What Do We Know After 15 Years of Using the United Nations Development Programme Human Development Index?

By

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Abstract

We examined the relevance of the Human Development Index (HDI) of the United Nations Development Programme (UNDP) over the period 1990–2004. We identified three factors that have influenced HDI throughout this period: Methodological modifications, changes of limit values of variables, and the evolution of living conditions of citizens. The hypothesis for this study was that HDI has not been relevant since 1990 because the evolution of living conditions was the least important factor. We used a Shapley-Owen-Shorrocks (SOS) approach to decompose annual variations of HDI, using the 15 UNDP databases published in the world human development reports since 1990. Our hypothesis was accepted for non-European high HDI countries but was rejected for the large majority of European high HDI and for low and average HDI countries. We formulated recommendations to increase the relevance of this index for all countries.

Acknowledgements

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1. Introduction

Since the end of the 1960s, when the limits of the gross national product (GNP) per capita were discovered, economists have been looking for a better development indicator. The required indicator must have three characteristics. First it must be synthetic, including economic and social aspects of well-being. Second, it must be relevant, i.e., its level and its variations must reflect the reality of living conditions of populations. Third, it must be operational, and serve as a dashboard for development policy.

Many authors have attempted to construct such a development measure. Some examples are the General Development Index (GDI) and the Physical Quality of Life Index (PQLI). McGranahan (1972) suggested GDI. This is an aggregated measure of the social aspects of life; economic aspects are not considered. GDI therefore is not synthetic and cannot be accepted by the majority. A few years later, Morris (1979) proposed PQLI, an aggregated measure of development, constructed on nine economic and nine social variables of living conditions. However, the numerous social and economic variables of PQLI are sometimes negatively correlated with each other. So PQLI cannot be considered relevant.

In 1990, the United Nations Development Programme (UNDP) proposed the Human Development Index (HDI). UNDP has computed HDI annually for every country each year since. Many political authorities and even economists refer to HDI to appreciate the relative development of countries. It gathers the most significant economic variable (revenue) and the two most representative social aspects of life (education and health); it is therefore a synthetic index. Nonetheless, the question of relevance[1] remains to be answered. From 1990 to 2004, have HDI variations been explained principally by changes in the living conditions of citizens? This study aims to provide an answer to this question.

The hypothesis of this study is: The evolution of living conditions of citizens has accounted for a residual share of variations of HDI through the period 1990–2004 for every individual UNDP country.

The main objective, on the other hand, is to appreciate the relevance of HDI from

1990 to 2004. This objective is realized through two specific objectives:

1. Identification and analysis of factors that, throughout the period, have been able to cause variations of HDI for a country.
2. Decomposition of HDI variations in order to estimate the contribution of each of these factors.

2. Presentation of the Human Development Index

HDI contains the most representative economic variable (revenue) and the two most relevant social variables (health and education). In 1990, health is represented by life expectancy at birth, education by adult literacy rate, and revenue or material well-being by real gross domestic product (GDP) per capita in purchasing power parity (PPP) dollar. Mathematically, HDI is calculated as the complementary one to unit of the simple arithmetic mean of the partial lack indicators (PLI) computed in these three domains.

Calculation of partial lack indicators

PLI for a country in one domain indicates the distance between this country and the most advanced country as a percentage of the whole distance between the most developed country (to catch up) and the least advanced country.

In the domain of health

In 1990 UNDP used life expectancy at birth as follows:

- Maximum (life expectancy) = 78.4 years = that of the most advanced country, Japan.
- Minimum (life expectancy) = 41.8 years = that of the least advanced country, Sierra Leone.

So if x_{ij} is life expectancy in country j, then its PLI is given by:

$$PLI_{1j} = \frac{78.4 - X_{1j}}{78.4 - 41.8} \tag{1}$$

In the domain of education

In 1990 UNDP used the adult literacy rate as follows:

- Maximum = 100 (level that many developed countries approached).
- Minimum = 12.3 (level of Somalia).

So that if x_{2j} is the adult literacy rate in country j, its Partial Lack Indicator is given as:

$$PLI_{2j} = \frac{100 - x_{2j}}{100 - 12.3} \tag{2}$$

In the domain of material well-being

Material well-being is computed from individual revenue. Average individual revenue is real GDP per capita, in PPP dollar. In order to take into consideration the law of decreasing marginal utility of revenue, UNDP calculated a logarithmic transformation of the GDP per capita. The organization also considered that above a certain threshold, (international poverty line, Y*),[2] marginal utility of additional units of revenue is null. Material well-being (W) as a function of GDP per capita was therefore defined as:

$$\begin{aligned} W(y_j) &= Log(y_j). && \text{if} \quad y_j < Y^* \\ &= LogY^* && \text{if} \quad y_j \geq Y^* \end{aligned} \tag{3}$$

Then PLI in the domain of material well-being for country j whose revenue per capita is y_j is given as:

$$\begin{aligned} PLI_{3j} &= \frac{\log(Y^*) - Log(y_j)}{Log(Y^*) - Log(y_{\min})} && \text{if} \quad y_j < Y^* \\ &= \frac{Log(Y^*) - Lo(Y^*)}{Log(Y^*) - Log(y_{\min})} = 0 && \text{if} \quad y_j \geq Y^* \end{aligned} \tag{4}$$

The average lack indicator

The average lack indicator (ALI) is the average of the PLIs:

$$ALI_j = \frac{PLI_{1j} + PLI_{2j} + PLI_{3j}}{3} \tag{5}$$

The Human Development Index

HDI is complementary to the unit of ALI:

$$HDI_j = 1 - ALI_j \tag{6}$$

So if HDI of a country is equal, for example, to 0.50, the level of development of this country is halfway between the most delayed and the most developed countries with regard to education and health, and halfway between the revenue per capita of the poorest country and the international poverty line Y*.

However, the method of calculation of HDI has changed many times since 1990. Many modifications have been introduced in the method of calculation of PLIs: The treatment of GDP per capita has been modified many times; the procedure of fixing the limit values of variables has been modified several times; other variables have been introduced in the domain of education, etc. These multiple methodological modifications of HDI are presented in detail in Section 4. In spite of these successive improvements, criticism of HDI continues. A review of this criticism will help us identify factors of variation of HDI.

3. Literature review

Since 1990, there has been external and internal criticism of HDI. A review of some of this criticism is presented by Fongang (1996). It can be classified according to whether they tackle representativeness of variables, their mathematical treatment, their overall coherence or the inter-temporal comparison of HDI.

Dasgupta and Weale (1992) reproach UNDP for limiting itself to the socio-economic sphere of life, neglecting certain political and civil variables, such as human freedoms, that significantly influence human development. Some authors think that adult literacy rate is not the best indicator of the level of education, and reproach UNDP for not considering non-formal education, the importance of which is already demonstrated (Coomb and Manzoor, 1974; Tinbergen, 1974; Cotlear, 1990; Kelly Allen, 1991; Hopkins, 1991; Dasgupta, 1993). As life expectancy is considered, Dasgupta (1993) thinks that survival does not mean individual capacities. Trabold-Nubler (1994) indicates that it is preferable to die at 70 years of age after a pleasant life rather than to live a miserable life for 75 years.

Concerning the overall coherence of variables, Cornia (1990) discovered that the fall in health expenditure during the 1980s in several developing countries directly influenced their infant mortality and malnutrition statistics. This means that a correlation may exist between revenue and health. So there should be a need to improve the coherence in a modified human development index (Noorbakhsh, 1997, 1998). This suspicion has been confirmed by Cahill (2000) and by UNDP economists who showed that the variables used in the calculation of HDI are strongly correlated (UNDP, 2001). Indeed, on the basis of data from 174 countries, UNDP obtained a correlation coefficients matrix (Table 1).

In order to examine this problem in greater detail, we have computed these

Table 1 : The correlation coefficients between human development variables across UNDP countries

	Life expectancy	Education indicator	Real GDP per capita
Life expectancy	1.00	0.79	0.82
Education indicator	0.79	1.00	0.77
Real GDP per capita	0.82	0.77	1.00

Source : UNDP (2001).

correlation coefficients on cross-country data for years 1992, 1995, 1998 and 2004. The results are presented in Table 2.

It appears that life expectancy at birth, instruction and material well-being used

Table 2 : Matrix of correlation coefficients among human development index variables on the basis of cross-country data, 1992, 1995, 1998 and 2004

		Life expectancy at birth				Indicator of instruction				Indicator of material well-being			
		1992	1995	1998	2004	1992	1995	1998	2004	1992	1995	1998	2004
Life expectancy at birth	1992	1	x	x	x	0.845	x	x	x	0.847	x	x	x
	1995	x	1	x	x	x	0.845	x	x	x	0.832	x	x
	1998	x	x	1	x	x	x	0.811	x	x	x	0.810	x
	2004	x	x	x	1	x	x	x	0.734	x	x	x	0.755
Indicator of instruction	1992	0.845	x	x	x	1	x	x	x	0.776	x	x	x
	1995	x	0.845	x	x	x	1	x	x	x	0.832	x	x
	1998	x	x	0.811	x	x	x	1	x	x	x	0.810	x
	2004	x	x	x	0.734	x	x	x	1	x	x	x	0.755
Indicator of material well-being	1992	0.847	x	x	x	0.776	x	x	x	1	x	x	x
	1995	x	0.832	x	x	x	0.832	x	x	x	1	x	x
	1998	x	x	0.810		x	x	0.810	x	x	x	1	x
	2004	x	x	x	0.755	x	x	x	0.755	x	x	x	1

Source. Author's work.

every year by UNDP in the calculation of HDI are strongly correlated with each other. Does this mean that the main development indicator remains GDP per capita, as social variables depend positively and strongly on it? If this is the case, HDI should be regarded as a useless complication, as pointed out by McGillivray (1991).

