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Human Development Rankings based on the Pareto Dominance: Illustrations using Cross-country Panel Data 1980-2007

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Abstract

This paper aims (a) to propose two types of human development rankings, a maximal order ranking (MAXOR) and a minimal order ranking (MINOR), and (b) to examine the characteristics of these rankings by using the ranking results derived from the balanced and unbalanced cross-country panel datasets for the period 1980 to 2007. As a means of illustration, I compare these ranking characteristics and results to those of the human development index (HDI), one of the most prevalent human development measurement tools.

The MAXOR and MINOR ranking results have a high correlation with the HDI ranking. However, unlike the HDI, the MAXOR and MINOR do not have to undergo aggregation or indexation when their rankings are being generated. Consequently, they successfully eliminate some of the arbitrariness that is implicit in other existing rankings. The MAXOR and MINOR ranking results are comparatively vaguer than those of other typical rankings such as the HDI in that multiple observations are often ranked identically. However, this vagueness also presents the possibility that these rankings will gain wide acceptance.

From 1980 to 2007, the number of rank groups and the distributions of the countries of the MAXOR and MINOR were relatively robust to changes in the total number of countries. This means that a rank order for a specific country in the MAXOR or MINOR shows its relative position against all other countries, regardless of the year in which the country is set and the number of countries. In this sense, these rankings are more appropriate for tracing the historical transition of each country compared to other typical rankings.

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1 Introduction

This paper focuses on how the levels of human development can be measured and ranked for observations such as individuals, households, villages, or countries. In this decade, poverty has come to be viewed as not merely an economic problem but a multifaceted issue that relates to various non-economic factors such as health, education, social exclusion, and safety. Both the measurement and comparison of the levels of human development of various objectives are important in order to set targets for various antipoverty policies.

Literature on the measurement and ranking of human development or multidimensional poverty can be traced back to early contributions such as the physical quality of life index by Morris (1979), the deprivation index by Townsend et al. (1989), and the quality of life index by Dasgupta and Weale (1992). In particular, the human development index (HDI), which is greatly influenced by the capability approach proposed by Sen (1985; 1992), is one of the most widely consulted human development indices, and it has accelerated research on the measurement of human development and multidimensional poverty.

The HDI succeeds in representing multidimensional poverty in one simple form. However, specific HDI indicators, such as life expectancy at birth and the formulas used to aggregate these indicators into one index have been criticized for their arbitrariness[1]. Critics claim that these specific indicators and formulas are not supported by logical or statistical grounding. Therefore, in order to develop a more concrete foundation, a number of modifications have been proposed by preceding works on the HDI, for example, Paul (1996) and Ranis et al. (2006), which proposed alternative HDI indicators. Some works, such as Noorbakhsh (1998) and Anand and Sen (1999), proposed alternative formulas to transform raw data into index values. Others suggested alternative weighting methods for the aggregation of the HDI (Chowdhury and Squire 2006; Chershye et al. 2008).

However, no matter how these formulas are modified, a combined index such as the HDI always carries some implicit arbitrariness, as there are always some reasons for the selection of particular formulas and weights. The index or ranking results can possibly even be manipulated by selecting specific formulas or weightings to calculate the index. In addition, if four indicators are compiled into one index, it will be difficult to capture the diverse nature of human development. A combined index does not provide information regarding the effectiveness of each

[1]See the appendix for details regarding the procedure of calculating the HDI.

indicator. Limited consideration of diversity contradicts the original concept of the HDI to a certain extent, since one of the aims of the HDI is to evaluate several distinct aspects of human development.

With the aim of alleviating the arbitrariness of the HDI indicators, I propose two methods to decide the ranking of the levels of human development, namely, a maximal order ranking (MAXOR) and a minimal order ranking (MINOR). These rankings do not require aggregation or indexation, but they involve certain binary relations and processes that are based on the Pareto dominance, which is one of the most commonly used concepts in economics. The MAXOR and MINOR significantly assume that we allow the incomparability of one dimension of human development with another. This reflects the implicit belief that we can never compare the levels of human development over dimensions because a distinct dimension represents a distinct aspect of human development. Consequently, the MAXOR and MINOR enable us to perceive different aspects of human development. The former highlights the "development" aspect of a observation, while the latter highlights its "deprivation" aspect.

Simultaneously, however, the abovementioned MAXOR-MINOR assumption has a practical disadvantage, whereby many observations can be positioned at an identical rank, while typically, in other rankings, one observation corresponds to one rank. As many incomparable observations are positioned at the same rank, the ranking results generated using the MAXOR and MINOR are possibly coarser than those generated by other typical rankings. This coarseness, however, increases the possibility that these rankings will enjoy wide acceptance compared to other typical rankings that accept only a single correspondence between a particular rank and a particular observation, because they never squeeze out any one-by-one ranking results ignoring incomparability or diversity among different dimensions.

