

The Human Development Index: Suggested Corrections*

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1. Introduction

Since 1990 the United Nations Development Programme (UNDP) has been publishing a *Human Development Index* (HDI). The methodology of its calculation has been modified several times over the years, but the main framework has remained substantially unchanged. In particular:

i) the three factors that go to make up the index – income, life expectancy, and literacy – have not been changed, although the methods of computing these indicators have been adjusted;

ii) there has been no change in the two assumptions implicit in the construction of the index: complete substitutability among the three variables and equal weighting of the three factors.

This paper deals specifically with these two assumptions. The aim is to discover analytical solutions enabling us to remove or at least relax them.¹

Before seeking to develop the analytical solutions, however, let us point to the usefulness, indeed the necessity, of finding a way to remove the assumptions of total substitutability and equal weighting.

Actually, the *Human Development Report* (HDR) itself has repeatedly noted that essentially there is no choice but to accept the

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¹ The paper does not consider the many criticisms of the methods used to compute the indices for the three component variables of the HDI.

substitutability among the three aspects of human development and the use of equal weighting, owing to the difficulty of formulating and constructing an alternative approach. The difficulty stems in particular from the impossibility of positing hypotheses that are free of subjective, *ex ante* choices. The issue is dealt with in the "Technical Notes", a passage of which states that

"Human development cannot take place without human life and health; people do not just want to be alive; they want to know their way around in life. They want to be knowledgeable; and they certainly may want a decent life, one that is not constant worry about sheer physical survival" (UNDP 1991, p. 88).

From this observation, which would appear to postulate not substitutability but complementarity among the three aspects of human development, the *Report* deduces that "All three of the HDI components thus deserve equal weight. And that is why the HDI proposes an unweighted average of a country's rank on the life expectancy, literacy and income scales" (*ibid.*).

To our mind, the *Report* appears to be confusing two distinct problems: that of substitutability, which arises from judging as 'acceptable' any and all values of the HDI emerging from an average; and that of weighting, which is bound up with the type of average one elects to use.² The HDR notes, further, that the utilization of alternative, non-equal weights does not substantially alter the rankings.

In our own view, however, it is unquestionably worthwhile to address the problems raised by the HDI as constructed, whether or

² The 1997 HDR itself confirms the confusion. It presents a new, secondary Human Poverty Index (HPI), whose method of aggregation introduces a parameter α designed to take account of the degree of substitutability among the components. Built according to the same structure as the HDI but with the possibility of differential weighting, the HPI is an index that gauges the degree of a population's deprivation in a number of spheres. In this framework the HDR argues that postulating perfect substitutability among the components is tantamount to judging the various deprivations as of equal gravity. Substitutability would be diminished, it is argued, by assigning a greater weight to the spheres in which the deprivation is greatest, in such a way that solving the problems involved in these aspects of poverty appears more urgent. Technically, within HPI a higher value for the substitutability parameter α assigns a greater weight to the variables whose indicators show greater deprivation. It seems clear to us, however, that this procedure merely introduces a second weighting level, interesting in and of itself, to be sure, but not helpful in resolving the problem of substitutability.

not the country rankings are significantly modified by dropping the two key assumptions and constructing an alternative indicator.³

2. Substitutability

The assumption of full substitutability among the three components of human development is implicit in the fact that the country rankings depend exclusively on the HDI values and that the index is not sensitive to differences in the distribution of the individual component values. It follows that in comparing the ranking of two countries, or of a single country over time, a change in the value of any one component may be offset (in other words, substituted for) by changes in the other two.

The solution suggested here is to devise a corrective mechanism incorporating a gauge of the distribution of the values for the three component aspects of human development.⁴

It may be belaboring the obvious to point out that income, literacy and life expectancy are closely linked and that they are indis-

³ The most radical critiques of the HDI are founded on the high correlation between that index and GDP (see McGillivray 1991 and Islam 1995). At all events, the HDI's critics reiterate the concept that the use of GDP as a measurement of development is partial and biased; notwithstanding the criticisms of the HDI, therefore, it appears to us that the course embarked on by the UNDP is the right one and that any advance in this direction is helpful. The limitation of the advances made lies mainly in the fact that the chosen human development variables "relate to aspects that are largely dependent on economic development; that is, they do not have much capacity to capture qualitative characteristics of social development as distinct from economic and quantitative ones" (Palazzi 1997, p. 144). The right route, then, is to introduce new variables better suited to capturing the 'human' side of development.

⁴ The HDR introduces a secondary index, alongside the HDI: a gender-related development index that considers the issue of different distribution of levels of development between the male and the female population. The HDI is accordingly corrected to reward countries in which there is parity between the sexes in human development and penalize those in which there is disparity. Another version of the HDI, corrected on the basis of income distribution, is also calculated. It is singular, to say the least, that equality between men and women and more equal distribution of income are rightly rewarded as factors of development while no importance at all is attached to the equilibrium between the fundamental determinants of human development.

pensable elements for the proper definition of human development.⁵ The problem is finding some proportion between the three indicators that characterizes a better or higher level of human development than do other proportions. In other words, we postulate that any given average value of the three components may correspond to different levels of human development, and that these may not be all equally acceptable in subjective, social, political or economic terms. We further postulate that there are explicit or potential endogenous forces working to move the values of the single variables towards a more balanced relation.

From the theoretical standpoint the solution depends on introducing a concept of *balanced and sustainable human development* in which the three aspects are not only indispensable but also reciprocally self-reinforcing.⁶

The simplest, most trivial solution is to define as 'balanced' and 'sustainable' a state of human development in which, regardless of absolute level, the three component variables have the same value: a sort of three-legged stool in which balance and sustainability depend on the legs being equal in length.