Concerning mathematical treatment of variables, Bhanojirao (1991) disapproves of UNDP considering ALI as a simple arithmetic mean, and considers all variables with the same importance. Kelly Allen (1991) criticizes the treatment of revenue per capita

in the 1990 HDI. According to these authors, UNDP erred by thinking that the surplus revenue above the international poverty line is useless. In response, from 1991 UNDP applied a simple version of the Atkinson (1983) formula which makes it possible to take into consideration the additional units of revenue above the international poverty line, by allotting them a progressively decreasing weight (UNDP, 1991). However, to date, despite many modifications, the treatment of revenue is unsatisfactory (Anand and Sen, 2000; Cahill, 2002).

Dealing with inter-temporal comparison, UNDP economists observed in 1994 that as HDI is calculated, a country that registers improvements in its human development variables can face a fall in its HDI, if the limit values of variables have changed more than proportionally (UNDP, 1994). By so recognizing that a country's HDI can change through time for reasons which have nothing to do with its results, UNDP economists joined a concern already expressed by Anand and Sen (1993). This poses the problem of relevance of HDI that this research aims to appreciate. The first step in this direction is to identify and analyse factors that have influenced HDI throughout this period.

4. Factors determining the level and variations of HDI

Given the foregoing discussion, any variation in HDI must be handled with care. For example, from 1990 to 1992, Cameroon's HDI fell from 0.474 to 0.313, but we must not immediately deduce that living conditions of Cameroonians worsened by this proportion, especially as the rank of this country sometimes moved in the opposite direction. Indeed, according to the results in Table 3, Cameroon (with a HDI estimated at 0.474 in 1991), was ranked 90th out of 130 countries. In 1995, with 0.503, it ranked 127th out of 174; in 2000 it ranked 134th in the same sample with a higher HDI (0.528). In 2004, out of 177 countries, Cameroon was 141st with a HDI estimated at 0.501.

Table 3: Evolution of HDI and the rank of Cameroon from 1990 to 2004

Years	1990	1992	1994	1995	1996	1997	1998	2000	2004
Cameroon HDI	0.474	0.313	0.447	0.503	0.481	0.468	0.481	0.528	0.501
Rank of Cameroon	90[b]	118[a]	124[a]	127[a]	127[b]	133[b]	132[a]	134[b]	141[b]
Number of countries	130	160	173	174	174	175	174	174	177

Source: Based on data contained in human development reports of UNDP (1990, 1992, 1994, 1995, 1996, 1997, 1998, 2000, 2004).

From Table 3, it appears that the retreat of HDI from 1995 to 1996 did not influence the country's rank. In the opposite direction, from 1998 to 2000, Cameroon's rank deteriorated while the HDI significantly increased. Given these contradictions, one question arises: What are the factors that determine HDI variations for a single country through time? From the 15-year experience, we realize that any country's HDI variation

In the field of material well-being, the method of computing the PLI has also registered two modifications: In 1991 and 1999.

1991 modification

In 1991, UNDP adopted an Atkinson (1983) formula so as to take into consideration revenues above the poverty line. Then for a country j whose revenue per capita is y_j, the material well-being (W) is given by:

$$\begin{aligned} W(y_j) &= y_j \quad \text{if} \quad y_j \le Y^* \\ &= Y^* + 2(y_j - Y^*)^{\frac{1}{2}} \quad \text{if} \quad Y^* < y_j < 2Y^* \\ &= Y^* + 2(Y^*)^{\frac{1}{2}} + 3(Y^*)^{\frac{1}{3}} + \ldots + n\left[y_j - (n-1)Y^*\right]^{\frac{1}{n}} \quad \text{if} \quad (n-1)Y^* < y_j < nY^* \end{aligned} \tag{9}$$

So the PLI of this country is given by:

$$PLI_j = \frac{W(y_{\max}) - W(y_j)}{W(y_{\max}) - W(y_{\min})} \tag{10}$$

1999 modification

In 1999, UNDP abandoned the Atkinson (1983) formula, and considered that even below the poverty line Y *, revenue faces decreasing marginal utility. It defined the material well-being W associated to y_j by:

$$W(y_j) = Log(y_j) \qquad \forall y_j \tag{11}$$

Consequently, the PLI for this country j is given as:

$$PLI_j = \frac{Log(y_{\max}) - Log(y_j)}{Log(y_{\max}) - Log(y_{\min})} \tag{12}$$

Impact of methodological changes on the value of HDI

From 1990 to 2004, UNDP modified the HDI formula three times: In 1991, 1995 and 1999. Everything being equal, these modifications are likely to change the trajectory of HDI of countries. This deviation can be appreciated as follows:

Let us define the HDI of a country j in year t as:

can be explained by three factors: The methodological transformations, changes of the limit values of variables, and the evolution of living conditions of its citizens. An appreciation of the importance of each of these factors will help underlying the question of research and orienting our research hypothesis.

Methodological modifications and their effects

By methodological modification, we mean any revision of the formula of PLI or the inclusion of any additional variable in the calculation of this. Since 1990, we have registered many methodological modifications that had an important impact on the trajectory of HDI, and on the ranking of countries.

Methodological changes in the domain of education

The PLI formula in the domain of education has been modified twice since 1990: In 1991 and in 1995.

1991 modification

In 1991, UNDP introduced a second variable, the Average Duration of Schooling. So the level of education in each country j is determined as:

$$E_j = \frac{2}{3}(ALR_j) + \frac{1}{3}(ADS_j) \tag{7}$$

where: ALR_j = adult literacy rate in country j, ADS_j = average duration of schooling in country j.

1995 modification

In 1995, the average duration of schooling (ADS) was replaced with the average gross rate of schooling (AGRS) in primary, secondary and higher education. So the level of education in each country is given by:

$$E_j = \frac{2}{3}(ALR_j) + \frac{1}{3}(AGRS_j) \tag{8}$$

Methodological changes in the field of material well-being

the country (V). So the effect of methodological change at any year t can be written as:

$$HDI_t(M_t, L_t, V_t) - HDI_{Mt}(M_{1990}, L_t, V_t) \quad \text{with} \quad t \geq 1991 \tag{14}$$

in which $HDI_{Mt}(M_{1990}, L_t, V_t)$ represents the HDI that would have prevailed at year t if the methodology used were that of 1990. For example in 1991, $HDI_{M1991}(M_{1990}, L_{1991}, V_{1991})$ is the HDI that would have prevailed for a country in 1991 if the methodology used were that of 1990. So for 1991 for example, this effect is measured by:

$$HDI_{1991} - HDI_{M1991} = HDI_{1991}(M_{1991}, L_{1991}, V_{1991}) - HDI_{1991}(M_{1990}, L_{1991}, V_{1991}) \tag{15}$$

By way of illustration, we have considered the cases of six countries randomly selected as follows: Two from the high HDI countries (Argentina and France), two from average HDI countries (South Africa and Romania) and two from the group of low HDI countries (Cameroon and Bhutan). In 1990–2004, the influence of methodological changes on the trajectory of the HDI of these countries is plotted in Figures 1 to 6.

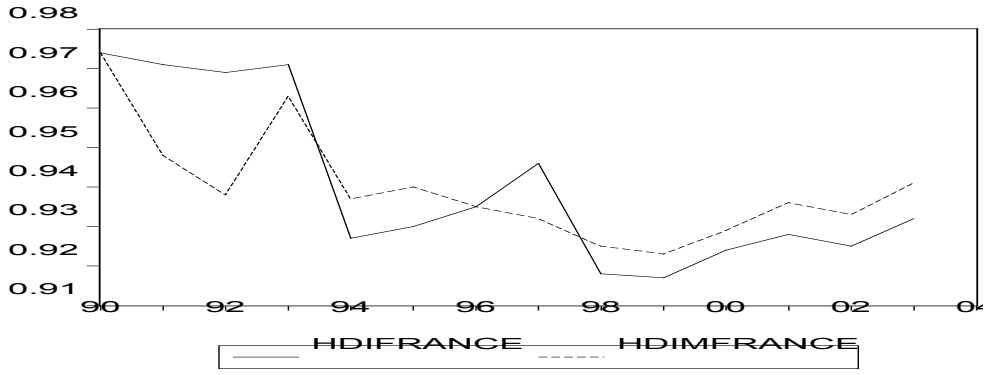
Figure 1: Evolution of the HDI of France (HDI_F) compared to its HDI_M from 1990 to 2004

Source: Author

Figure 2: Evolution of the HDI of Argentina (HDI_A) compared to its HDI_M from 1990 to 2004

Source: Author

Figure 3: Evolution of the HDI of South Africa (HDI_{SA}) compared to its HDI_M from 1990 to 2004



