Human Development Index and its Original Methodology of Measurement[1]

1. Introduction

Human beings are the real ends of all activities, and development must be centered on enhancing their achievements, freedoms and capabilities. It is the lives they lead that are of intrinsic importance, not the commodities or income that they happen to possess. Income, commodities ('basic' or otherwise), and wealth do of course have instrumental importance but they do not constitute a direct measure of the living standard itself [Anand and Sen (1994)]. Thus, development is not simply reflected by increase in income per capita, it is determined by enhancement of human lives – enhancements of capabilities, freedoms and ultimately achievements of different ends of human lives. Human development should be the ultimate objective of any society; economic development in terms of growth of per capita income is not unnecessary but should be directed towards human development – this was the basic agenda of the Human Development Report of 1996.

Human development is a composite measure. It tries to measure average enhancement of different ends of human lives. The appeal of such a measure of human development is appreciable but the problem is in the measurement of the 'achievements, freedoms and capabilities' of human beings. A society is said to be more developed than another if the human beings of that society are more capable of enjoying a decent and long life, liberty, freedom, etc., and are more capable of avoiding hunger, under-nourishment, poverty, illiteracy, etc. – or, if they are more capable of being what they want to be (or ought to be) and capable of not being what they do not want to be (or do not ought to be), capable of having what they want to have (or ought to have) and capable of not having what they do not want to have (or do not ought to have). So, the list of variables measuring the achievements, freedoms and capabilities is quite large and it is very difficult to make it comprehensive and complete.

The success of the human development measure constructed under the UNDP lies in the fact that it has identified some basic variables indicating human development and has combined them in an almost scientific way so that inter-national as well as inter-temporal comparisons of the performances of different nations with respect to human development are possible. It addresses to three basic problems. Are the human beings capable of enjoying a long life

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(measured by life expectancy at birth)? Are they capable of being educated (measured by enrolment ratio and adult literacy rate)? Are they capable of enjoying a decent standard of living (measured by per capita income)? It is admitted that the measure is not the ideal or complete measure of human development because it fails to accommodate all possible aspects of human development; at the same time, it is claimed that the measure captures all major aspects of human development.

1.1. The Human Development Index

"The HDI (Human Development Index) is a summary measure of human development. It measures the average achievements in a country in three basic dimensions of human development.

- A long and healthy life, as measured by life expectancy at birth.
- Knowledge, as measured by the adult literacy rate (with two-thirds weight) and the combined primary, secondary and tertiary gross enrolment ratio (with one-third weight).
- A decent standard of living, as measured by GDP per capita (PPP US$).

Before the HDI itself is calculated, an index needs to be created for each of these dimensions. To calculate these dimension indices – the life expectancy, education and GDP indices – minimum and maximum values (goalposts) are chosen for each underlying indicator." Goalposts are kept fixed over successive reports so as to enable an inter-temporal comparison. Variables like adult literacy and enrolment ratio have normative minima and normative maxima at 0 and 100 percent respectively and they are used as the goalposts, but for variables like life expectancy at birth and GDP per capita there are no such normative values and the goalposts are fixed from observed and observable minima and maxima.

Goalposts used for calculating the HDI are as shown below:

Indicator	Minimum value	Maximum value
Life expectancy at birth (years)	25	85
Adult literacy rate (%)	0	100
Combined gross enrolment ratio (%)	0	100
GDP per capita (PPP US$)	100	40,000

Index in each dimension is obtained as a value between 0 and 1 by applying the following formula: $Dimension\ index = \frac{Actual\ value - Minimum\ value}{Maximum\ value - Minimum\ value}$. For GDP per capita the formula uses logarithm of the values in place of the actual values. Thus: $GDP\ index = \frac{Log(Actual\ value) - Log(Minimum\ value)}{Log(Maximum\ value) - Log(Minimum\ value)}$. Education index is calculated as a weighted average of adult literacy index and combined enrolment ratio with $2/3$ and $1/3$ weights respectively. Finally, the HDI is calculated as simple average of life expectancy index, education index and GDP per capita index.