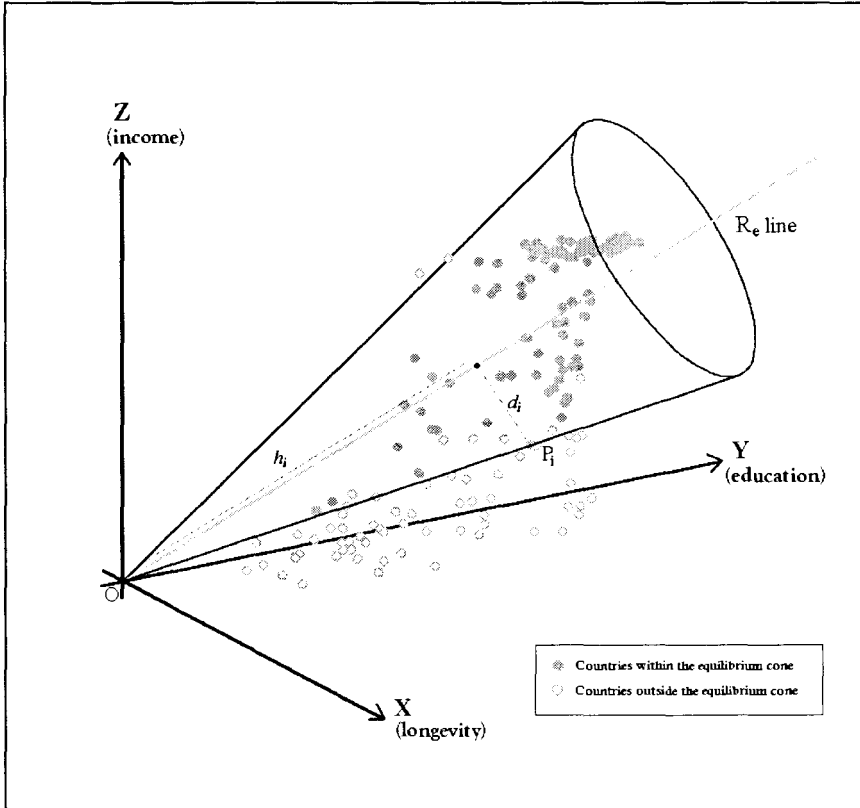
This approach can be represented graphically by a cloud of country points, whose coordinates are the values of the three indicators. Figure 1 gives the values of the three indicators, taken from HDR 1997, on three coordinate axes. In this trivial solution the line R_e starting from the origin and running equidistant from the three axes represents the theoretical values of HDI for perfectly balanced and sustainable development.

⁵ The UNDP defines human development as a "process of enlarging people's choices" (UNDP 1993, p. 104). Consistent with this definition, the programme holds that in evaluating a country's level of development, a crucial consideration is the possibility it offers its people for longevity and good health, for the acquisition of knowledge and for access to the goods and labor markets to obtain the resources needed to enjoy a decent standard of living.

⁶ Both qualifiers, 'balanced' and 'sustainable', appear equally necessary. Balanced development alone is not enough, because balance refers essentially to a static equilibrium, while in the case of development only dynamic equilibrium has any significance, as the indispensable condition for the sustainability of development itself. Nor is the concept of 'sustainable' development alone sufficient, because that concept is now universally used in relation to ecological sustainability. Thus what is required, as we have said, is 'balanced and sustainable human development' (Palazzi 1990).

FIGURE 1

THE COUNTRY-POINTS CLOUD AND THE CONE



The geometric distance between the point designated by the actual values of the three indicators and the point corresponding to the same level of human development along R_e gives a rough idea of the degree of imbalance between the three aspects.

A second, less rigid approach is to define balanced and sustainable development not as a line but as an area. The reason for this more flexible solution lies in the self-evident fact that there is room for objective and subjective compensation and substitution between the three aspects. This scope can demarcate an area of full substitutability between income, life expectancy and literacy.

Graphically, this space is defined as the points within a cone whose vertex is at the origin and which rotates around the axis R_e ; all

the points within this cone represent states of balanced and sustainable development.

By this definition, then, we do not have for every given level of development a single proportion between the variables that designates balance and sustainability but an area of balanced, sustainable iso-development made up by the points of the circle traced by intersecting the cone with a plane, perpendicular to the origin, that intersects R_e at the point corresponding to the same level of development. The points outside the cone, conversely, represent states of unbalanced, unsustainable human development.

The purpose of defining the space of sustainability is to devise a mechanism for correcting the values of human development for countries situated outside the area of sustainability. The solution we suggest is to 'penalize' states of human development that fall outside this area in proportion to their relative distance from the surface of the cone.

The area outside the cone of sustainability can be divided into three segments, each corresponding to 'abnormal' values of one of the three human development variables (i.e., values that are too low in relation to the other two). The countries that fall outside the area of sustainability, and whose HDI will be corrected (penalized), can then be classified according to which variable puts them outside the cone.

3. The problem of weighting

In taking the simple mean of its three HDI component indicators, the UNDP *Report* applies equal weights to all. Obviously, equal weighting represents a choice, tantamount to the assertion that this is better than possible alternatives.

The question is whether other weighting systems may not be more opportune. It is hard to argue the usefulness of alternatives in the abstract, i.e. divorced from the effective possibility of formulating the criteria for different, more credible weighting. Any *a priori* determination of some 'meta production function' of human development would be perfectly arbitrary (as is equal weighting, for that mat-

ter). As the *Report* notes, “[i]n an ideal world, the ‘meta production function’ of human development would be specified, and the contribution of each variable to human development would be its weight” (UNDP 1993, p. 109). This ideal world not being available, however, the HDR’s decision to assign equal weights is, in our opinion, taken too hastily for granted.

Our suggested solution is strictly empirical: to discover whether there exists a stable relation over time between the three component variables, which would help us to judge the reasonableness of a different weighting criterion.

The purpose of the exercise is to calculate the effective weight of each of the three variables, on average, for all the countries, in determining human development. This amounts to hypothesizing that overall a country’s actual position with respect to the values of the three variables reflects a *de facto* evaluation of their relative importance to human development.

This approach is based on two propositions:

i) the concept of human development and the evaluation of its component aspects must be comparable for all countries;

ii) the concept and the evaluations must not vary significantly over time.

The first proposition is evidently indispensable to treat any problem of international comparative measurement and study of human development. Our own view is that, given the structure of the index and the variables utilized, we can safely assume the proposition as given, without this implying rejection of cultural relativism or the historical nature of human values.

The second proposition can be subjected to empirical testing to render it acceptable. If the estimation of the relation between the three variables remains stable over time, this may mean that the countries’ position, while changing, rotates around a stable, balanced path. As we shall see, there are indications that this is the case at least for the years for which estimation of the relation is possible.

The empirical solution suggested here is based on the possibility of synthesizing, via a line, the arrangement in three-dimensional space of the cloud of points marking the positions of the various countries according to the values of the three HDI component variables.

That is, we interpolate the cloud of country-points with a line that minimizes the distances between points. What this minimizes, in other words, is the information loss that would occur in passing from the actual points to their projection on that line. If the interpolation is meaningful, i.e. if the information loss is relatively slight, then by evaluating the slope of the line and its position with respect to the coordinate axes we obtain indications concerning the tendency of the points to take a given position depending on the level of development to which they refer.