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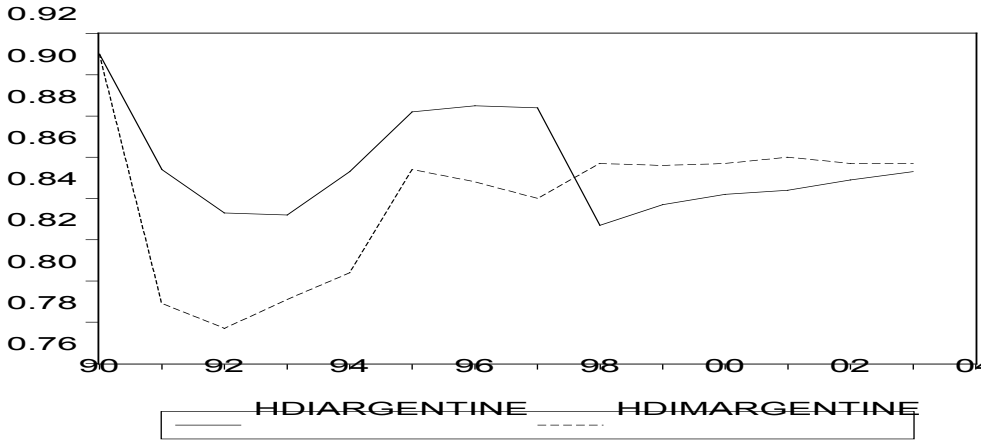
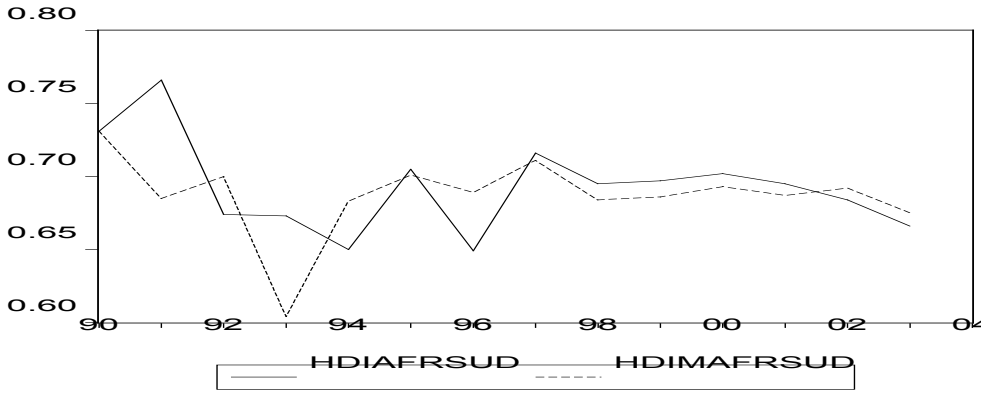


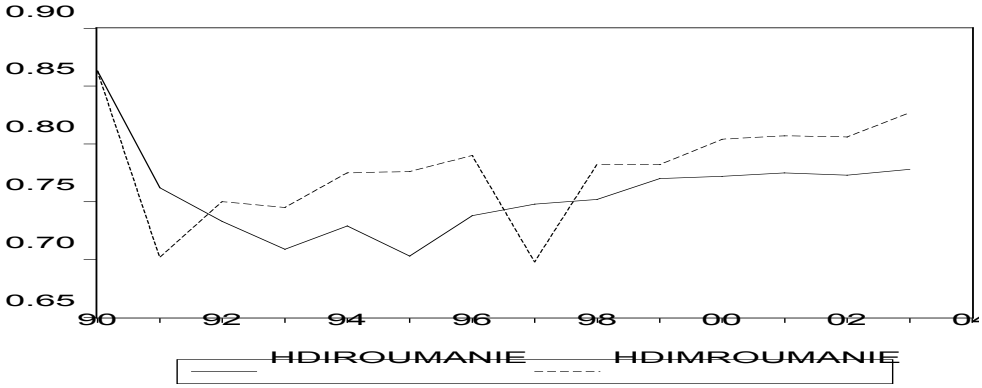
$$HDI_t = HDI_t(M_t, L_t, V_t) \quad \text{with} \quad t \geq 1990 \qquad (13)$$

That is HDI of any country at year t is a function of the methodology used (M), of



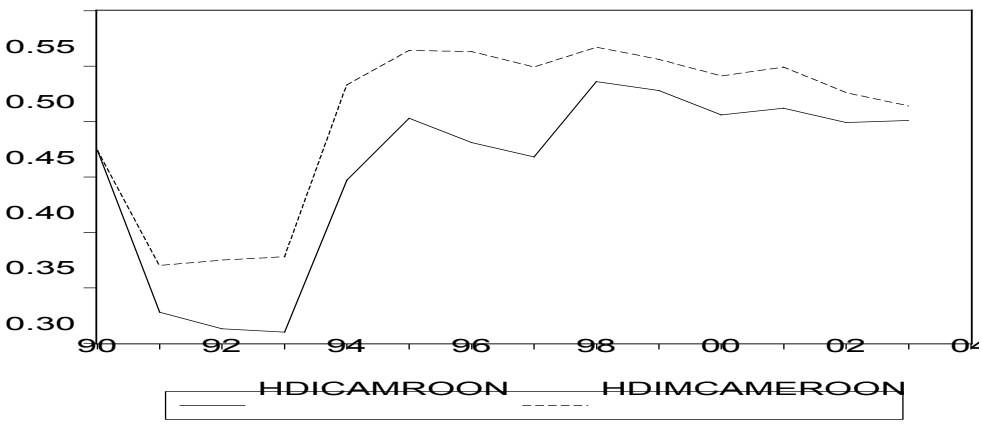
the limit values of variables (L) and the value taken by human development variables in

We made another ranking of countries according to their HDI_{M90}. This ranking differs significantly from the one made by UNDP on the basis of its HDI, especially in the



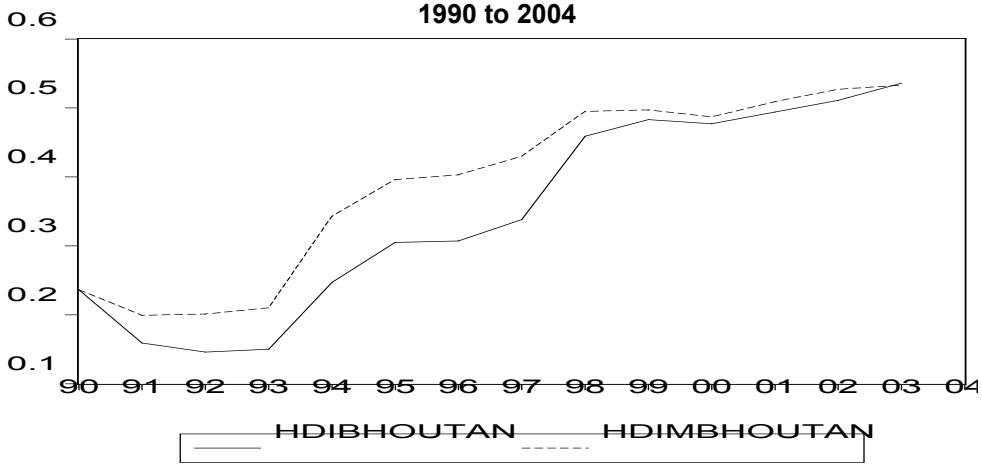
HDI countries in general, HDI would have been more important throughout the sub-period 1998–2004 than the one indicated by UNDP if the 1990 formula had been used.

These figures indicate that the methodological changes have influenced the evolution of HDI of different countries in different ways. The consequence is that these changes would also have modified the ranking of countries.



The impact on the ranking of countries

Figure 4: Evolution of the HDI of Romania (HDI_R) compared to its HDI_M from 1990 to 2004



Source: Author

Figure 5: Evolution of the HDI of Cameroon (HDI_C) compared to its HDI_M from 1990 to 2004

Source: Author

Figure 6: Evolution of the HDI of Bhutan (HDI_{BH}) compared to its HDI_M from 1990 to 2004

Source: Author

According to the results in these figures, HDI of these countries would have followed the trajectory in dotted lines if the method of 1990 had been preserved. The relative position of the two curves indicates whether the influence of the methodological modifications is negative or positive. The influence is negative if the dotted line is situated on the other continuous line, and positive in the opposite situation. The distance between the two curves indicates the importance of this influence.

So in the cases of Cameroon (Figure 5) and Bhutan (Figure 6), the influence of the methodological modifications on the value of HDI has been negative. This negative influence is more important for Cameroon than for Bhutan. So if the 1990 methodology had been preserved, HDI for Cameroon and Bhutan in particular, and for low HDI countries in general, would have been more important than the one indicated by UNDP.

For South Africa and Romania, the relative position of the two curves is not constant throughout the period. The HDI_M curve is sometimes above and sometimes under the HDI curve. The distance between the two curves is also not constant. This means that for these countries in particular, and for average HDI countries in general, there is no obvious tendency.

As far as Argentina (Figure 2) and France (Figure 1) are concerned, from 1998 to 2004 the HDI_M curve is situated under the HDI curve. Before 1998, the HDI_M curve is situated under the HDI one (Argentina), but there is no clear and constant tendency in the case of France. We can conclude that for Argentina and France, and for high

to US$350. These levels varied every year until 1995. From 1995, after the taking into account the sexo-specificity, maximum GDP per capita was US$40,000, and the

group of high HDI countries. In Table 4 we present some of the countries whose position on the HDI_{M90} order has significantly changed compared with their position in the HDI order.

The most important modification is that of Luxembourg. The county had higher rankings using HDI_{M90} than when using the UNDP rankings in 1991, 1993 and 1995 (Figure 4). Since 1997, Luxembourg has held the top position in our HDI_{M90} ranking except in 1999 when it was 2nd (Figure 4). This impact confirms the results of Morse (2003).

Modifications of limit values of variables and their effects

The modifications of limit values since 1990

In 1990, the maximum values of variables were essentially the level of the variable in the most advanced country and the minimum value of this variable in the least advanced country. By so proceeding, these limit values of variables were to change every year. To avoid this perpetual modification, UNDP later tried to fix them normatively, once over a long period.

In the field of health

In the field of health the minimal and maximal values of life expectancy at birth were 41.8 and 78.4 years in 1990, 42 and 78.6 years in 1991, 1992 and 1993. From 1994, they are normatively fixed at 25 and 85 years respectively. Two significant modifications of limit values of variables in this domain were therefore registered from 1990 to 2004.