The methodology of construction of the HDI has undergone a number of changes since its inception in 1990. In the first report the HDI was constructed from a deprivation perspective. For each dimension a deprivation index was calculated by the formula: $Dimension\ index = \frac{Maximum\ value - Actual\ value}{Maximum\ value - Minimum\ value}$ to indicate the relative amount of deprivation of the country from the maximum attained by the most developed country. The composite deprivation index was obtained as an average of the dimension deprivation indices and the HDI was calculated in an indirect way as one minus the composite deprivation index. From the report of 1991 the direct method of calculation was introduced and it continues till now.

In the first report adult literacy was the only variable in educational attainment. In the report of 1991 mean years of schooling was added as a second component with $1/3$ weight leaving $2/3$ weight for adult literacy. From the report of 1995 mean years of schooling was replaced by gross enrolment ratio.

In the first report logarithm of per capita income was taken to accommodate diminishing marginal importance of increasing income. The method was severely criticised on the ground that discounting income seems unreasonable when the income is less than that required for minimum necessities. In next eight reports it was replaced by a highly regressive discounting method. This method was also criticised severely not only for its high regressive nature but also for its method of discounting as such. From the report of 1999 it reverted to the logarithm of per capita income.

"Until 1994 observed maxima and minima were used in normalising variables. This created a serious problem. First, there was no way of knowing whether the changes in the HDI value of a country were because of its improved performance or because the goalposts had shifted. Second, since the observed maxima and minima alter from year to year, representing changes in the goalposts themselves, any meaningful intertemporal comparison was not possible. To deal with these issues, fixed maxima and minima were introduced in 1994. These were no longer observed, but rather based on the trends of the variables and their probable values in the next 25 years. Fixing the maxima and minima for variables made it possible to carry out meaningful trend analysis of the HDI."

The HDI has drawn attention of both policy makers and academicians. For policy makers, attention is towards its inherent policy implication part. Many countries in the nineties have calculated human development indices for different regions, races and communities and have taken policies to reduce the disparities observed therein and many of them have succeeded in fulfilling their objectives. Many academicians have welcomed this novel index and have tried to employ the technique in other fields of development while others have scrutinised and criticised it in terms of its choice of indicators, method of weighting and combining etc.

2. A Critique of the Human Development Index Methodology

Human development includes several aspects of human life and can be expressed only by a composite index of those aspects of human life. Automatically, the construction of the Human Development Index involves three basic instruments, viz., choice of variables, indexing of variables and combining the variables. The HDI methodology used under the UNDP has made some specific assumptions regarding these instruments. The assumption regarding indexing of variables includes the choice of goalposts and the method of discounting variables; the assumption regarding combining variables involves the linearity assumption and the choice of weights. The HDI methodology is criticised for almost all these assumptions, viz., choice of variables, method of indexing, choice of goalposts, method of discounting variables and choice of weights. As already mentioned, the chosen variables in the HDI are most important ones but are not comprehensive. The methodology for constructing the HDI leaves no scope for accommodating other variables.

2.1. Choice of Variables (Ends versus Means):

Traditionally (economic) development was viewed as an improvement of economic condition and so per capita income was treated as the end of all (economic) activities. In the approach of human development human beings are treated as the real end and so enhancement of 'their achievements, freedoms and capabilities' is treated as the real development. Up to this point there is no problem. The real problem arises when we try to identify the real ends by such achievements, freedoms and capabilities and try to measure them through the variables included in the HDI. Health, knowledge and living standard are assumed three most important ends and so the above three (actually four) variables. There are other ends and other variables also.

Opposing the traditional view of development though it is argued that per capita income has an instrumental effect only and that per capita income is not the end of development, it is actually treated as an end, though not as the only end of development. It is used as one of three ends though the real ends are somewhat different. Per capita income is included because it acts as an important instrument for achieving some of the real ends all of which are not perfectly measurable.