We can view this line as corresponding to the theoretical path of balanced and sustainable human development which also pinpoints the optimal relation between the variables and the corresponding weighting system. Only in the case in which the interpolating line coincides with the line that is equidistant from the axes and starts at the origin, in fact, will the validity and reliability of equal weighting be confirmed.

To find the line that adequately interpolates the cloud of country-points, one may use principal components analysis, representing the units in small sub-spaces that retain as much statistical information as possible. Using this method, we are interested in locating the line generated by the first principal component, which is the line through the centre of gravity of the cloud of points with respect to which the loss of information concerning its variability is minimum.⁷

In Figure 2, which relates to the 1997 HDI, the line pc interpolates the cloud of country-points and intersects the XY plane at a point designated O' .

An initial solution is to derive the weights of the individual variables directly from the angular coefficients of the equation for pc . If pc is defined by:

$$\begin{cases} z = ax + c \\ z = by + d \end{cases}$$

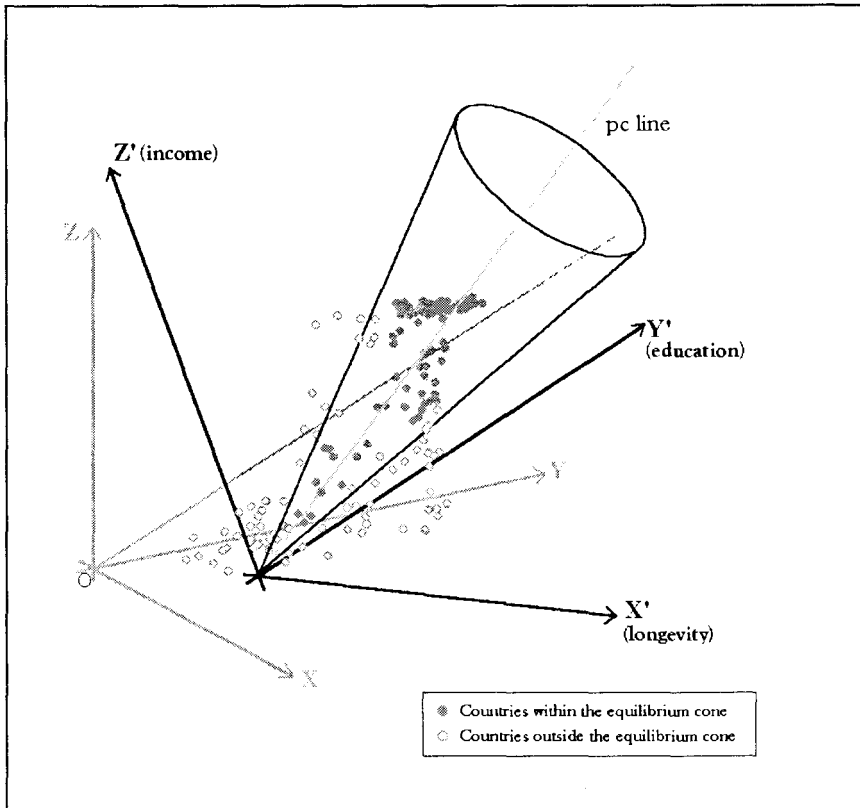
the slope of the pc line is the same of a theoretical pc_0 line, starting from the origin, whose symmetric form is:

$$ax = by = z$$

⁷ The information loss can be quantified as the inverse of the ratio between the variability explained by the first factor and total variability, to verify that this procedure makes sense.

FIGURE 2

THE COUNTRY-POINTS CLOUD AND THE CONE AFTER ROTOTRANSFORMATION



The former equilibrium line represented by $x = y = z$ would be now represented by the new line: $ax = by = z$. The weighting coefficients of the three variables would be, therefore, proportional to the values ' $a, b, 1$ '.

This implies that the less cp slopes away from each axis, the less is the weight assigned to the corresponding variable. When the line lies very close to the axis, this means that equal weighting overvalues the effective importance of that variable in determining the growth path.

This solution is not entirely satisfactory, however, in that it does not take into account that the interpolating line may not pass through the origin. This carries the important implication that for

one or two of the variables, significant values of the HDI can exist only for values of the variables above the threshold corresponding to the intercept on the plane.

A more satisfactory solution, in our view, is the complete recalculation of the HDI by means of rototranslation of the axes so as to get, as the equidistant line representing perfect equilibrium, exactly the interpolating line cp .

In order to use cp as the objective of perfect balance, we first effect a translation of the axes such that O' is the new origin. The next step is the rotation of the XYZ axes such that in the definitive reference cp coincides with the line that is equidistant from the new axes, which we designate as $X'Y'Z'$ (Figure 2).⁸

This serves two purposes.

i) First, expressing the coordinates of the country-points within the new reference through the rototranslation formulas, we reproduce conditions similar to those of the general case. As we shall see later, this enables us to apply a correction criterion for balance and sustainability perfectly analogous to that used in the case of equal weighting.

ii) Second, the calculation of the new HDI (HDI_w = weighted Human Development Index) deriving from the correction following the rototranslation takes account of the different roles that they play in determining the growth path in two ways: both through differential weighting (rotation) and by introducing a minimum level, not equal to zero, for one or two variables (translation). In this second solution the *ex post* weighting of variables is different for each country-point. Even though the *ex post* weighting coefficients are different for each country, it is possible to regard to the direction numbers of the line as approximate to represent the importance of each variable in the new index.

As we shall see, this solution enables us to introduce the concept of 'unsustainable human development' to define countries which, despite a positive value for the overall HDI, have a negative value for at least one of the components of the new index.

⁸ In the direction designated by the plane passing through cp and through the equidistance line in the $X'Y'Z'$ referent. The axis of rotation will thus be the line that is perpendicular to that plane and intersects the origin O' .

4. Correction of the HDI

Let us now set out the correction mechanism we have adopted. Once we have determined the reference line, either the equidistant line passing through the origin or that found with the introduction of differential weighting, and defined the size of the cone representing balanced, sustainable development, the HDI must be corrected for the countries falling outside these equilibrium values.

As we have seen, the degree of correction must be proportional, in some way, to the distance from the nearest equilibrium point, geometrically (the length of the line segment perpendicular to the surface of the cone). We thus define a disequilibrium index 'e', which measures the relative distance of the country-point from the objective-point on the equilibrium line R_e , given by the ratio:

$$e_i = \frac{d_i}{h_i}$$

where d_i indicates the absolute distance of the country-point from the perfect-equilibrium line R_e (i.e., the absolute level of country i 's disequilibrium); and h_i indicates the distance between the origin and the objective-point along the perfect-equilibrium line (i.e., country i 's HDI score) (see Figure 1).

