | 0.05 | 0.09 | 0.32 | 0.52 | 0.76 | 1.00 | 0.00 | 0.02 | 0.04 | 0.22 | 0.42 | 0.67 | 1.00 | 0.141 |
| Venezuela | 0.10 | 0.44 | 0.54 | 0.76 | 0.86 | 0.95 | 1.00 | 0.00 | 0.22 | 0.31 | 0.57 | 0.74 | 0.88 | 1.00 | 0.305 |

## Table A3: Distributional Data for Income

| | | | Cumulative share of pop | | | | | | | | Cumulative shares of income | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Country | Data year | | 0-10 | 10-20 | 20-40 | 40-60 | 60-80 | 80-90 | 90-100 | | 0-10 | 10-20 | 20-40 | 40-60 | 60-80 | 80-90 | 90-100 | | | Income Gini coefficient |
| Argentina | 2001 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.01 | 0.03 | 0.10 | 0.23 | 0.44 | 0.61 | 1.00 | | | 0.504 |
| Australia | 1994 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.02 | 0.06 | 0.18 | 0.35 | 0.59 | 0.75 | 1.00 | | | 0.341 |
| Austria | 1997 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.03 | 0.08 | 0.21 | 0.39 | 0.62 | 0.77 | 1.00 | | | 0.292 |
| Belgium | 1998 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.03 | 0.08 | 0.22 | 0.40 | 0.63 | 0.77 | 1.00 | | | 0.277 |
| Brazil | 2001 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.01 | 0.02 | 0.08 | 0.19 | 0.37 | 0.53 | 1.00 | | | 0.567 |
| Bulgaria | 2001 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.02 | 0.07 | 0.20 | 0.38 | 0.61 | 0.76 | 1.00 | | | 0.309 |
| Canada | 1998 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.02 | 0.07 | 0.20 | 0.37 | 0.60 | 0.75 | 1.00 | | | 0.320 |
| Chile | 2000 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.01 | 0.03 | 0.10 | 0.20 | 0.38 | 0.53 | 1.00 | | | 0.547 |
| Colombia | 1999 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.01 | 0.03 | 0.09 | 0.20 | 0.38 | 0.54 | 1.00 | | | 0.551 |
| Costa Rica | 2000 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.01 | 0.04 | 0.13 | 0.27 | 0.49 | 0.65 | 1.00 | | | 0.449 |
| Croatia | 2001 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.03 | 0.08 | 0.21 | 0.38 | 0.60 | 0.76 | 1.00 | | | 0.301 |
| Czech Republic | 1996 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.04 | 0.10 | 0.25 | 0.42 | 0.64 | 0.78 | 1.00 | | | 0.244 |
| Denmark | 1997 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.03 | 0.08 | 0.23 | 0.41 | 0.64 | 0.79 | 1.00 | | | 0.262 |
| Ecuador | 1998 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.01 | 0.03 | 0.11 | 0.23 | 0.42 | 0.58 | 1.00 | | | 0.512 |
| Egypt | 2000 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.04 | 0.09 | 0.21 | 0.36 | 0.56 | 0.70 | 1.00 | | | 0.330 |
| El Salvador | 2000 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.01 | 0.03 | 0.10 | 0.23 | 0.43 | 0.59 | 1.00 | | | 0.511 |
| Finland | 2000 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.04 | 0.10 | 0.24 | 0.41 | 0.63 | 0.77 | 1.00 | | | 0.259 |
| France | 1995 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.03 | 0.07 | 0.20 | 0.37 | 0.60 | 0.75 | 1.00 | | | 0.317 |
| Germany | 2000 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.03 | 0.09 | 0.22 | 0.40 | 0.63 | 0.78 | 1.00 | | | 0.274 |
| Greece | 1998 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.03 | 0.07 | 0.19 | 0.34 | 0.56 | 0.72 | 1.00 | | | 0.350 |
| Guatemala | 2000 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.01 | 0.03 | 0.09 | 0.18 | 0.36 | 0.52 | 1.00 | | | 0.572 |