In the construction of the HDI one should try to accommodate all possible ends where human development is really reflected. But all of them are not measurable, they are not equally important and, in many occasions, they are not mutually exclusive. The problem accentuates further when some ends are observed to act as means for achieving other ends. Human beings, which are the real end of development, are also one of the important means of development. In the same way per capita income can be viewed as an end of development from one angle; it can also be viewed as an important means for achieving other ends.

In the construction of any development index inclusion of all important, identifiable, measurable and mutually exclusive ends poses no problem. For the ends which are important but not measurable some means through which those important ends are achieved can be used as proxies. Per capita income is used in the HDI as such a proxy for several economic ends. Eventually, however, it has become one of three ends. Inclusion of an important means (like per capita income) in such index may also be reasonable if it leads to a large number of individually unimportant but jointly important ends. This reduces the number of variables to a large extent. But the problem of including per capita income along with life expectancy and

educational attainment is that these latter two variables also partially influence and are partially influenced by the former and this leads to the problem of double counting of some ends.

As the distinction between means and ends is not clear it is very difficult to have a pure indicator of development. However, what is clear from the above discussion is that because it is totally difficult to identify and measure an exhaustive and mutually exclusive set of pure ends, we have to include all important and measurable ends as well as means, at least those means which are not mostly reflected in the ends considered.

It combines stock variables like life expectancy and educational attainment with flow variables like per capita income and this creates some conceptual problems. It also faces problem in identifying and combining variables indicating enhancement in capabilities with those indicating enhancement in freedom and also with those indicating enhancement in attainment.

2.2. Method of Indexing (Deprivation versus Development)

For each dimension of development dimensional index can be constructed from two perspectives – development perspective and deprivation perspective. If human deprivation index is the ultimate index of interest then dimensional indices are to be constructed from deprivation perspective; but if Human Development Index is of primary importance there is no merit to see the things from deprivation viewpoint.

2.3. Choice of Goalposts (Development versus Disparity)

The term development generally means improvement over time. In the first four HDRs variables were normalised by observed maxima and minima and the HDI was methodologically sufficient to make an inter-country comparison in any year in terms of human development – to examine whether a country is more or less developed in comparison to another in terms of human development. Thus, the index was basically an index for measuring disparity among the countries or an index to locate a country's position relative to the countries at the two extremes. It was not methodologically strong to examine whether a country's position is improving over time or not, or whether the country is developing or not. When the variables were normalised by observed maxima and minima an increase in the HDI of a country over years would not necessarily imply an improvement of the country. It might be simply due to the fact that the goalposts had shifted. Fixed goalposts in place of observed maxima and minima were introduced in 1994 to facilitate a meaningful trend analysis and to express the HDI as a true index of development.

With fixed goalposts an increase in the HDI of a country over years would obviously imply an improvement of the country over time. As already mentioned, fixed maxima and minima were based on the trends of the variables and their probable values in the next 25 years. Thus, with new HDI both cross-sectional and inter-temporal comparisons were possible. Some academicians are still unwilling to accept it as an index of development. According to them it is still a disparity index or relative development index, relative not to the observed extremes but to the projected extremes [8]. The problem actually crops up elsewhere; from the way the goalposts are fixed. Inter-temporal comparison is no doubt possible with fixed goalposts, however they are fixed. But as goalposts are fixed from trends and projections of the variables the inter-temporal analysis of development gets affected with the change in the projection period or projection method. Moreover, with fixed goalposts obtained from projection of variables leads to less meaningful inter-country comparison. Suppose the HDI of Country-A is greater than that of country-B in a year with goalposts fixed from a 25-year projection. If projection period is changed the HDI of Country-A may become less than that of country-B. Thus, the strength of meaningful inter-country comparison is less in the fixed goalpost approach (if there do not exist notionally fixed goalposts for all variables).