The size of the balanced and sustainable development cone is defined by finding a value of 'e' representing the lowest acceptable level of balance and sustainability; this value can be designated e^* .⁹ Taking as referent the cone defined by e^* , we can observe which countries fall inside and which outside.¹⁰

Once the reference level e^* has been set, it is necessary to devise a method for correcting the HDI of the countries above the cut-off.

In defining the index e_i we used a measure of relative distance (the ratio d_i/h_i) which is equivalent to the tangent of the angle be-

⁹ The assumption that the concept of balance and sustainability is independent of the absolute level of development could be easily removed by defining a function such as $e_i^* = F(h_i)$ making the area of the balanced iso-development surface a function of the absolute level of HDI.

¹⁰ Geometrically, the value of e^* coincides with the tangent of the cone's angle of rotation.

tween the perfect equilibrium objective line R_e and the line joining the origin to point the country-point P_i .

In determining the correction coefficient, we continue to use angles as gauges of relative distance.

If:

$\text{arctg}(e_i) = \hat{E}$ is the angle between R_i (the line joining the origin to P_i) and R_e ;

$\text{arctg}(e^*) = \hat{E}^*$ is the angle of rotation of the cone;

$\max(\hat{E}^*)$ is the angle between R_e and each of the coordinate axes ($\max(\hat{E}_i) = 54.78^\circ$)

We designate as k_i the coefficient of correction relative to the i -th country, where:

$$k_i = 1 - \frac{\hat{E}_i^* - \hat{E}^*}{\max(\hat{E}_i^*) - \hat{E}^*} = \frac{\max(\hat{E}_i) - \hat{E}^*}{\max(\hat{E}_i^*) - \hat{E}^*}$$

The HDI ratings of countries whose disequilibrium indicators are higher than e^* will be corrected, multiplying the HDI index score by the correction coefficient k_i .

The equilibrium-adjusted human development index, EHDI, for country i shall thus be defined as follows:

$$EHDI_i = K_i HDI_i$$

if $e_i \leq e^*$ then $k_i = 1$ and $EHDI_i = HDI_i$

if $e_i > e^*$ then $0 \leq k_i < 1$ and $EHDI_i < HDI_i$

if one of the

variables is negative then $k_i = 0$ and $EHDI_i = 0$.¹¹

The EHDI brings a new element into the evaluation of human development, taking its balance and sustainability into account. This means that a country's overall ranking is not determined solely by the average of the three variables but also by the value of the disequilibrium index.

¹¹ This can occur only after the rototranslation of the axes.

As noted, the HDI correction applies only to those countries whose coordinates for the three aspects of human development place it outside the cone corresponding to balanced and sustainable development.¹² The key problem is determining the angle of rotation that defines that cone. In our view no *ex ante* theoretical or analytical solution is possible. All we can do is try various *ex post* hypotheses, test them empirically and discuss the various results that follow.

5. Some empirical results

On the basis of the foregoing considerations, we have used the HDI data taken from the 1997 *Human Development Report* for some exercises in correcting the index and removing the equal weighting criterion.

To correct the HDI for the distribution of the values of the single components, we make various assumptions concerning the size of the perfect substitutability cone. Table 1 gives the percentage share of countries within the cone on three assumption of the e^* value, both with non equal weighting and with rototranslation.¹³ We chose a cone whose angle of rotation is 20% of its maximum breadth.¹⁴

Table 2 gives the data for the correction when equilibrium concept is introduced. The correction changed the rankings of 82 countries (47%).

¹² In terms of iso-development surface, we would have for each level of development a bowl-shaped level surface with a plate basis perpendicular to the line, instead of a plane perpendicular to the *pc* line. The basis of each bowl is a circle in the cone (in which there is substitutability, and therefore equal weight). The points lying on the edges of the level surface correspond to those countries whose HDI (or HDI_w) is higher than EHDI (or EHDI_w), i.e. their level of development is reduced, because of the correction, to that of the points lying in the corresponding circle in the cone (the basis of the bowl).

¹³ The e^* values represent the percentage of level of disequilibrium in proportion of the level of development. A value $e^* = 0.20$ represents an angle of rotation equal to 11.31° , that is, the countries whose absolute level of disequilibrium is more than 20% of their level of development would be considered out of the equilibrium area.

¹⁴ Of course, we also performed corrections using other angles. The results are available from the authors on request.

TABLE 1

SHARE OF COUNTRIES WITHIN THE EQUILIBRIUM CONE

e* value	% of countries within the cone	
	Equal weighting	After rototranslation
0.20	43	57
0.25	35	65
0.33	25	77

Inevitably, the correction involved only countries at a low absolute level of HDI (the first to be adjusted is Turkmenistan, ranked 85th).¹⁵ For the countries undergoing correction, the variable responsible for location outside the cone is indicated. It is immediately apparent that with just two exceptions the factor responsible is always income. This is an indication that this variable plays too great a role in the determination of levels of human development.

The change in ranking is in many cases striking, and in our view significant. Table 3 gives the number of countries affected, with the extent and direction of the ranking change from the original HDI ranking to the new EHDI. For some 30% of the countries, ranking is changed by more than five places.

Table 4 sets out the revised HDI rankings after rototranslation of the axes and after bringing the regression line into correspondence with perfectly balanced HDI values.¹⁶ With rototranslation, a much

¹⁵ This was only to be expected, in that the range of the income indicator is much broader than those of the other two variables. As such authors as Gormely (1995) and Luchters and Menkhoff (1996) have noted, the HDR's method of calculating the income indicator leads to distortions in the HDI values. In our view, this distortion can be partially corrected by our rototranslation procedure.