| Hong Kong | 1996 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.02 | 0.05 | 0.15 | 0.29 | 0.49 | 0.65 | 1.00 | | | 0.430 |
| Hungary | 2002 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.04 | 0.10 | 0.23 | 0.41 | 0.63 | 0.78 | 1.00 | | | 0.259 |
| Ireland | 1996 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.03 | 0.07 | 0.19 | 0.35 | 0.57 | 0.72 | 1.00 | | | 0.344 |
| Israel | 1997 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.02 | 0.07 | 0.18 | 0.35 | 0.58 | 0.74 | 1.02 | | | 0.341 |
| Italy | 2000 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.02 | 0.06 | 0.18 | 0.35 | 0.58 | 0.73 | 1.00 | | | 0.341 |
| Korea | 1998 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.03 | 0.08 | 0.21 | 0.39 | 0.63 | 0.78 | 1.00 | | | 0.284 |
| Mexico | 2000 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.01 | 0.03 | 0.10 | 0.22 | 0.41 | 0.57 | 1.00 | | | 0.524 |
| Netherlands | 1999 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.02 | 0.08 | 0.21 | 0.38 | 0.61 | 0.77 | 1.00 | | | 0.299 |
| New Zealand | 1997 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.02 | 0.06 | 0.18 | 0.34 | 0.56 | 0.72 | 1.00 | | | 0.357 |
| Norway | 2000 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.04 | 0.10 | 0.24 | 0.41 | 0.63 | 0.77 | 1.00 | | | 0.265 |
| Panama | 2000 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.01 | 0.02 | 0.09 | 0.20 | 0.40 | 0.57 | 1.00 | | | 0.542 |
| Paraguay | 2002 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.01 | 0.02 | 0.08 | 0.20 | 0.39 | 0.55 | 1.00 | | | 0.554 |
| Philippines | 2000 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.02 | 0.05 | 0.14 | 0.27 | 0.48 | 0.64 | 1.00 | | | 0.443 |
| Poland | 2002 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.03 | 0.08 | 0.20 | 0.36 | 0.58 | 0.73 | 1.00 | | | 0.329 |
| Portugal | 1997 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.02 | 0.06 | 0.17 | 0.32 | 0.54 | 0.70 | 1.00 | | | 0.380 |
| Romania | 2002 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.03 | 0.08 | 0.20 | 0.37 | 0.59 | 0.74 | 1.00 | | | 0.318 |
| Russia | 2002 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.03 | 0.08 | 0.21 | 0.38 | 0.61 | 0.76 | 1.00 | | | 0.300 |
| Singapore | 1998 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.02 | 0.05 | 0.14 | 0.29 | 0.51 | 0.67 | 1.00 | | | 0.420 |
| Slovenia | 1999 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.04 | 0.09 | 0.23 | 0.41 | 0.64 | 0.79 | 1.00 | | | 0.256 |
| Sweden | 2000 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.04 | 0.09 | 0.23 | 0.41 | 0.63 | 0.78 | 1.00 | | | 0.265 |
| Thailand | 2000 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.03 | 0.06 | 0.16 | 0.29 | 0.50 | 0.66 | 1.00 | | | 0.416 |
| United Kingdom | 1999 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.02 | 0.06 | 0.18 | 0.34 | 0.56 | 0.72 | 1.00 | | | 0.362 |
| Uruguay | 2000 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.02 | 0.05 | 0.14 | 0.28 | 0.50 | 0.66 | 1.00 | | | 0.430 |
| USA | 2000 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.02 | 0.05 | 0.16 | 0.32 | 0.54 | 0.70 | 1.00 | | | 0.386 |
| Venezuela | 1998 | | 0.10 | 0.20 | 0.40 | 0.60 | 0.80 | 0.90 | 1.00 | | 0.01 | 0.03 | 0.11 | 0.25 | 0.47 | 0.64 | 1.00 | | | 0.477 |