2.4. Treatment of Per Capita Income

It is argued that per capita income has a diminishing marginal contribution to human development. Now as normalisation takes the form of a linear transformation and as the HDI is formed as a linear combination of three normalised variables, per capita income is to be discounted before normalisation, and discounting should increase with income so as to compensate its diminishing marginal contribution provided that the marginal contributions of other variables are constant. It is very difficult to argue whether logarithm of per capita income can be the proper method of discounting and it is further difficult to say that other variables have constant marginal contribution to human development. Probably, life expectancy has an increasing marginal contribution and educational attainment has a slightly decreasing marginal contribution to human development.

2.5. Choice of Weights

This again involves two aspects. **First (Equal versus Unequal weights),** the HDI gives equal weights to the indices of log per capita income, educational attainment and life expectancy, and while calculating the educational attainment index it gives $1/3$ weight to gross enrolment ratio and $2/3$ weight to adult literacy. It is argued that attaining a long life, attaining knowledge

and attaining a decent standard of living are equally important to human lives. This weighting principle has been criticised as arbitrary. Hopkins (1991) claimed that the summation of the three dimensions implies perfect substitutability between longevity, knowledge and living standard but this is not actually the case. Desai (1991) suggested that the indices should be combined in a log additive form so that the effect is multiplicative, and there is very limited substitutability. Ravillion (1997) described that implied trade-off among the dimensions is a matter of public choice and so equal and constant weights might not reflect the reality.

Noorbakhsh (1998) and others claimed that weights to individual indices should also be obtained from the data. Many of them suggested that the coefficients of the first principal component of the individual indices could be used as their weights. Weights calculated by Noorbaksh by following this principle, however, gave weights very close to $1/3$ each and he claimed that the equal weighting is not a serious problem. Biswas and Caliendo (2002) also calculated weights by the principal component method by using the data used in the HDR of 2001 and came to the same conclusion that the principle of equal weighting is not a serious problem. They further observed that the variances of three individual indices were more or less equal at about 0.036 and so were the three co-variances at about 0.030 and this led to equal coefficients of individual indices in the first principal component and so equal weights for them.

Second (Fixed versus Flexible weights), the HDI gives weights to different dimension indices fixed across countries and over time. Ravillion (1997) has pointed out that fixed weights imply a particular pattern of trade-off among the dimensions. But as the pattern of trade-off is a matter of public choice it should not be assumed to be constant across countries and over time. However, when per capita income is discounted by taking its logarithm the weight of the per capita income dimension falls with the increase in per capita income of a country over years or in comparison to others in any year.

2.6. Other Aspects

Human Development Improvement Index versus Human Development Stock Index: The HDI is criticised because it combines stock variables like life expectancy and educational attainment with flow variables like per capita income. Though it is argued that per capita income acts as a proxy for the stock variables reflecting economic development of a country, it is very difficult to accept a flow variable as proxy for one or more stock variables. It is better to construct a Human Development Improvement Index (HDII) with the help of flow variables

and a Human Development Stock Index (HDSI) separately for the stock variables than to construct a hotchpotch of flow and stock variables.

Composite versus Separate Index: The HDI is a composite index. It is an aggregation of a number of dimension indices. The process of aggregation leads to some information loss contained in the individual indices. Some critics of the HDI suggested to construct separate indices for each of the dimensions of development and not to combine them into any composite index because that would not carry any meaning, while others were of the view that the construction of a composite index was unnecessary because the correlations among the dimension indices were very high and only a little improvement was obtained through their aggregation.

Insensitive to distribution: The HDI is based only on the average values of the dimensions and is insensitive to their distribution among the individuals. The basic reason for which the Index is kept insensitive to distribution is the non-availability of required data for all variables and for all countries.

As the HDI is insensitive to distribution, the UNDP has started publishing Human Poverty Index (HPI) one for the developing countries and the other for selected OECD countries.

Insensitive to discrimination: Gender bias is another important aspect in social underdevelopment and this is not taken care of in the Human Development Index. To overcome this problem the UNDP has started publishing two other indices, viz., Gender-related Development Index (GDI) and Gender Empowerment Measure (GEM).