¹⁶ Applying our methodology to the data published in the 1997 HDR, we get the following results:

i) the new balanced and sustainable development path (the straight line cp) for the data is defined by the equations:

$$\begin{cases} z = 2.06x - 0.782 \\ z = 1.92y - 0.775 \end{cases}$$

in which x = life expectancy, y = literacy, z = income, and the implicit weights are, respectively, 41.4%, 38.5% and 20.1%. For the years 1995 and 1996, for which comparison is possible, the results of the interpolation are very similar:

TABLE 2

CHANGES BETWEEN ORIGINAL HDI RANKING AND
CORRECTED EHDI RANKING

Original HDI ranking	Country	Original HDI value	Corrected EHDI value	HDI-EHDI ranking change	Disequilibrium cause
1	Canada	0.960	0.960	0	
2	France	0.946	0.946	0	
3	Norway	0.943	0.943	0	
4	USA	0.942	0.942	0	
5	Iceland	0.942	0.942	0	
6	Netherlands	0.940	0.940	0	
7	Japan	0.940	0.940	0	
8	Finland	0.940	0.940	0	
9	New Zealand	0.937	0.937	0	
10	Sweden	0.936	0.936	0	
11	Spain	0.934	0.934	0	
12	Austria	0.932	0.932	0	
13	Belgium	0.932	0.932	0	
14	Australia	0.931	0.931	0	
15	United Kingdom	0.931	0.931	0	
16	Switzerland	0.930	0.930	0	
17	Ireland	0.929	0.929	0	
18	Denmark	0.927	0.927	0	

$$\begin{cases} z = 2.06x - 0.758 \\ z = 1.78y - 0.615 \end{cases}$$

$$\begin{cases} z = 2.08x - 0.818 \\ z = 1.78y - 0.687 \end{cases}$$

showing substantial stability of the position of the cloud of points. Moreover, the loss of significance due to the regression is very small, in all cases less than 13% (1995=12.8%, 1996=12.8%, 1997=12.8%).

ii) O' , the origin of the coordinate space $X'Y'Z'$, is at the point (0.38, 0.41, 0), the intersection of cp with the XY plane in the XYZ space.

iii) The coordinates of the country points in the new reference space are obtained by the following rototranslation formulas:

$$\begin{cases} X' = 0.96X - 0.05Y + 0.27Z - 0.34 \\ Y' = X + 0.98Y + 0.2Z - 0.4 \\ Z' = 0.28X - 0.9Y + 0.94Z - 0.18 \end{cases}$$

TABLE 2 (cont.)

CHANGES BETWEEN ORIGINAL HDI RANKING AND
CORRECTED EHDI RANKING

Original HDI ranking	Country	Original HDI value	Corrected EHDI value	HDI-EHDI ranking change	Disequilibrium cause
19	Germany	0.924	0.924	0	
20	Greece	0.923	0.923	0	
21	Italy	0.921	0.921	0	
22	Hong Kong	0.914	0.914	0	
23	Israel	0.913	0.913	0	
24	Cyprus	0.907	0.907	0	
25	Barbados	0.907	0.907	0	
26	Singapore	0.900	0.900	0	
27	Luxembourg	0.899	0.899	0	
28	Bahamas	0.894	0.894	0	
29	Antigua and Barbuda	0.892	0.892	0	
30	Chile	0.891	0.891	0	
31	Portugal	0.890	0.890	0	
32	Korea, Rep. of	0.890	0.890	0	
33	Costa Rica	0.889	0.889	0	
34	Malta	0.887	0.887	0	
35	Slovenia	0.886	0.886	0	
36	Argentina	0.884	0.884	0	
37	Uruguay	0.883	0.883	0	
38	Brunei Darussalam	0.882	0.882	0	
39	Czech Rep.	0.882	0.882	0	
40	Trinidad and Tobago	0.880	0.880	0	
41	Dominica	0.873	0.873	0	
42	Slovakia	0.873	0.873	0	
43	Bahrain	0.870	0.870	0	
44	United Arab Emirates	0.866	0.866	0	
45	Panama	0.864	0.864	0	
46	Fiji	0.863	0.863	0	

TABLE 2 (cont.)

CHANGES BETWEEN ORIGINAL HDI RANKING AND
CORRECTED EMDI RANKING

Original HDI ranking	Country	Original HDI value	Corrected EMDI value	HDI-EMDI ranking change	Disequilibrium cause
47	Venezuela	0.861	0.861	0	
48	Hungary	0.857	0.857	0	
49	Saint Kitts and Nevis	0.853	0.853	0	
50	Mexico	0.853	0.853	0	
51	Colombia	0.848	0.848	0	
52	Seychelles	0.845	0.845	0	
53	Kuwait	0.844	0.844	0	
54	Grenada	0.843	0.843	0	
55	Qatar	0.840	0.840	0	
56	Saint Lucia	0.838	0.838	0	
57	Saint Vincent	0.836	0.836	0	
58	Poland	0.834	0.834	0	
59	Thailand	0.833	0.833	0	
60	Malaysia	0.832	0.832	0	
61	Mauritius	0.831	0.831	0	
62	Belarus	0.806	0.806	0	
63	Belize	0.806	0.806	0	
64	Libyan Arab Jamahiriya	0.801	0.801	0	
65	Lebanon	0.794	0.794	0	
66	Suriname	0.792	0.792	0	
67	Russian Fed.	0.792	0.792	0	
68	Brazil	0.783	0.783	0	
69	Bulgaria	0.780	0.780	0	
70	Iran, Islamic Republic of	0.780	0.780	0	
71	Estonia	0.776	0.776	0	
72	Ecuador	0.775	0.775	0	
73	Saudi Arabia	0.774	0.774	0	
74	Turkey	0.772	0.772	0	

TABLE 2 (cont.)

CHANGES BETWEEN ORIGINAL HDI RANKING AND
CORRECTED EHDI RANKING

Original HDI ranking	Country	Original HDI value	Corrected EHDI value	HDI-EHDI ranking change	Disequilibrium cause
75	Korea, Dem. Republic of	0.765	0.765	0	
76	Lithuania	0.762	0.762	0	
77	Croatia	0.760	0.760	0	
78	Syrian Arab Republic	0.755	0.755	0	
79	Romania	0.748	0.748	0	
80	Macedonia. FYR	0.748	0.748	0	
81	Tunisia	0.748	0.748	0	
82	Algeria	0.737	0.737	0	
83	Jamaica	0.736	0.736	0	
84	Jordan	0.730	0.730	0	
85	Turkmenistan	0.723	0.697	-7	Income
86	Cuba	0.723	0.688	-7	Income
87	Dominican Republic	0.718	0.718	2	
88	Oman	0.718	0.621	-10	Literacy
89	Peru	0.717	0.717	3	
90	Sri Lanka	0.716	0.716	3	
91	South Africa	0.711	0.711	3	
92	Latvia	0.711	0.709	3	Income
93	Kazakhstan	0.709	0.703	2	Income
94	Paraguay	0.706	0.706	4	
95	Ukraine	0.689	0.614	-4	Income
96	Samoa (Western)	0.684	0.613	-5	Income
97	Botswana	0.673	0.625	0	Life exp.
98	Philippines	0.672	0.605	-4	Income
99	Indonesia	0.668	0.668	5	

TABLE 2 (cont.)