In the field of education

In the field of education, minimal and maximal values of adult literacy rate were respectively 12.3% and 100% in 1990 , 13.3% and 99% in 1992. From 1994 they have been normatively fixed at 0% and 100%. The minimal and maximal values of the average duration of schooling were respectively 0.1 and 12.2 years in 1991, 0.1 and 12.3 years in 1992 and 1993; as from 1994, they have been normatively fixed at 0 and 15 years. From 1991 to 2004 we have registered two modifications of the limit values of adult literacy rate and two modifications of those of the average duration of schooling.

In the field of material well-being

For revenue per capita, the maximum in 1990 was US$17,615 (that of the USA) and the minimum was US$220 (the level of Zaire). The international poverty line was US$4,829. In 1991, the maximum increased to US$19,850 and the minimum

The impact on the trajectory of HDI of countries

From 1990 to 2004, limit values of human development variables have been modified several times. These modifications are likely to change the trajectory of HDI.

Let us say $HDI_t(M_t, L_{1990}, V_t)$ represents the HDI that would have prevailed for country j at year t if limit values of variables had not changed since 1990. For example, $HDI_{L1991} = HDI_{1991}(M_{1991}, L_{1990}, V_{1991})$ represents the HDI that would have prevailed for country j in 1991 if the limit values used had been those of 1990. We can then define the effect of modification of limit values for country j at t by:

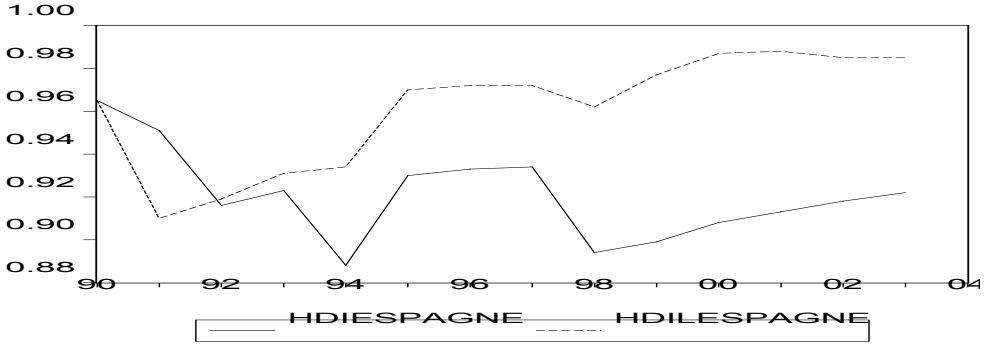
$$HDI_t - HDI_{Lt} = HDI_t(M_t, L_t, V_t) - HDI_{Lt}(M_t, L_{1990}, V_t) \tag{16}$$

For example, this effect on the HDI of country j in 1991 is given as:

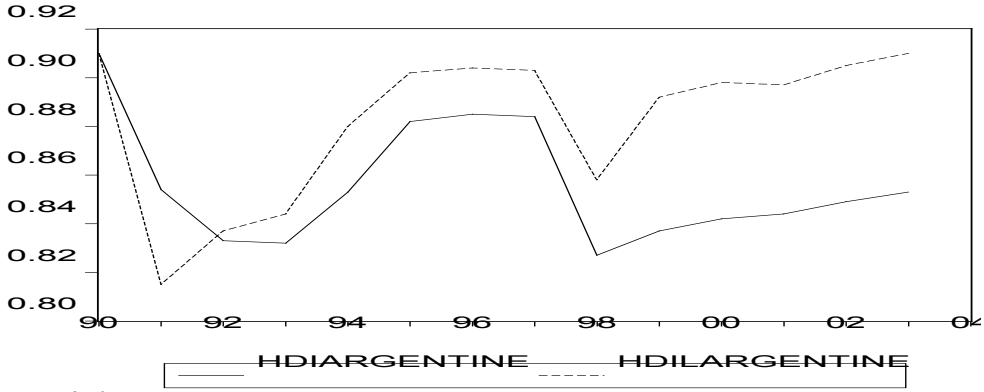
$$HDI_{1991} - HDI_{L1991} = HDI_{1991}(M_{1991}, L_{1991}, V_{1991}) - HDI_{L1991}(M_{1991}, L_{1990}, V_{1991}) \tag{17}$$

As an illustration, an application on the cases of six countries randomly chosen, with two from the high HDI countries group (Spain and Argentina), two from the average HDI countries (South Africa and Sri Lanka) and two from low HDI countries (Côte d'Ivoire and Niger), during the same period (1990–2004) gave the results represented in Figures 7 to 12.

Figure 7: The evolution of HDI of Spain (HDI_{Es}) compared to its HDI_{LEs} (1990–2004)

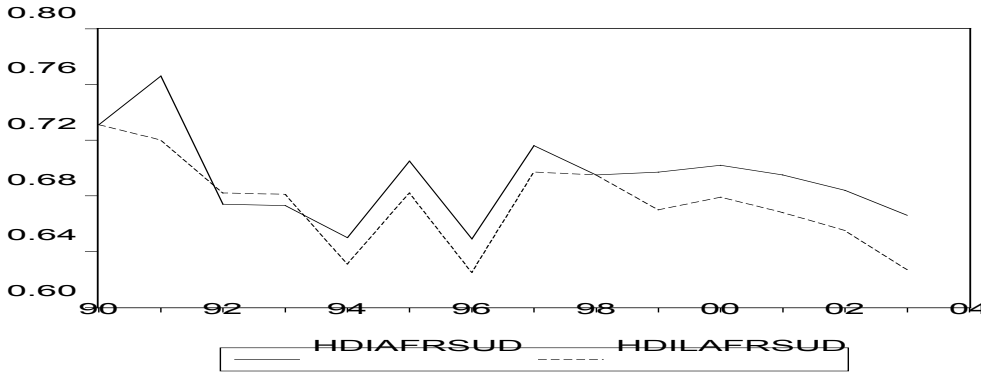


minimum US$100, and the poverty line estimated at US$5,711.



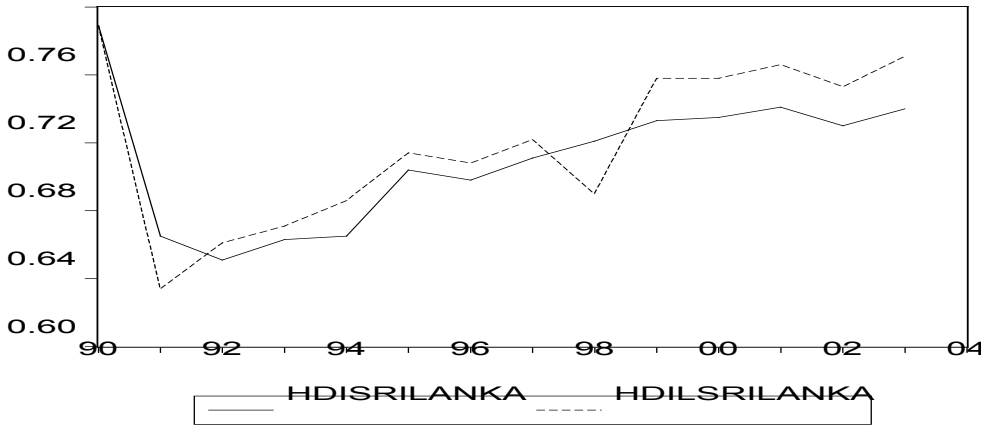
Source: Author

Figure 8: The evolution of HDI of Argentina (HDI_{Ar}) compared to its HDI_{LAr} (1990–2004)



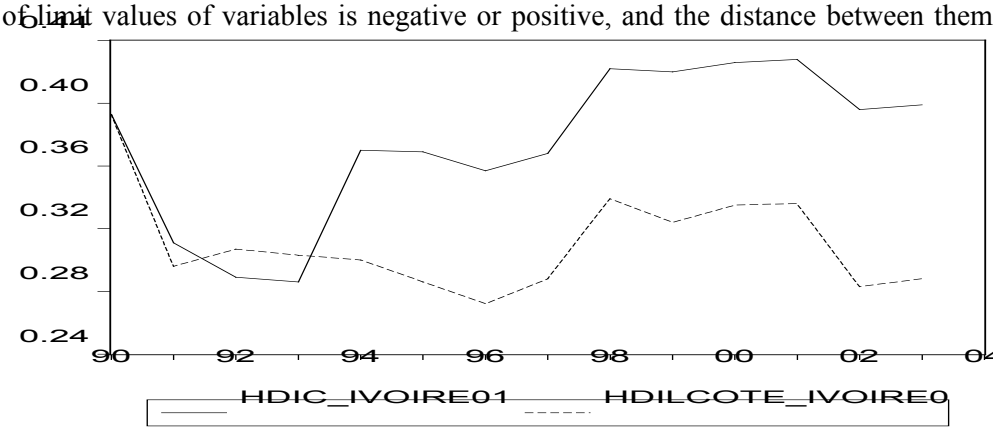
Source: Author

Figure 9: The evolution of HDI of South Africa (HDI_{S}) compared to its HDI_{LS} (1990–2004)



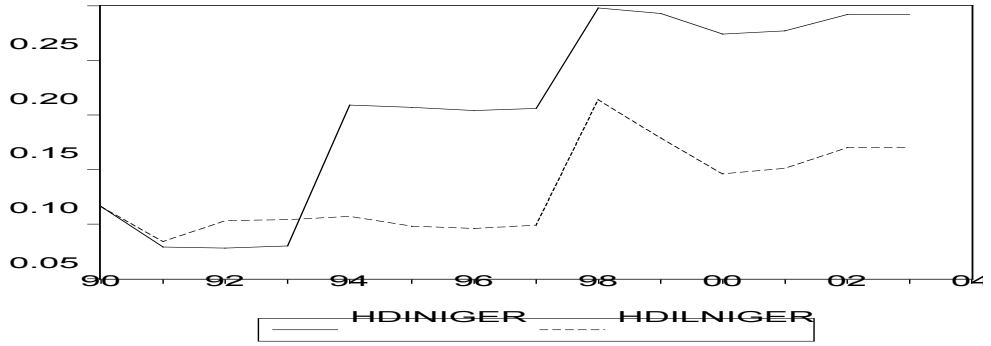
Source: Author

the relative position of the two curves indicates whether the influence of the evolution of limit values of variables is negative or positive, and the distance between them



indicates the importance of this influence.