As regards the arbitrariness of a ranking, the relevance of the time series variation of the rank order of each observation can be a yardstick for appropriate human development rankings. If the rank order of a specific observation and the total number of observations change over time, it will be impossible to judge whether the change in the rank order is induced by the change in the total number of observations or by the change in the relative position of each against all other observations. From this viewpoint, with regard to some periodic rankings such as the HDI, it is desirable that a rank order assigned to a specific observation is sufficiently robust against the passage of time and change in the number of total observations. In other words, any rank order

for any observation at any time should show the relative position of each observation against all other observations, regardless of the passage of time and the total number of observations. The ranking results derived from balanced and unbalanced panel datasets for the period 1980 to 2007 show that the MAXOR and MINOR are better at satisfying the abovementioned requirement than the HDI.

The rest of this paper is organized as follows. The next section describes the MAXOR and MINOR framework. Section 3 discusses ranking results using the HDI indicators for the period 1980 to 2007, and it examines the characteristics of these rankings. The final section provides concluding remarks.

2 Maximal Order Ranking (MAXOR) and Minimal Order Ranking (MINOR)

In this section, I propose a maximal order ranking (MAXOR) and a minimal order ranking (MINOR), both of which are methods for ranking the levels of human development for observations such as individuals or countries.

Let us assume that the level of human development for each observation is represented using "the human development profile," which is a bundle of the values of the multiple indicators representing the level of poverty, such as GDP per capita, infant mortality rate, and adult literacy rate. These indicators are common among all counties. I also assume that the data for each indicator are represented using real positive numbers. The greater the numbers are, the better are the situations.

Let C be a set of observations, and I, a set of the poverty indicators. The number of elements in C and I is denoted as $|C|$ and $|I|$ respectively. Let $\mathbf{R}_+$ denote a set of all positive real numbers, and $\mathbf{R}_+^I$ is the $|I|$-fold Cartesian product of $\mathbf{R}_+$. The level of human development for any observation in C is described as $f(c) = (f_c^i)_{i \in I}$, where f is the mapping that assigns the $|I|$-dimensional poverty level to a observation c in C.

Assume that $\succeq$ denotes the binary relation on C; this means that C is "at least as developed as." This binary relation is defined as $c \succeq \hat{c} :\Leftrightarrow \forall c, \hat{c} \in C \ \& \ \forall i \in I, \ f_c^i \geq f_{\hat{c}}^i$. Corresponding to $\succeq$, I define three binary relations on C: (1) $\succ$, which is interpreted as "strictly more developed than," is defined as $c \succ \hat{c} :\Leftrightarrow \forall c, \hat{c} \in C \ \& \ \forall i \in I, \ f_c^i \geq f_{\hat{c}}^i \ \& \ \exists f_c^i$ such that $f_c^i > f_{\hat{c}}^i$; (2) $\sim$, which is interpreted as "as developed as," is defined as $c \sim \hat{c} :\Leftrightarrow \forall c, \hat{c} \in C \ \& \ \forall \ i \in I, \ f_c^i = f_{\hat{c}}^i$;

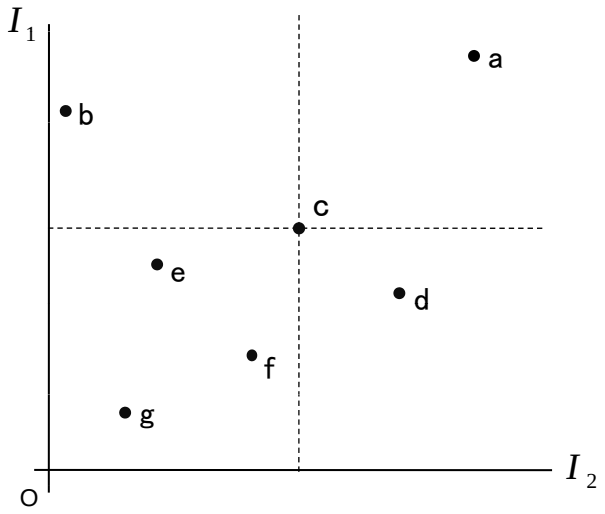

Figure 1: Illustration of the binary relations

and (3) $\bowtie$, which is interpreted as "incomparable," is defined as $c \bowtie \hat{c} :\Leftrightarrow \forall c, \hat{c} \in C,\ \exists i \in I$ such that $f_c^i > f_{\hat{c}}^i$ & $\exists j \in I$ such that $f_c^j < f_{\hat{c}}^j$. Here $\succ$ and $\sim$ represent asymmetric and symmetric factors of $\succeq$ respectively, and $\bowtie$ is an incomparable relation that corresponds to $\succeq$, namely, $c \bowtie \hat{c} \Leftrightarrow \neg(c \succeq \hat{c})$ & $\neg(\hat{c} \succeq c)$[2]. If $c \succ \hat{c}\ \forall c, \hat{c} \in C$, we assume that c dominates $\hat{c}$ so that the binary relation $\succ$ signifies the existence of the Pareto dominance.