CHANGES BETWEEN ORIGINAL HDI RANKING AND
CORRECTED EHDI RANKING

Original HDI ranking	Country	Original HDI value	Corrected EHDI value	HDI-EHDI ranking change	Disequilibrium cause
100	Uzbekistan	0.662	0.570	-7	Income
101	Mongolia	0.661	0.661	6	
102	Albania	0.655	0.629	6	Income
103	Armenia	0.651	0.475	-16	Income
104	Guyana	0.649	0.582	0	Income
105	Georgia	0.637	0.461	-18	Income
106	Azerbaijan	0.636	0.465	-15	Income
107	Kyrgyzstan	0.635	0.489	-11	Income
108	China	0.626	0.593	5	Income
109	Egypt	0.614	0.614	9	
110	Moldova, Republic of	0.612	0.434	-18	Income
111	Maldives	0.611	0.506	-5	Income
112	El Salvador	0.592	0.547	0	Income
113	Bolivia	0.589	0.553	2	Income
114	Swaziland	0.582	0.577	9	Income
115	Tajikistan	0.580	0.368	-19	Income
116	Honduras	0.575	0.494	-1	Income
117	Guatemala	0.572	0.572	11	
118	Namibia	0.570	0.570	10	
119	Morocco	0.566	0.566	10	
120	Gabon	0.562	0.562	10	
121	Vietnam	0.557	0.370	-12	Income
122	Solomon Islands	0.556	0.475	2	Income
123	Cape Verde	0.547	0.458	-3	Income
124	Vanuatu	0.547	0.514	9	Income
125	Sao Tome and Principe	0.534	0.426	-4	Income
126	Iraq	0.531	0.531	13	
127	Nicaragua	0.530	0.409	-3	Income

TABLE 2 (cont.)

CHANGES BETWEEN ORIGINAL HDI RANKING AND
CORRECTED EHDI RANKING

Original HDI ranking	Country	Original HDI value	Corrected EHDI value	HDI-EHDI ranking change	Disequilibrium cause
128	Papua New Guinea	0.525	0.525	14	
129	Zimbabwe	0.513	0.399	-2	Income
130	Congo	0.500	0.463	8	Income
131	Myanmar	0.475	0.315	-15	Income
132	Ghana	0.468	0.443	5	Income
133	Cameroon	0.468	0.459	8	Income
134	Kenya	0.463	0.340	-5	Income
135	Equatorial Guinea	0.462	0.334	-7	Income
136	Lao People's Democratic Republic	0.459	0.459	12	
137	Lesotho	0.457	0.318	-8	Income
138	India	0.446	0.348	2	Income
139	Pakistan	0.445	0.399	7	Income
140	Comoros	0.412	0.337	0	Income
141	Nigeria	0.393	0.321	-3	Income
142	Zaire	0.381	0.192	-24	Income
143	Zambia	0.369	0.199	-20	Income
144	Bangladesh	0.368	0.297	-3	Income
145	Côte d'Ivoire	0.368	0.360	10	Income
146	Benin	0.368	0.341	8	Income
147	Togo	0.365	0.282	-3	Income
148	Yemen	0.361	0.242	-8	Income
149	Tanzania, U. Rep. of	0.357	0.212	-13	Income
150	Mauritania	0.355	0.341	13	Income
151	Central African Rep.	0.355	0.274	0	Income

TABLE 2 (cont.)

CHANGES BETWEEN ORIGINAL HDI RANKING AND
CORRECTED EHDI RANKING

Original HDI ranking	Country	Original HDI value	Corrected EHDI value	HDI-EHDI ranking change	Disequilibrium cause
152	Madagascar	0.350	0.218	-9	Income
153	Cambodia	0.348	0.270	1	Income
154	Nepal	0.347	0.263	0	Income
155	Bhutan	0.338	0.296	7	Income
156	Haiti	0.338	0.237	-2	Income
157	Angola	0.335	0.335	16	
158	Sudan	0.333	0.266	5	Income
159	Uganda	0.328	0.241	2	Income
160	Senegal	0.326	0.326	17	Income
161	Malawi	0.320	0.162	-8	Income
162	Djibouti	0.319	0.283	13	Income
163	Guinea-Bissau	0.291	0.191	-4	Income
164	Chad	0.288	0.198	0	Income
165	Gambia	0.281	0.228	5	Income
166	Mozambique	0.281	0.235	7	Income
167	Guinea	0.271	0.247	12	Income
168	Eritrea	0.269	0.196	3	Income
169	Burundi	0.247	0.181	1	Income
170	Ethiopia	0.244	0.137	-2	Income
171	Mali	0.229	0.142	0	Income
172	Burkina Faso	0.221	0.150	2	Income
173	Niger	0.206	0.120	0	Income
174	Rwanda	0.187	0.071	-1	Income
175	Sierra Leone	0.176	0.113	1	Income

Countries in bold are equilibrium corrected (outside the equilibrium cone).

HDI = Human Development Index.

EHDI = Equilibrium corrected HDI.

TABLE 3

RANK DIFFERENCES BETWEEN HDI AND EHDI

Rank differences	Number of countries		Total	%
	+	-		
0	93		93	53
1	3	2	5	3
2-4	13	12	25	14
5-9	16	11	27	15
10 >	13	12	25	14
<i>Total</i>	45	37	82	47
Total			175	100

HDI = Human Development Index.

EHDI = Equilibrium corrected Human Development Index.

larger number of countries change rank, because the introduction of differential weighting and translation alters the HDI value of all countries. Only 28 countries retain the same ranking, and the modification of the others is often very substantial.

The same correction criterion as before can be applied in the case of rototranslation as well, using the disequilibrium index as we did when equal weighting was retained. As noted, the results of the correction and the ranking changes are given also in Table 4. There are now only 12 countries whose ranking does not change. The original HDI rankings are thus very substantially altered, and 20 countries are in absolute disequilibrium, and while most of these are at very low HDI values some are not.

Again, for every country undergoing a correction we can identify the variable responsible for the position of unsustainability, and absolute disequilibrium. Following rototranslation the situation changes; the causes for imbalance are distributed as follows: of the 82 countries, in 12% the disequilibrium is due to life expectancy, in 42% to literacy and in 46% to income. Of the 20 countries in absolute disequilibrium, the causes are: life expectancy 30%; literacy 60% and income only 10%.