In the cases of Spain (Figure 7) and Argentina (Figure 8), the HDI_L curve is situated above the HDI curve since 1992, meaning that the modifications of limit values of variables reduced the HDI of these countries. But this negative influence is more



important in Spain than in Argentina. These results for randomly selected countries indicate that the impact of modifications of limit values of variables is negative in high HDI countries.

For countries with average HDI, no general tendency appears. The relative position and the distance between the two curves differ from one country to another.

For Côte d'Ivoire (Figure 11) and Niger (Figure 12), HDI_L is situated under the HDI curve from 1993 to 2004. This means that the modifications of limit values of variables, since 1990, have increased the value of HDI of these countries. This result on randomly selected countries indicates that the impact of modifications of limit values would be positive in low HDI countries.

The impact on the ranking of countries

The results in Figures 7 to 12 indicate that the impact of modifications of limit values of variables is more important in some countries than in others. Therefore these modifications should have had an influence on the ranking of countries.

Indeed, we reclassified countries according to their HDI_{L90} and compared with the

Figure 10: The evolution of HDI of Sri Lanka (HDI_{Sr}) compared to its HDI_{LSr} (1990–2004)

Source: Author

Figure 11: The evolution of HDI of Côte d'Ivoire (HDI_{CI}) compared to its HDI_{LCI} (1990–2004)

Source: Author

Figure 12: The evolution of HDI of Niger (HDI_{NI}) compared to its HDI_{LNI} (1990–2004)

Source: Author

If limit values of human development variables used in 1990 had been preserved, HDI of these countries would have followed the trajectory in dotted lines. Once again

Table 5: Evolution of HDI compared to HDI_{L90}, with their corresponding rankings, for certain high HDI countries, 1991-2004

Countries			1991	1992	1996	1997	1998	2001	2002	2004
Canada	HDI	HDI	0.983	0.982	0.980	0.999	0.932	0.936	0.937	0.943
		Rang	2	2	1	1	1	3	8	4
	HDI_{L90}	HDI_{L90}	0.977	0.984	0.988	0.976	0.996	0.994	0.991	0.992
		Rang	2	1	1	1	3	5	9	9
Iceland	HDI	HDI	0.982	0.999	0.936	0.941	0.919	0.932	0.942	0.941
		Rang	3	11	6	5	9	7	2	7
	HDI_{L90}	HDI_{L90}	0.948	0.961	0.974	0.978	0.996	0.985	0.987	0.986
		Rang	10	11	3	4	13	12	11	12
United Kingdom	HDI	HDI	0.997	0.994	0.916	0.931	0.918	0.923	0.930	0.936
		Rang	11	10	18	15	10	14	13	12
	HDI_{L90}	HDI_{L90}	0.997	0.996	0.992	0.996	0.999	0.999	0.993	0.996
		Rang	6	10	18	16	5	8	7	7
Japan	HDI	HDI	0.993	0.993	0.937	0.940	0.924	0.928	0.932	0.938
		Rang	1	1	3	7	4	5	5	5
	HDI_{L90}	HDI_{L90}	0.978	0.983	0.972	0.973	0.960	0.977	0.978	0.980
		Rang	1	2	4	8	14	17	16	16
Sweden	HDI	HDI	0.982	0.977	0.929	0.936	0.923	0.936	0.941	0.946
		Rang	4	5	10	10	6	4	3	2
	HDI_{L90}	HDI_{L90}	0.982	0.978	0.971	0.976	1	0.987	0.987	0.987
		Rang	4	6	5	5	1	2	1	1

Source: Author's work.

Some of the notable modifications of the ranking are presented in Table 5.

Results in Table 5 indicate that the most important changes concern Japan and Sweden; this change is negative for Japan and positive for Sweden. Indeed, Japan's ranking according to HDI_{L90} is worse than that published by UNDP according to HDI. In 1999 for example, according to UNDP ranking, Japan is ranked 4th, but according to our HDI_{L90}, it occupied the 14th position. In 2004 Japan was 9th according to UNDP, but with our classification it was ranked 16th. Conversely, Sweden was at the top of the classification according to HDI_{L90}, contrary to the HDI ranking, so that since 1999 it has been ranked 1st.

Modifications of living conditions of citizens and the trajectory of HDI

The evolution of living conditions of citizens of a country must normally influence the trajectory of its HDI. To measure the importance of this influence let us say $HDI_{jVt} = HDI_{jVt}(M_t, L_t, V_{1990})$ is the HDI that would have prevailed for a country j at year t if the living conditions of citizens had not changed compared with 1990. We can then measure the effect of the evolution of these living conditions by:

$$HDI_{jt} - HDI_{jVt} = HDI_{jt}(M_t, L_t, V_t) - HDI_{jVt}(M_t, L_t, V_{1990}) \quad (18)$$

For example this effect for country j at 1991 is defined as:

$$HDI_{1991} - HDI_{V1991} = HDI_{1991}(M_{1991}, L_{1991}, V_{1991}) - HDI_{V1991}(M_{1991}, L_{1991}, V_{1990}) \quad (19)$$

To illustrate this, Figures 13 to 18 show the evolution of HDI and HDI_V in two high HDI countries (France and Japan), two average HDI countries (Sri Lanka and Myanmar) and two low HDI countries (Nigeria and Bhutan). These countries were randomly chosen.

UNDP classification. This comparison showed serious differences between the two rankings. The most important difference appeared in the group of high HDI countries.

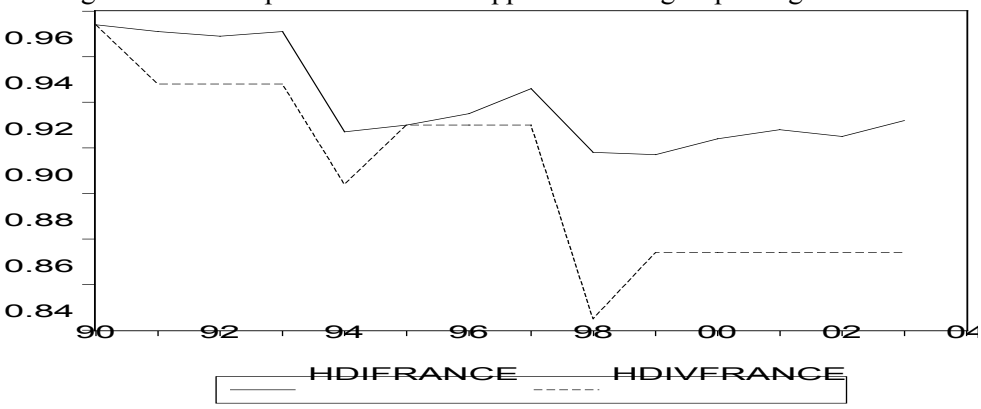


Figure 13: The evolution of HDI of France (HDI_F) compared to its HDI_{VF}, 1990–2004

Source: Author

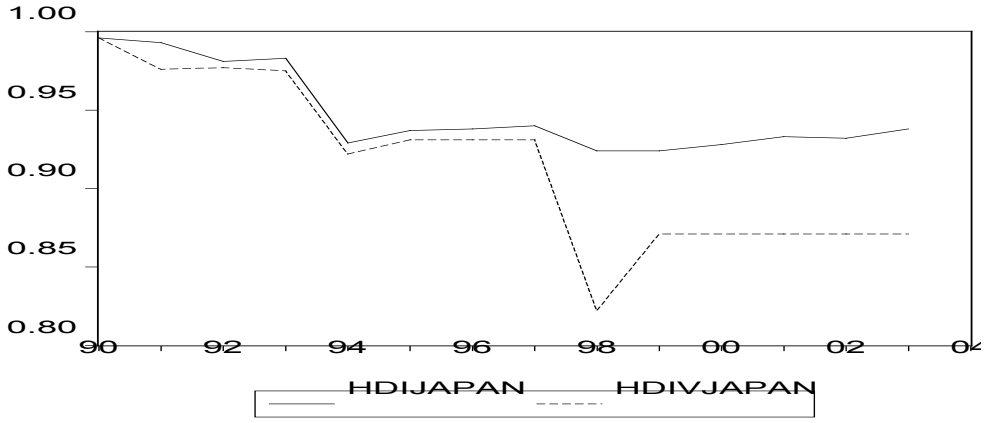


Figure 14: The evolution of HDI of Japan (HDI_J) compared to its HDI_{VJ}, 1990–2004