## Appendix B: Results

**Table B: IHDI Results with comparisons to HDI and Hicks' HDI$^{B*}$ (2003)**

| IHDI rank | Country | IHDI | HDI | Hicks' HDI$^{B*}$ | HDI rank less IHDI rank | HDI rank less HDI$^{B*}$ rank |
|---|---|---|---|---|---|---|
| 1 | Norway | 0.682 | 0.963 | 0.808 | 0 | 0 |
| 2 | Sweden | 0.646 | 0.949 | 0.787 | 1 | 1 |
| 3 | Canada | 0.636 | 0.949 | 0.769 | 1 | 1 |
| 4 | USA | 0.616 | 0.944 | 0.737 | 3 | -4 |
| 5 | Finland | 0.610 | 0.941 | 0.765 | 4 | 5 |
| 6 | Australia | 0.608 | 0.955 | 0.753 | -4 | -4 |
| 7 | Denmark | 0.596 | 0.941 | 0.758 | 3 | 5 |
| 8 | Germany | 0.588 | 0.930 | 0.745 | 8 | 8 |
| 9 | New Zealand | 0.583 | 0.933 | 0.726 | 6 | 1 |
| 10 | Netherlands | 0.580 | 0.943 | 0.749 | -2 | 1 |
| 11 | Ireland | 0.580 | 0.946 | 0.741 | -6 | -4 |
| 12 | Korea | 0.568 | 0.901 | 0.731 | 11 | 10 |
| 13 | Belgium | 0.557 | 0.945 | 0.740 | -7 | -4 |
| 14 | Austria | 0.556 | 0.936 | 0.733 | -1 | 1 |
| 15 | United Kingdom | 0.542 | 0.939 | 0.715 | -4 | -5 |
| 16 | Czech Republic | 0.537 | 0.874 | 0.701 | 8 | 7 |
| 17 | France | 0.529 | 0.938 | 0.720 | -5 | -3 |
| 18 | Hong Kong | 0.515 | 0.916 | 0.670 | -1 | -6 |
| 19 | Israel | 0.515 | 0.915 | 0.699 | -1 | 0 |
| 20 | Greece | 0.515 | 0.912 | 0.698 | -1 | 0 |
| 21 | Poland | 0.498 | 0.858 | 0.677 | 6 | 5 |
| 22 | Slovenia | 0.476 | 0.904 | 0.690 | -1 | 1 |
| 23 | Italy | 0.476 | 0.934 | 0.687 | -9 | -7 |
| 24 | Singapore | 0.452 | 0.907 | 0.651 | -4 | -6 |
| 25 | Hungary | 0.436 | 0.862 | 0.652 | 1 | 1 |
| 26 | Romania | 0.419 | 0.792 | 0.621 | 10 | 9 |
| 27 | Portugal | 0.408 | 0.904 | 0.654 | -5 | -2 |
| 28 | Argentina | 0.402 | 0.863 | 0.611 | -3 | -5 |
| 29 | Croatia | 0.381 | 0.841 | 0.614 | 0 | 1 |
| 30 | Uruguay | 0.378 | 0.840 | 0.611 | 0 | 1 |
| 31 | Bulgaria | 0.371 | 0.808 | 0.585 | 2 | -1 |
| 32 | Chile | 0.365 | 0.854 | 0.589 | -4 | -4 |
| 33 | Costa Rica | 0.355 | 0.838 | 0.593 | -2 | 0 |
| 34 | Russian | 0.343 | 0.795 | 0.589 | 1 | 2 |
| 35 | Panama | 0.343 | 0.804 | 0.557 | -1 | -2 |
| 36 | Mexico | 0.335 | 0.814 | 0.556 | -4 | -5 |
| 37 | Philippines | 0.334 | 0.758 | 0.567 | 5 | 7 |
| 38 | Thailand | 0.323 | 0.778 | 0.547 | 1 | 1 |
| 39 | Venezuela | 0.291 | 0.772 | 0.544 | 1 | 1 |
| 40 | Paraguay | 0.281 | 0.755 | 0.520 | 3 | 3 |
| 41 | Ecuador | 0.241 | 0.759 | 0.512 | 0 | 0 |
| 42 | Colombia | 0.238 | 0.785 | 0.497 | -4 | -5 |
| 43 | Brazil | 0.229 | 0.792 | 0.502 | -6 | -5 |
| 44 | El Salvador | 0.215 | 0.722 | 0.463 | 0 | 0 |
| 45 | Egypt | 0.201 | 0.659 | 0.455 | 1 | 1 |
| 46 | Guatemala | 0.098 | 0.663 | 0.385 | -1 | -1 |

*Note: For the purposes of this comparison, HDI was reranked out of just the 46 countries in this sample.*