TABLE 4

CHANGES BETWEEN ORIGINAL HDI RANKING AND WEIGHTED HDI_w
AND CORRECTED EHD_w RANKING

Original HDI ranking	HDI _w ranking	EHD _w ranking	Country	HDI-HDI _w ranking change	HDI-EHD _w ranking change	Disequilibrium cause
1	1	1	Canada	0	0	
2	3	3	France	-1	-1	
3	2	2	Norway	1	1	
4	5	5	USA	-1	-1	
5	4	4	Iceland	1	1	
6	6	6	Netherlands	0	0	
7	7	7	Japan	0	0	
8	9	9	Finland	-1	-1	
9	10	10	New Zealand	-1	-1	
10	8	8	Sweden	2	2	
11	14	14	Spain	-3	-3	
12	11	11	Austria	1	1	
13	12	12	Belgium	1	1	
14	15	15	Australia	-1	-1	
15	13	13	United Kingdom	2	2	
16	18	18	Switzerland	-2	-2	
17	19	19	Ireland	-2	-2	
18	16	16	Denmark	2	2	
19	17	17	Germany	2	2	
20	21	21	Greece	-1	-1	
21	20	20	Italy	1	1	
22	22	22	Hong Kong	0	0	
23	23	23	Israel	0	0	
24	24	24	Cyprus	0	0	
25	27	27	Barbados	-2	-2	
26	26	26	Singapore	0	0	
27	25	25	Luxembourg	2	2	
28	28	28	Bahamas	0	0	
29	30	30	Antigua and Barbuda	-1	-1	
30	34	34	Chile	-4	-4	
31	29	29	Portugal	2	2	
32	33	33	Korea, Rep. of	-1	-1	
33	39	39	Costa Rica	-6	-6	
34	32	32	Malta	2	2	
35	36	36	Slovenia	-1	-1	
36	35	35	Argentina	1	1	
37	40	40	Uruguay	-3	-3	
38	31	31	Brunei Darussalam	7	7	
39	37	37	Czech Republic	2	2	
40	38	38	Trinidad and Tobago	2	2	
41	44	44	Dominica	-3	-3	
42	42	42	Slovakia	0	0	
43	41	41	Bahrain	2	2	
44	43	43	United Arab Emirates	1	1	
45	45	45	Panama	0	0	
46	49	49	Fiji	-3	-3	

TABLE 4 (cont.)

CHANGES BETWEEN ORIGINAL HDI RANKING AND WEIGHTED HDI_w
AND CORRECTED EHD_w RANKING

Original HDI ranking	HDI _w ranking	EHD _w ranking	Country	HDI-HDI _w ranking change	HDI-EHD _w ranking change	Disequilibrium cause
47	46	46	Venezuela	1	1	
48	47	47	Hungary	1	1	
49	48	48	Saint Kitts and Nevis	1	1	
50	51	51	Mexico	-1	-1	
51	53	53	Colombia	-2	-2	
52	54	54	Seychelles	-2	-2	
53	50	50	Kuwait	3	3	
54	60	60	Grenada	-6	-6	
55	52	52	Qatar	3	3	
56	58	58	Saint Lucia	-2	-2	
57	59	59	Saint Vincent	-2	-2	
58	63	63	Poland	-5	-5	
59	57	57	Thailand	2	2	
60	55	55	Malaysia	5	5	
61	56	56	Mauritius	5	5	
62	67	66	Belarus	-5	-4	
63	62	62	Belize	1	1	
64	61	61	Libyan Arab Jamahiriya	3	3	
65	68	67	Lebanon	-3	-2	
66	71	70	Suriname	-5	-4	
67	69	68	Russian Fed.	-2	-1	
68	66	65	Brazil	2	3	
69	77	74	Bulgaria	-8	-5	
70	65	64	Iran, Islamic Rep. of	5	6	Literacy
71	78	76	Estonia	-7	-5	
72	76	73	Ecuador	-4	-1	
73	64	75	Saudi Arabia	9	-2	Literacy
74	70	69	Turkey	4	5	
75	80	79	Korea, Dem. Rep. of	-5	-4	
76	79	78	Lithuania	-3	-2	
77	81	80	Croatia	-4	-3	
78	72	71	Syrian Arab Rep.	6	7	
79	82	81	Romania	-3	-2	
80	83	82	Macedonia, FYR	-3	-2	
81	74	72	Tunisia	7	9	
82	75	77	Algeria	7	5	Literacy
83	87	85	Jamaica	-4	-2	
84	85	83	Jordan	-1	1	
85	90	94	Turkmenistan	-5	-9	Income
86	95	98	Cuba	-9	-12	Income
87	88	86	Dominican Republic	-1	1	
88	73	97	Oman	15	-9	Literacy
89	89	87	Peru	0	2	
90	86	84	Sri Lanka	4	6	
91	94	90	South Africa	-3	1	Income
92	93	89	Latvia	-1	3	Income

TABLE 4 (cont.)

CHANGES BETWEEN ORIGINAL HDI RANKING AND WEIGHTED HDI_w
AND CORRECTED EHD_w RANKING

Original HDI ranking	HDI _w ranking	EHD _w ranking	Country	HDI-HDI _w ranking change	HDI-EHD _w ranking change	Disequilibrium cause
93	92	93	Kazakhstan	1	0	Income
94	91	88	Paraguay	3	6	
95	98	106	Ukraine	-3	-11	Income
96	99	104	Samoa (Western)	-3	-8	Income
97	84	96	Botswana	13	1	Life exp.
98	101	103	Philippines	-3	-5	Income
99	96	91	Indonesia	3	8	
100	104	112	Uzbekistan	-4	-12	Income
101	97	92	Mongolia	4	9	
102	102	99	Albania	0	3	Income
103	109	126	Armenia	-6	-23	Income
104	103	107	Guyana	1	-3	Income
105	116	129	Georgia	-11	-24	Income
106	115	127	Azerbaijan	-9	-21	Income
107	111	124	Kyrgyzstan	-4	-17	Income
108	106	102	China	2	6	Income
109	100	95	Egypt	9	14	Literacy
110	119	132	Moldova, Republic of	-9	-22	Income
111	112	116	Maldives	-1	-5	Income
112	117	113	El Salvador	-5	-1	Income
113	114	101	Bolivia	-1	12	Income
114	113	100	Swaziland	1	14	
115	125	-	Tajikistan	-10	-	Income
116	120	117	Honduras	-4	-1	Income
117	110	110	Guatemala	7	7	Literacy
118	105	108	Namibia	13	10	Literacy
119	108	115	Morocco	11	4	Literacy
120	107	105	Gabon	13	15	Life exp.
121	129	137	Vietnam	-8	-16	Income
122	123	123	Solomon Islands	-1	-1	Income
123	124	119	Cape Verde	-1	4	Income
124	122	114	Vanuatu	2	10	Income
125	128	125	Sao Tome and Principe	-3	0	Income
126	118	109	Iraq	8	17	Literacy
127	130	128	Nicaragua	-3	-1	Income
128	121	111	Papua New Guinea	7	17	
129	126	130	Zimbabwe	3	-1	Income
130	127	118	Congo	3	12	Income
131	137	141	Myanmar	-6	-10	Income
132	133	121	Ghana	-1	11	
133	132	120	Cameroon	1	13	
134	136	135	Kenya	-2	-1	Income
135	135	139	Equatorial Guinea	0	-4	Income
136	131	122	Lao People's Democratic Republic	5	14	Life exp.