Source: Author

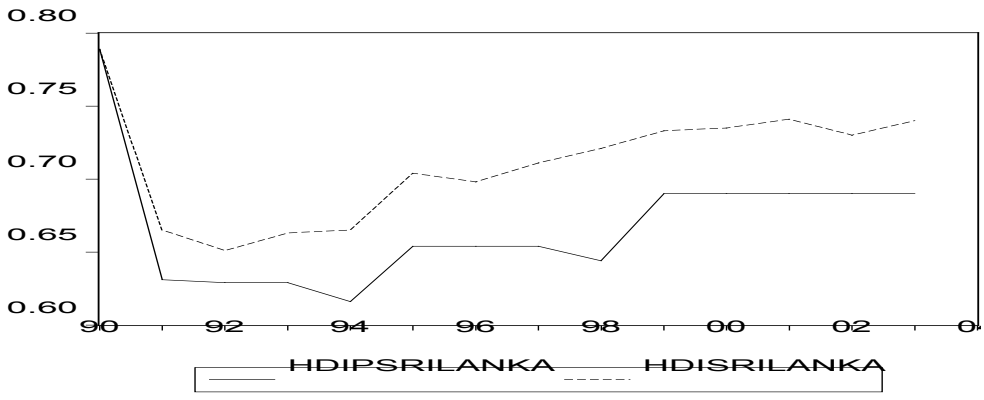
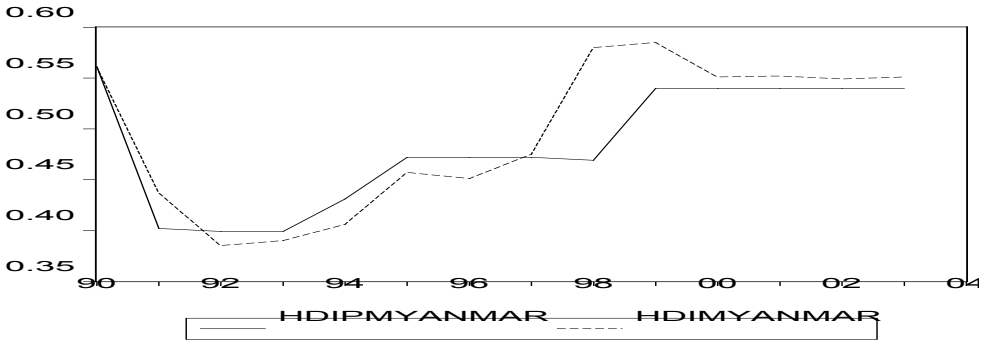


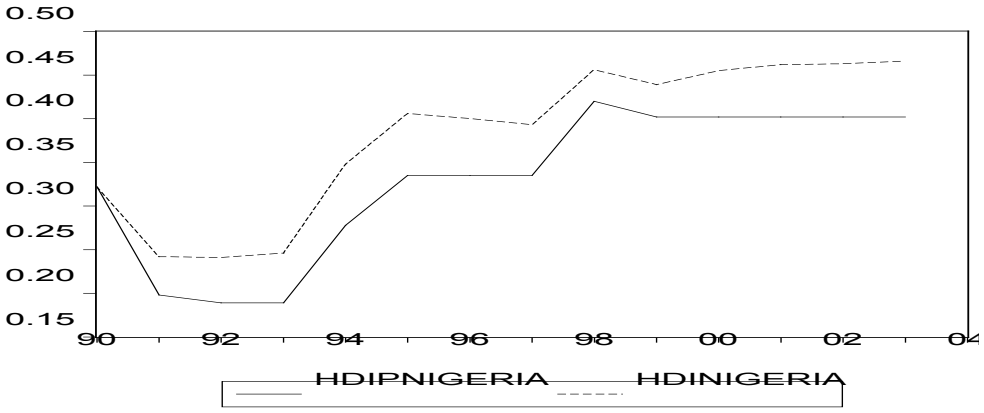
Figure 15: The evolution of HDI of Sri Lanka (HDI_{Sr}) compared to its HDI_{VSr}, 1990–2004

Figure 17: The evolution of HDI of Nigeria (HDI_{Ngria}) compared to its HDI_{VNgria}, 1990–2004



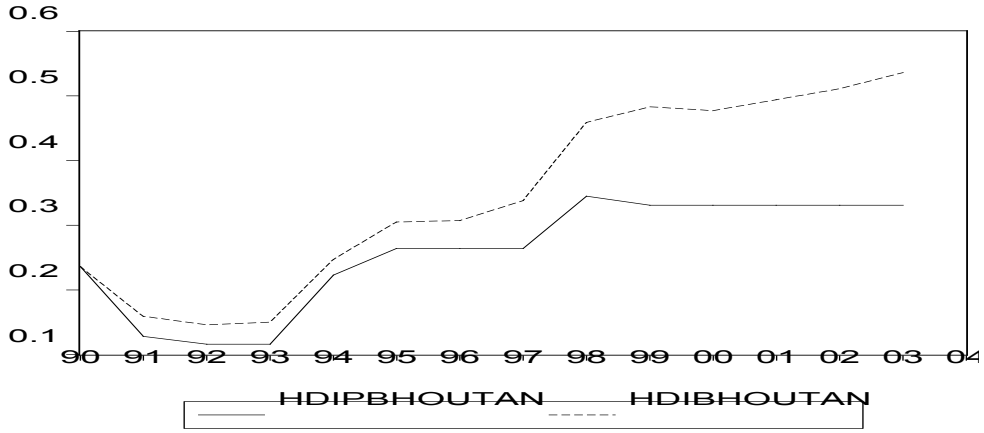
Source: Author

Figure 18: The evolution of HDI of Bhutan (HDI_{Bh}) compared to its HDI_{VBh}, 1990–2004



Source: Author

In Figures 13 to 18, the trajectory of the official HDI of each country is almost always above that of the HDI_V. This means that the evolution of living conditions in all these countries from 1990 to 2004 has been favourable, permitting an increase in their HDI.



The results in these figures also indicate that each of our three factors differently influenced the level of HDI of various countries. Each of them should then have influenced the ranking of UNDP countries according to the level of their HDI.

Source: Author

Figure 16: The evolution of HDI of Myanmar (HDI_{My}) compared to its HDI_{VMy}, 1990–2004

Source: Author

5. Methodology

Let us consider a player k, the marginal contribution to the profit of the coalition S is defined as the difference between what this coalition widened with the player k could obtain, and the profit of the not widened coalition S, is:

$$V(S \cup \{k\}) - V(S) \tag{22}$$

The contribution of the player k to the total profit, i.e. what the player must receive (or pay) as the share of the total profit (or of the total loss), is given as the expectation of its marginal contributions for the $(m-1)!$ coalitions of size $s < m$ that can be formed without the player.

There are s! ways of forming each coalition S containing s players (in different order), ordering the (m–s–1) other players in $(m-s-1)!$ different ways. This means that for each coalition S of s players, there are $s!(m-s-1)!$ possibilities.
So we can say that the probability of getting any coalition S of s players, without the player k, in any order, is $\dfrac{s!(m-s-1)!}{m!}$.

Given that coalitions of many different sizes (s=1,2,…,m-1) can be formed without the player k, the share of profit (or of loss) of this player, the Shapley value for this player, is obtained by:

$$\phi_k^s(K,V) = \sum_{s=0}^{m-1} \sum_{S \subseteq K-\{k\}} \frac{s!(m-s-1)!}{m!} \left[V(S \cup \{k\}) - V(S) \right] \tag{23}$$

In the literature, we distinguish two methods of decomposition of the level and the variations of a similar index: The Datt and Ravallion (1992) method and that of Shorrocks (1999). The two methods are based on the Shapley (1953) value, developed by Owen (1977), and called the Shapley-Owen-Shorrocks (SOS) approach after Shorrocks and Kolenilov (2001). The advantage of the second approach is that it does not leave any residue. It has already been used to break up the variations of poverty index in Burkina Faso (Kabore, 2002) and Cameroon (Baye Menjo, 2004). This study uses the second approach for its precision. I examine its theoretical framework before adopting a modality of its application to this study.

The conceptual framework of the SOS approach

The purpose

It is supposed that I (value or variation of the index) is related to m factors:

$$I = f(X_1, X_2, ..., X_m) \tag{20}$$

The aim of the decomposition is to attribute to each factor X_k a share I_k so as to have:

$$\sum_{k=1}^{m} I_k = I \tag{21}$$

After this specification of the problem, we remember in the proposal by Shapley (1953), within the framework the cooperative game theory, a method of equitably sharing the total profit (or the total loss) of the game among the players, so that each of them receives exactly its marginal contribution. This marginal contribution to the total profit (or to the total loss) is called the Shapley value. How is this Shapley value determined?

The determination of the Shapley value

According to its author, for each player k, the Shapley value is equal to the expectation of its marginal contributions to the profit of all coalitions that can be formed without the player. Then:

- Considering that there is m players k, (k=1,2,…,m), i.e. the population K of players has m elements k, and since the order is important, m! coalitions can be formed with or without the player k.
- For each coalition S of s players, with $S \subseteq K$, Shapley measures by $V(S)$ the profit that this coalition could have, without the assistance of any non-member player.

The application of the SOS approach to the decomposition of HDI variations

When we apply the SOS approach to the decomposition of the level or variation of an indicator such as poverty index, inequality or development index, we talk of m factors instead of m players. In the literature there are several applications on indexes depending on two factors (generally easy to carry out), but there are not enough applications on indexes depending on more than two factors. In this study, HDI or its variations depend on three factors:

$$HDI_t = f(M_t, L_t, V_t) \tag{24}$$

So HDI variations can be written as:

$$\Delta HDI_t = HDI_t - HDI_{t-1} = f(\Delta M_t, \Delta L_t, \Delta V_t) \tag{25}$$

in which ΔM_t is the methodological modifications, ΔL_t the modifications of the limit values of variables, and ΔV_t the modifications of living conditions of citizens.

In order to facilitate the application of the formula (Equation 23), we can construct Table 6, given that $m = 3$ and $m! = 6$.