Thus, the existing methodology of the HDI fails to accommodate all relevant variables of human development. It may not be possible to include all of them in a single index formed by an additive function because the variables may not have linear substitutability. The existing methodology also fails to value the included aspects properly and this raises several criticisms to the methodology.

In the HDI the range divides the deviations of the actual values of a variable from its minimum value. This normalises not only the unit of measurement of the variable but to a large extent its variance also. Thus, the variances of all three dimension-indices in the HDI become almost equal (at about 0.036 as calculated by Biswas and Caliendo (2002)). The method of indexing leads to some information loss.

Some academicians use ranks of different dimension variables as the indices. But it contains further less information and the methodology is worse than the existing one.

If the standardised values of the variables (for which deviations of the actual values from the mean value are divided by the standard deviation) are used, the values of the dimension indices and so the development index, normally but not necessarily, lie in between –3.0 and +3.0 and the variances of all dimension indices become equal to 1.0. The countries or regions having negative development indices can be called less than average and those having positive indices can be called more than average. This index will have a greater explanatory power. But as the variances of these new indices will also become equal this cannot show any significant improvement over the original one. However, if the deviations of the actual values from the mean value or from the minimum value are divided by the mean value or the minimum value respectively, the variances of the new indices will not become equal and they will to a great extent reflect the variances of the original variables. Specifically, if the deviations of the actual values from the respective mean values are divided by the mean values, the variances of the new indices will just be the squares of their coefficients of variations, which are comparable.

A proper measure of human development should include all variables reflecting any one or more of different aspects of human development. It is neither proper to choose only four of them or to assign some predetermined probabilities to a few of them and to assign zero probability to all other, nor it is proper to assign constant or equal probabilities to them.

Variables reflecting different aspects of human development are dependent and interdependent. A variable that is completely dependent on others has no independent weight and can be excluded. Variables relating to any one aspect of human development will have high interdependence unless they are related to different mutually exclusive sub-aspects. In any aspect a variable that has high correlation with all other variables will receive maximum weight because that can be treated as the key variable governing that aspect of human development. In this way variables may be assigned different weights. If variables are not properly measured or if observations are not sufficient the choice of a social planner may be incorporated. Weights should not be constant. They should vary across regions and also over time.

Moreover, when human development index is constructed as a linear combination of individual indices, non-linear relation among different variables are to be eliminated through suitable transformation of the individual indices.

3. The UNDP Methodology Modified

This section proposes some modifications to the UNDP methodology so as to eliminate the problems with indexing, discounting and choice of weights and to make the Human Development Index more policy implicative. There is no doubt about the fact that human development and not simply economic development is the ultimate objective of development programmes. If some social ends, which the human beings are willing to achieve or should achieve, are neglected in achieving economic end only, the extent of human development will be less. Thus, programmes should be devised in such a way that there occurs an all-round development. Construction of Human Development index loses its importance unless the index can lend itself for framing policies for human development. Through the modifications proposed below the Human Development Index can also be used as policy tools. Though the modifications are involved mainly with the problem of indexing and discounting variables and choosing weights for different variables, the problem regarding the choice of variables and choice of goalposts are also eliminated to a great extent and other problems are assumed away by restricting the domain of analysis. This modified methodology is used to reconstruct Human Development Index for the countries included in the HDRs of 1995 and 2003, to reconstruct Human Development Index for major states of India for the years 1991 and 2001, to reconstruct Human Development Index for the districts of West Bengal for the years 1991 and 2001 and also to construct Human Development Index for the blocks of Midnapore district for the years 1991 and 2001 in Mondal (2005).