TABLE 4 (cont.)

CHANGES BETWEEN ORIGINAL HDI RANKING AND WEIGHTED HDI_w
AND CORRECTED EHD_w RANKING

Original HDI ranking	HDI _w ranking	EHD _w ranking	Country	HDI-HDI _w ranking change	HDI-EHD _w ranking change	Disequilibrium cause
137	138	136	Lesotho	-1	1	Income
138	139	133	India	-1	5	Income
139	134	140	Pakistan	5	-1	Literacy
140	140	131	Comoros	0	9	
141	141	134	Nigeria	0	7	Income
142	156	-	<i>Zaire</i>	-14	-	Income
143	148	-	<i>Zambia</i>	-5	-	Life exp.
144	145	146	Bangladesh	-1	-2	Literacy
145	142	144	Cote d'Ivoire	3	1	Literacy
146	143	-	<i>Benin</i>	3	-	Literacy
147	146	138	Togo	1	9	
148	153	145	Yemen	-5	3	Literacy
149	157	150	Tanzania, U. Rep. of	-8	-1	Income
150	144	147	Mauritania	6	3	Literacy
151	149	142	Central African Rep.	2	9	Life exp.
152	158	153	Madagascar	-6	-1	Literacy
153	152	143	Cambodia	1	10	Literacy
154	154	-	<i>Nepal</i>	0	-	Literacy
155	151	149	Bhutan	4	6	Literacy
156	161	152	Haiti	-5	4	Literacy
157	147	151	Angola	10	6	Literacy
158	159	148	Sudan	-1	10	Literacy
159	155	-	<i>Uganda</i>	4	-	Life exp.
160	150	-	<i>Senegal</i>	10	-	Literacy
161	162	-	<i>Malawi</i>	-1	-	Life exp.
162	160	154	Djibouti	2	8	Literacy
163	165	-	<i>Guinea-Bissau</i>	-2	-	Life exp.
164	167	155	Chad	-3	9	Literacy
165	166	-	<i>Gambia</i>	-1	-	Literacy
166	163	-	<i>Mozambique</i>	3	-	Literacy
167	164	-	<i>Guinea</i>	3	-	Literacy
168	168	-	<i>Eritrea</i>	0	-	Literacy
169	169	-	<i>Burundi</i>	0	-	Literacy
170	171	-	<i>Ethiopia</i>	-1	-	Literacy
171	173	-	<i>Mali</i>	-2	-	Literacy
172	172	-	<i>Burkina Faso</i>	0	-	Literacy
173	174	-	<i>Niger</i>	-1	-	Literacy
174	170	-	<i>Rwanda</i>	4	-	Life exp.
175	175	-	<i>Sierra Leone</i>	0	-	Life exp.

Countries in bold are equilibrium corrected (outside the equilibrium cone).

Countries in italics are in absolute disequilibrium level.

HDI = Human Development Index.

HDI_w = Weighted corrected HDI.

HDI_w = Equilibrium and weighted corrected index.

To our mind, this very pronounced diminution in the importance of income as a factor of disequilibrium (both absolute and relative), especially in the low-income countries, is highly significant. It means, in fact, that in many cases the disequilibrium or unsustainability of human development in the poor countries does not depend on poverty as such but above all on the inadequacy of social development, which may be disproportionately low even *vis-à-vis* their very low level of income.

Tables 5a and 5b show the ranking changes by extent and direction in the two new rankings (HDI_w = Human Development Index after the rototranslation; and EHDI_w = Equilibrium corrected Human Development Index after the rototranslation). In the first case (Table 5a) 25% of the countries display substantial ranking changes (more than five places). Table 5b shows that 11% of countries are excluded from the rankings as having absolutely unsustainable levels of human development and 33% have a ranking change of more than 5 places.

TABLE 5A

RANK DIFFERENCES BETWEEN HDI AND HDI_w

Rank differences	Number of countries		Total	%
	+	-		
0	28		28	16
1	17	19	36	21
2-4	32	36	68	39
5-9	14	19	33	19
10 >	7	3	10	6
<i>Total</i>	70	77	147	84
Total			175	100

HDI = Human Development Index.

HDI_w = Weighted corrected Human Development Index (after rototranslation).

TABLE 5B

RANK DIFFERENCES BETWEEN HDI AND EHDI_w

Rank differences	Number of countries		Total	%
	+	-		
0	12		12	7
1	17	21	38	22
2-4	23	25	48	27
5-9	23	10	33	19
10 >	14	10	24	14
<i>Total</i>	77	66	143	82
<i>Absolute disequilibrium</i>	20		20	11
Total			175	100

HDI = Human Development Index.

EHDI_w = Equilibrium and weighted corrected Human Development Index.

6. Conclusion

The most important conclusion of this paper is methodological: namely, that in the construction of the HDI the principles of full substitutability and equal weighting should be dropped.

We have proposed two methods for calculating the index that permit the introduction of different, more complex hypotheses than those of the HDR, relegating the latter to the status of special case.

As regards substitutability, an index can be devised in order to correct the HDI in proportion to each country's distance from the perfect-equilibrium point at the same HDI value, but with equal distribution of the values of the component variables. This correction introduces an evaluation of the distribution of the three component values. The correction should be applied to the countries that are outside an area of sustainability and balance. In our exercise, we considered as being in equilibrium countries whose displacement was less than 20%.

The problem of differential weighting was attacked empirically, using the principal components method to define a line in three-dimensional space that interpolates the country-points. This line, which proves to be highly significant and stable in time, was used, after a rototranslation procedure, as the reference line for calculating new HDI values, both with and without correction for balance.

Our numerical application shows clearly that index values and rankings can change notably. In our view, the end result corrects certain incongruities in the Human Development Index rankings. Moreover, it appears to provide greater methodological rigor.

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