We read:

$V(\varnothing)$ = HDI variation at year t if none of these factors had changed, that is if the three factors had kept their level of year t-1. So we can write:

$$V(\varnothing) = HDI_t(M_{t-1}, L_{t-1}, V_{t-1}) - HDI_{t-1}(M_{t-1}, L_{t-1}, V_{t-1}) = 0 \tag{26}$$

Table 6: Conditional probabilities for the application of the [illegible] for the discrete case with [illegible] and [illegible]

		Probability	Marginal contribution
Count Modifications of [illegible]:			
Number of [illegible]			
Factor 2: [illegible]			
Number of [illegible]			

			Probability		Hungarian contributors	
	x_i	x_j	$\frac{\exp(-\|x_i - x_j\|)}{\sum_{k \neq i} \exp(-\|x_i - x_k\|)}$		$p_{ij} \log \frac{p_{ij}}{q_{ij}}$	
Factors: Evaluation of life conditions in the Country of x_i:						
	$x_i = 69$	x_j	$\geq$	0	$p_{ij} \log \frac{p_{ij}}{q_{ij}}$	(0)
Number of countries with similar life conditions	$x_j = 69$	-	=	0	$p_{ij} \log \frac{p_{ij}}{q_{ij}}$	(0)
	$x_j = 67$	-	=	0	$p_{ij} \log \frac{p_{ij}}{q_{ij}}$	(0)
	$x_j = 69$	x_j	$\geq$	0	$p_{ij} \log \frac{p_{ij}}{q_{ij}}$	(0)

Source: Author's work.

$V(\{\Delta M_t\}) =$ HDI variation in year t if only the methodology had changed, the other two factors being considered as in year t-1. So we can define the marginal contribution of ΔM_t to a coalition of factors:

$$V(\varnothing \cup \{\Delta M_t\}) = HDI_t(M_t, L_{t-1}, V_{t-1}) - HDI_{t-1}(M_{t-1}, L_{t-1}, V_{t-1}) \tag{27}$$

$V(\{\Delta M_t\} \cup \{\Delta L_t\}) = HDI(M_t, L_t, V_{t-1})$ is the HDI variation in year t if the methodology and the limit values of variables had changed, or precisely are taken at their levels of the current period t. So we can write the marginal contribution of ΔL_t in a coalition of one element, ΔM_t :

$$V(\{\Delta M_t\} \cup \{\Delta L_t\}) - V(\{\Delta M_t\}) = HDI_t(M_t, L_t, V_{t-1}) - HDI_t(M_t, L_{t-1}, V_{t-1}) \tag{28}$$

Then the Shapley value for the methodology, that is the marginal contribution of methodological modifications in HDI variation at year t is given by:

$$CM_t = \frac{2}{6}\left[V(\varnothing \cup \{\Delta M_t\}) - V(\varnothing)\right] \tag{29}$$

That of the limit values modifications at year t is:

$$CL_t = \frac{2}{6}\left[HDI_t(M_{t-1}, L_t, V_{t-1}) - HDI_t(M_{t-1}, L_{t-1}, V_{t-1})\right] \tag{30}$$

And that of changes in living conditions of citizens is:

$$\begin{aligned}
&+\frac{1}{6}\left[V(\{\Delta L_t\} \cup \{\Delta M_t\}) - V(\{\Delta L_t\})\right] \\
&+\frac{1}{6}\left[V(\{\Delta V_t\} \cup \{\Delta M_t\}) - V(\{\Delta V_t\})\right] \\
&+\frac{2}{6}\left[V(\{\Delta L_t, \Delta V_t\} \cup \{\Delta M_t\}) - V(\{\Delta L_t, \Delta V_t\})\right] \\
&=\frac{2}{6}\left[HDI(M_t, L_{t-1}, V_{t-1}) - HDI(M_{t-1}, L_{t-1}, V_{t-1})\right] \\
&+\frac{1}{6}\left[HDI(M_t, L_t, V_{t-1}) - HDI(M_{t-1}, L_t, V_{t-1})\right] \\
&+\frac{1}{6}\left[HDI(M_t, L_{t-1}, V_t) - HDI(M_{t-1}, L_{t-1}, V_t)\right] \\
&+\frac{2}{6}\left[HDI(M_t, L_t, V_t) - HDI(M_{t-1}, L_t, V_t)\right]
\end{aligned}$$

$$CV_t = \frac{2}{6}\left[HDI_t(M_{t-1}, L_{t-1}, V_t) - HDI_t(M_{t-1}, L_{t-1}, V_{t-1})\right] \tag{31}$$

The data

$$+\frac{1}{6}\left[HDI(M_t, L_t, V_{t-1}) - HDI_t(M_t, L_{t-1}, V_{t-1})\right]$$
$$+\frac{1}{6}\left[HDI_t(M_{t-1}, L_t, V_t) - HDI_t(M_{t-1}, L_{t-1}, V_t)\right]$$
$$+\frac{2}{6}\left[HDI_t(M_t, L_t, V_t) - HDI_t(M_t, L_{t-1}, V_t)\right]$$

We used all 15 UNDP databases published in the *Human Development Reports* since 1990. Calculations were carried out for all UNDP countries using Excel 2000 spreadsheet.

$$+\frac{1}{6}\left[HDI_t(M_t, L_{t-1}, V_t) - HDI_t(M_t, L_{t-1}, V_{t-1})\right]$$
$$+\frac{1}{6}\left[HDI_t(M_{t-1}, L_t, V_t) - HDI_t(M_{t-1}, L_t, V_{t-1})\right]$$
$$+\frac{2}{6}\left[HDI_t(M_t, L_t, V_t) - HDI_t(M_t, L_t, V_{t-1})\right]$$

6. Results

According to the results obtained, we cannot accept our research hypothesis. Throughout the period 1990–2004 in a large majority of countries, modifications of living conditions of citizens don't constitute the least important factor of HDI variations. The detailed results for 15 randomly selected countries are presented in Annex 1. A ranking of these factors, from the most to the least important, is given in Table 7.

Table 7: Ranking of factors, from the most to the least important, for some randomly selected countries, 1990–2004 averages

Countries	Ranks of factors*		
	Methodological modifications	Modifications of limit values of variables	Modifications of living conditions of citizens
Japan	3	1	2
Canada	3	1	2
USA	3	1	2
France	3	2	1
Belgium	3	2	1
Chile	1	2	3
South Africa	3	1	2
Costa Rica	2	3	1
Brazil	2	3	1
Honduras	2	3	1
Nicaragua	3	2	1
Cameroon	1	3	2
Haiti	2	3	1
Côte d'Ivoire	2	3	1
Kenya	2	3	1

* 1 stands for the most important factor, 3 for the least important.
Source: Author's work.

In 1991

From 1990 to 1991, the HDI of all countries dropped. This drop is largely explained by the methodological modification of 1991. Thus, that of Canada dropped by 0.0035, the methodological modification contributing 0.0108 of the drop. In the United Kingdom, HDI dropped by 0.0075 with a fall of 0.0076 coming from methodological modification. These figures are respectively 0.067 and 0.057 in Argentina; 0.070 and 0.125 in Honduras; 0.148 and 0.130 in Cameroon; 0.0577 and 0.1026 in Haiti; and 0.0706 and 0.0637 in Burkina-Faso.

In 1995

In 1995, methodological modification increased the HDI for almost all the countries. Canada's HDI increased by 0.0187, 0.0207 coming from methodological modification. In Sweden, it increased by 0.00128, of which 0.00222 was from methodological improvement. These increases were respectively 0.0303 and 0.0196 in Argentina; 0.0359 and 0.03814 in Portugal; 0.0528 and 0.0411 in Turkey; 0.1795 and 0.0526 in Algeria; 0.04617 and 0.04629 in Kenya; 0.0176 and 0.0277 in Senegal; and 0.00719 and 0.0134 in Mali.

Methodological stability from 1996 to 1998

From 1996 to 1998, the contribution of methodological transformations to the variations of HDI was null in all countries; these variations were mainly explained by the evolution of living conditions of citizens and, to a lesser extent, by the evolution of the limit values of variables. So in 1996, HDI for France increased by 0.0036, of which 0.0226 came from the improvement of living conditions; that for Luxembourg increased by 0.0029, of which 0.0211 was due to the improvement in living conditions. These figures were respectively 0.0026 and 0.0216 for Austria; 0.0254 and 0.0560 for the Antigua and Barbuda; 0.0022 and 0.02531 for Mexico; -0.0559 and -0.0350 for South Africa; -0.0417 and -0.0266 for Pakistan; and -0.0083 and –0.0041 for Malawi. In 1997, these figures were respectively 0.0036 and 0.0089 for Belgium; 0.00698 and 0.0124 for Italy; 0.00518 and 0.01117 for Costa Rica; 0.00238 and 0.00861 for the United Arab Emirates; and -0.04119 and -0.04106 for Sierra Leone. In 1998, they were 0.00124 and 0.0068 for USA; 0.00072 and 0.00702 for Denmark; 0.0011 and 0.0059 for Luxembourg; -0.0229 and –0.0165 for Russia; -0.0143 and –0.0101 for Yemen; and -0.00216 and -0.001207 for Burkina-Faso.