3.1. Choice of Variables: As indicated earlier, human development includes several aspects of human life. There may exist more than one sub-aspect and so more than one variable to explain any single aspect. They are not usually independent of one another. Dependence may be singular or multiple, linear or non-linear, one-way or both-way, etc. Variables in a single aspect are more closely related within themselves than with the variables in any other aspect. Although the variables in any single aspect may exhibit low correlations within themselves if they are related to independent sub-aspects in the said aspect. When variables are chosen, when they are indexed and when the weights and functions of discounting are constructed the above relations and correlations are to be considered properly, because that not only gives proper importance to the variables, but raises the scope for including other variables also.

Human development encompasses development in economic as well as social, cultural as well as spiritual, moral as well as ethical, sociological as well as political, demographic as well as

vital aspects of human life. If non-availability of proper data on variables measuring development in the above aspects is the main problem of forming a true human development index, non-identification of interrelations (both theoretical and observed) among them is the next important problem. Even if the analysis is restricted to economic and social aspects of human life only, even if social aspect is judged by knowledge (education) and health only and even if economic development is measured by per capita income, development in knowledge (education) is measured by adult literacy and enrolment, and development in health is measured by life expectancy at birth only, the variables lead to a different human development index if the interrelations among the variables are properly analysed and the correlations among them are used in the construction of the index.

Social development measured in terms of development of knowledge and health is not independent of economic development measured by per capita income. Similarly, development of knowledge is not totally independent of development of health. Moreover, the relations among them are not all linear. In the modified UNDP methodology, all these relations (linear or non-linear) and correlations (degree of association) are used in the formulation of the HDI so that the scope for accommodating other relevant variables increases.

3.2. Choice of Goalposts: With goalposts made fixed from future projection, the cross-section analysis becomes less meaningful than that with goalposts determined by observed maxima and minima, and the inter-temporal analysis becomes dependent on the time span and on the method of projection. On the other hand, with goalposts determined by observed maxima and minima in any year the inter-temporal analysis becomes meaningless. But if observed maxima and minima, observed not in a particular year but over all the years for which the comparison is desired, are taken as goalposts both cross-section and inter-temporal analyses can be made meaningfully. But then in each new year the comments made about the past will be constantly revised.

3.3. Choice of Weights: As human development includes several aspects of human life, human development index is to be formed as a weighted combination of individual indices. Weights should not only be the choice of social planners; it should also be according to the explanatory power of the individual indices. In the modified methodology weights of individual indices are kept proportional to their explanatory powers in explaining the variation of the final index (that is, to their correlation with the final index). Variance and covariance of

individual indices now enter into the weights and so the existing method of indexing can be retained.

If I_1, I_2 and I_3 are three indices to be combined then in the modified method I_1 will have larger weight than I_2 and I_2 will have larger weight than I_3 if the correlation between I_1 and I_2 is greater than that between I_1 and I_3 and the correlation between I_1 and I_3 is greater than that between I_2 and I_3. Larger is the difference between these correlations; larger will be the difference of the weights. This weighting principle is based on the assumption that the correlation between any two indices is due to their interdependence and we have no specific knowledge about the direction of this dependence. Thus, a high correlation between I_1 and I_2 leads to large weights both of I_1 and I_2. But if is known beforehand that this high correlation is totally due to dependence of I_2 on I_1 then this large correlation is transmitted only to a large weight of I_1 and I_2 will receive no credit from this high correlation.

As the final index cannot be calculated unless the weights are determined and as the weights (or the correlations) cannot be calculated unless the final index is determined, they are calculated simultaneously through an iterative process. The process starts with some arbitrarily fixed weights of the individual indices. On the basis of these weights a human development index is determined. In the third step correlations of the individual indices with the human development index are obtained and these are used as weights to arrive at the new human development index. In the next step new correlations and new weights and so another new human development index is obtained. The process is repeated until the correlations converge to their earlier values and the final weights along with the final human development index is obtained. This method can be called the Iterative Correlation Method (ICM).

Human development is a weighted average of development in different aspects of human life. Weights are neither expected to be equal nor they are observed to be equal. Observed weights of different indicators can be measured to a great extent by the correlation method mentioned above under the assumption that weights attached by the social planners (or the policy makers) to the individual indicators for the most developed region are equal. In the calculation of human development index both the difference in weights proposed by the social planners and the same observed in reality are to be considered. It is relevant to mention in this context that social planners have a theoretical understanding about the relations among the variables that can be observed or they can observe the reality more easily than a common man and the observed weights are not expected to differ much from those prescribed by the planners.

Assigning weights by the observed correlations has a real danger. Observed correlations are outcome of different types of theoretical relations among the variables, of the priorities attached by the social planners about and around those variables and of the priorities attached by the people regarding them. To what extent and in what way correlations can be used as weights depend on the underlying theoretical relations. Correlations will not be very good representative of weights if the social planners are willing to change their priorities drastically.

In proposing correlations (degrees of linear association) as weights it is assumed that the priorities attached by the social planners are no longer overriding or there is no drastic change in the priorities of the social planners. It is further assumed that there exists no strong non-linear relation among the variables indexed and combined. It is also assumed that the variables used reflect distinctly different ends. If more than one variable are used for a single end or for two different aspects of an end, then they are to be combined first before combining the combination with the variables reflecting other ends.

3.4. Method of Discounting Variables: When weights of different variables are constant, whatever be the method of fixing weights, human development becomes a linear combination of different indices, even if there exist clear non-linear relations among them. For example, index of literacy rate, or the literacy rate as such, is both expected and observed to increase at a decreasing rate with the increase in per capita income. In many circumstances literacy rate is observed to increase at a constant rate with the increase in log of per capita income. Thus per capita income is discounted by taking its logarithm before indexing and combining with other indices. This leads to decreasing relative weights of per capita income and increasing relative weights both of education and health indices. A method very similar to the correlation method can be used to examine how weights of different variables change over their values and from that, suitable method of transformation of variables can be developed so that unequal and varying weights for each variable can be meaningfully used. With this method the weight of any variable does not remain fixed over time or across regions.

There may be significant non-linear relation between any two indicators and the linear combination of them becomes meaningful only if some or all of them are transformed to eliminate such non-linearity. This is what is tried by the UNDP by an arbitrary transformation of per capita GDP. The new methodology proposes to transform all relevant variables so that any non-linear correlation of them with the final index is eliminated.

The transformation used in the book by Mondal (2005) is mainly a quadratic transformation. For GDP per capita a logarithmic transformation along with a quadratic transformation is used to have best results. For this variable, as we shall see in Mondal (2005), even logarithmic transformation is not sufficient to bring about linearity with other variables. After having an estimate of human development index obtained by the correlation method it is examined whether the human development index has a significant quadratic relation with the individual indices. A restricted least square procedure is used for the estimation of the parameters in the equation

$$HDI = a + b(\text{individual index}) + c(\text{individual index})^2$$

with the restriction that a=0 and c=(1-b). Thus, only b is estimated. If the value of b is found to be less than 1 the relation is convex and for b greater than 1 the relation becomes concave. If any such significant relation is found, the individual index is transformed with the help of that quadratic relation so that the individual index is modified by

$$\text{modified individual index} = \hat{b}(\text{individual index}) + (1 - \hat{b})(\text{individual index})^2$$

These new indices are then combined into the new human development index with the help of the correlation method explained earlier. In the next step variables are transformed once again and another new index of human development is obtained. The process is continued until the non-linear relation of the final index with the individual indices are eliminated.

To sum up, the modified methodology that is used in Mondal (2005) includes same types of variables and same grouping of variables as are used in the UNDP approach. This is how the assessment of the social planners regarding the relative weights of different indicators is incorporated in the formulation of human development index. Observed minima and maxima, observed in any of the years for which comparison is desired, are used as goalposts. Each variable is normalised by dividing the deviations of values from the minimum value by its range. Weights of the individual indices are made proportional to their correlations with the final index. Individual indices are transformed so that any quadratic correlations of them with the final index are eliminated.

For further discussion and empirical verification on international as well as on Indian data see Mondal (2005).

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