In 1999

The methodological modification of 1999 had a different influence on the HDI in different groups of countries. In high HDI countries and in the upper half of average HDI countries, there was a reduction in HDI, but in low HDI countries and in the lower half of average HDI countries, we recorded a rise in HDI. In the first case one can quote Australia whose HDI dropped by 0.0078, of which 0.0553 was due to the methodological modification, and Luxembourg where HDI dropped by 0.0463, of

Three main issues can be gleaned from the results in Table 7:

1. In almost all non-European high HDI countries, the most important factor was the modification of limit values of variables, followed by the modifications of living conditions of citizens; methodological changes were the least important. So for Canada from 1990 to 2004, the variation of HDI is -0.0398, of which -0.0105 (26.28%) was due to methodological modifications; -0.0981 (246.07%) to the variations of limit values of variables and 0.0687 (-172.36%) to a significant improvement of Canadians' living conditions.[3] For USA from 1990 to 2004 the variation of HDI was -0.021, of which -0.003 (13.8%) was due to methodological modifications; 0.091 (433.9%) to the modifications of limit values of variables; and 0.073 (-347.7%) to a clear improvement in the living conditions of Americans. For Japan, during the same period, methodological modifications explained 94.01% of the variations of HDI, modifications of limit values 182.45% and effective evolution of living conditions 176.46%.
2. In almost all European high HDI countries, the most important factor was the evolution of living conditions of citizens, followed by the evolution of limit values of variables; the least important factor was the methodological modifications. For France, during the same period, average variation of HDI was -0.042, of which 0.1004 (-237%) was due to changes in the living conditions, -0.094 (222%) to changes in the limit values of variables and -0.049 (115%) to methodological modifications. For Belgium, HDI variation was -0.008, of which 1106.25% was due to modifications of limit values of variables, 553.75% to methodological modifications and -1560% to changes in the living conditions of populations.
3. In the large majority of average and low HDI countries, the most important factor was the modifications of living conditions of populations, followed either by the methodological modifications or the modifications of limit values of variables. In the case of Kenya, the variation of HDI was 0.011, of which -0.016 (-145.45%) was due to methodological transformations; -0.0012 (-10.9%) to the evolution of limit values of variables; and 0.0282 (256.35%) to a positive evolution of living conditions of Kenyans. In Haiti, the variation of HDI was 0.1095, of which 0.0054 (4.93%) was due to methodological modifications; 0.0499 (45.57%) to the variations of limit values of variables; and 0.0542 (49.5%) to the evolution of living conditions of the population. For Côte d'Ivoire, this variation was 0.0078 over the whole period, of which 0.08 (1,025.64%) was due to the methodological modifications; 0.0303 (388.46%) to the variations of the limit values of variables; and -0.1025 (-1,314.10%) to an important deterioration of living conditions of citizens in this country.[4]

The impact of methodological modifications

In 1991, 1995 and 1999, methodological modification was the most important factor of variation of HDI in almost every country.[5]

which 0.0498 was due to methodological change. These falls were respectively 0.0328 and 0.0626 in Portugal; 0.0136 and 0.0262 in Peru; 0.061 and 0.0568 in Jordan. In the second case we can quote the Cape Verde where HDI increased by 0.1521, of which 0.09 was explained by the methodological modification. These rises were respectively 0.0288 and 0.0223 in Bolivia; 0.0474 and 0.044 in Egypt; 0.048 and 0.066 in Cote d'Ivoire.

The impact of variations of limit values of variables

From 1993 to 1994, variations of HDI of almost all high HDI countries and low HDI countries can be largely explained by the modifications of limit values of variables. Those of almost all the average HDI countries can be mainly explained by changes in the living conditions of the population. From 1993 to 1994, HDI of almost all high HDI countries dropped whereas that of almost all average and weak HDI countries increased. Thus in Norway it dropped by 0.0493, of which a fall of 0.0627 was due to modifications of the limit values of HDI variables. These figures were respectively 0.0384 and 0.0566 for Germany; 0.0294 and 0.0422 for Hungary; and 0.044 and 0.0536 in Luxembourg. Among the average HDI countries one can quote Saudi Arabia where HDI increased by 0.0539, of which an increase of 0.0534 came from the improvement of the living conditions of the population; Albania where HDI increased by 0.0147, of which 0.044 was explained by the improvement of living conditions. The figures were respectively 0.0449 and 0.0453 for Suriname; and 0.023 and 0.0295 for South Africa.

The modifications of limit values of variables had a stronger impact on HDI in low and high HDI countries (the peripheries) than on the average HDI countries (the middle class countries).

The period of total relevance of HDI, 2001–2004

From 2001 to 2004, variations in HDI for every country can be exclusively explained by the modifications of living conditions of their citizens. Thus in 2001, HDI for Estonia increased by 0.0096 because of improvement in the living conditions of the population; that of Georgia dropped by 0.0182 because of a degradation of the living conditions of the populations. In 2002, the degradation of the living conditions of population in Brunei-Darussalam caused a drop of 0.00127 in HDI; the improvement of Nigerians' living conditions permitted a rise of 0.0067 in HDI in the country. In 2003, the degradation of the living conditions of Cameroonians caused a fall of 0.0138 in the HDI of the country; in Côte d'Ivoire this degradation of living conditions caused a drop in HDI of 0.0313.

Discussion of the results

In the majority of countries (in European high HDI countries and in average and low HDI countries), our research hypothesis is rejected for the period 1990–2004. This is due to the sub-period 2001–2004 during which methodology and the limit values of variables remained unchanged, and therefore did not contribute to the variations of HDI (Appendix 2). The ranking of the same factors, from the most to the least important, for the period 1990–2000 are presented in Table 8.

Table 8 : Ranking of the factors, from most to least important, for selected countries, 1990–2000 averages

Countries	Ranks of factors* Methodological modifications	Modifications of limit values of variables	Modifications of living conditions of citizens
Japan	3	1	2
Canada	3	1	2
USA	3	1	2
France	3	1	2
Belgium	3	2	1
Chile	1	2	3
South Africa	3	1	2
Costa Rica	1	3	2
Brazil	2	3	1
Honduras	2	3	1
Nicaragua	3	2	1
Cameroon	2	3	1
Haiti	3	1	2
Côte d'Ivoire	2	3	1
Kenya	2	3	1

* 1 stands for the most important factor, and 3 for the less important one.
Source : Author's work.

Even during the sub-period 1990–2000, our hypothesis should be rejected in the majority of countries. However, comparing Appendix 1 and Appendix 2, we realize that in almost all countries, from Appendix 1 (period 1990-2004) to Appendix 2 (period 1990-2000), the contribution of the variations of limit values and that of the evolution of living conditions of populations were reduced, and this reduction benefited the effect of methodological modifications that increased.

In the case of Japan, for example, over the period 1990–2004, the variation of HDI was -0.0576, the contribution of methodological variations was 94.01%, that of variations of the limit values of variables was 182.45% and that of the evolution of living conditions was -176.46%. But during the sub-period 1990–2000, the variation of

HDI in this same country was -0.07304, of which only 143.92% came from variations of limit values of variables and -118.08% from the evolution of living conditions.

In the case of Canada, the contribution of variations of limit values of variables to the variations of HDI decreased from 246.07% over the period 1990–2004 to 205.08% over the sub-period 1990–2000, and that of the evolution of living conditions from -172.36% to 126.98%. In the case of Cameroon, the contribution of the variations of limit values of variables to variations of HDI fell from 145.83% in the period 1990–2004 to 69.55% over the sub-period 1990–2000, that of the evolution of the living conditions of citizens from 325% to 208.83%, in favour of the contribution of methodological variations.

Therefore the relevance of HDI was stronger during the period 1990–2004 than during the period 1990–2000.

10. Conclusion

Over the period 1990–2004, we could not accept our research hypothesis for all UNDP countries. Indeed, the most important factor that explained the variations of HDI was, for non-European high HDI countries, the variations of limit values of variables. For a large majority of European high HDI countries and for average and low HDI countries, it was the modifications in the living conditions. So during the period 1990–2004, HDI was more relevant for average and low HDI countries and for European high HDI countries than for non-European high HDI countries.

However, we observed that the rejection of our research hypothesis, over the period 1990–2004, was due to the sub-period 2001–2004 during which 100% of the variations of HDI in all UNDP countries was due to the evolution in the living conditions of citizens, because the methodology and the limit values of variables have not changed. Indeed, we showed that over the sub-period 1990–2000, the shares of HDI variations due to the modifications of limit values of variables and to the evolution of living conditions of populations decreased, compared with their importance in the period 1990–2004, whereas that of methodological modifications increased. However, even during this sub-period our research hypothesis could not be accepted.

Therefore from 1990 to 2000, HDI was not relevant, but since 2001 it was comparable through time, because UNDP changed neither methodology nor limit values of variables. We therefore recommend UNDP to continue keeping these factors unchanged. However, there are still many points that need to be improved in the calculation of this index, among which the most important is the treatment of revenue.

Notes

1. According to some authors, HDI (as computed by UNDP) is an ordinal value, not a cardinal one. They argue that UNDP computes HDI in order to rank countries each year, so that time series comparison is discouraged. We believe that changes in this ordinal value for a country from one year to another can be considered as a measure of human development progress if the variations are exclusively due to changes in the living standards, in education or in the health of citizens.
2. In 1990, UNDP chose as the international poverty line the arithmetic mean of the poverty lines in nine rich countries (Federal Republic of Germany, Australia, Canada, USA, Norway, the Netherlands, Great Britain, Sweden and Switzerland), in PPP dollar.
3. In Canada, life expectancy at birth increased from 77 years in 1990 to 79.3 years in 2004; the GDP per capita increased from US$16,375 in 1990 to US$29,480 in 2004; and the adult literacy rate remained constant at 99%.
4. From 1990 to 2004, life expectancy in Côte d'Ivoire decreased from 53 to 41.2 years, adult literacy rate increased slowly from 41% to 49.7% and the GDP per capita increased from US$1,120 to US$1,520. The positive effect of the increase in the literacy rate and in GDP per capita has been unable to compensate for the dramatic fall in life expectancy.
5. Indeed, very deep methodological modifications occurred during these years, in the domains of education (1991 and 1995) and material well-being (1991 and 1999). These modifications have been presented in Section 2 of this study.

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Appendix

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COUNTRIES			[illegible]				[illegible]				[illegible]				[illegible]			[illegible]		
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