Here, I illustrate the abovementioned binary relations. For simplification and to facilitate the understanding of the binary relations, let us assume that $C = \{a, b, c, d, e, f, g\}$ and $I = \{I_1, I_2\}$. Each point from a to g in Figure 1 denotes the human development level with regard to each observation. If c is taken as the base point, a, located to the northeast, achieves higher values for both I_1 and I_2; hence, we infer that a Pareto-dominates c. Conversely, e, f, and g, located southwest of c, have lower values for both I_1 and I_2, whereupon we can judge that these observations are Pareto-dominated by c. The point b, located northwest of c, and d, located southeast of c, are superior to c with regard to one indicator but inferior with regard to another, and hence, we infer that they are incomparable to c. In addition, if a observation has all indicator values that are identical to those of c, we infer that the observation is indifferent to c.

On the basis of the above binary relations, I now define two types of human development ranking rules. Note that while the binary relation over C are not an ordering but a quasi-ordering, the ranking results of the MAXOR and MINOR are an ordering[3].

[2]The symbol $\neg$ denotes the negation of a logical statement.

[3]An ordering is a binary relation satisfying reflexivity, completeness and transitivity. On the other hand, a quasi-ordering satisfies reflexivity and transitivity, but not completeness. See Sen (1970) et al. for details.

As a preliminary step to generate the MAXOR, I define a maximal set, X, as follows:

$\overline{M}(X, \succ) = \{x \mid x \in X$ & there is no $y \in X$ such that $y \succ x\}$

On the basis of the concept of maximal sets, the MAXOR over C is generated through the following recursive steps:

(1) Prepare a maximal set of C, and call it $\overline{M}_1$.

(2) Define $C \backslash \overline{M}_1$ as C_1.

(3) Again, prepare a maximal set $\overline{M}_2$ of C_1, namely,

$\overline{M}_2(C_1, \succ) = \{c \mid c \in C_1$ there is no $\hat{c} \in C_1$ such that $\hat{c} \succ c\}$.

(4) Similarly, consecutively prepare maximal sets $\overline{M}_i$ of C_{i-1} until $C_{i-1} \backslash \overline{M}_i = \emptyset$.

These procedures will give us a sequence of maximal sets, $\overline{M}_1$, $\overline{M}_2$, ..., $\overline{M}_i$, ..., $\overline{M}_m$. For all $c \in \overline{M}_i$, the subscript i corresponds to r^c_{MAXOR}, where r^c_{MAXOR} denotes the rank of c in the MAXOR. In short, the subscript number in each maximal set denotes the rank of the observations belonging to the maximal set. Hence, the MAXOR can be regarded as a partition of a set of observations.

Next, I define the MINOR as an application of the MAXOR. Similar to the MAXOR, I initially define a minimal set, X, as follows:

$\underline{M}(X, \succ) = \{x \mid x \in X$ there is no $y \in X$ such that $x \succ y\}$

The MINOR over C is derived through recursive steps similar to those used for the MAXOR:

(1) Prepare a minimal set of C, and call it $\underline{M}_1$.

(2) Define $C \backslash \underline{M}_1$ as C_1.

(3) Again, prepare a minimal set $\underline{M}_2$ of C_1, namely,

$\underline{M}_2(C_1, \succ) = \{c \mid c \in C_1$ there is no $\hat{c} \in C_1$ such that $c \succ \hat{c}\}$.

(4) Similarly, consecutively prepare maximal sets $\underline{M}_i$ of C_{i-1} until $C_{i-1} \backslash \underline{M}_i = \emptyset$.

These procedures give us a sequence of minimal sets, $\underline{M}_1$, $\underline{M}_2$, ..., $\underline{M}_i$, ..., $\underline{M}_m$. When the number of minimal sets is m, r^c_{MINOR} is defined as $m - i + 1$ for all $c \in \underline{M}_i$, where r^c_{MINOR} denotes the rank of c in the MINOR. Note that the subscript number in each minimal set does not directly denote the rank of the observations belonging to the minimal set. As in the MAXOR, the MINOR can be regarded as a partition of a set of observations.

Table 1 shows the ranking results of the example. In both the MAXOR and MINOR, "rank" denotes the rank order of a relevant observation and "n-th group" denotes the number of the maximal (or minimal) set that the relevant observation is positioned at, namely, $\overline{M}_n$ (or $\underline{M}_n$).

	MAXOR		MINOR	
	rank	n−th group	rank	n−th group
a	1	1	1	1
b	2	2	6	4
c	2	2	2	2
d	2	2	2	2
e	5	3	4	3
f	5	3	4	3
g	7	4	6	4

Table 1: Ranking results of the example

For example, e is positioned as the third maximal set $\overline{M}_3$ in the MAXOR, so the "n-th group" of e is three, while e's "rank" is five because four countries are positioned higher than e. The importance of the "n-th group" is mentioned in the following section. I define a set that consists of observations positioned at the same rank (a maximal or minimal set) as a "rank group." With respect to this example, both the MAXOR and MINOR are constructed as four rank groups[4].

Note that the rank order of b is second in the MAXOR, while it is the lowest in the MINOR (sixth). This is because f_b^1 is relatively high although f_b^2 is extremely low. Since the value of indicator one is relatively high with regard to b, other observations find it difficult to dominate b, and therefore, b is positioned relatively high in the MAXOR. On the other hand, b finds it difficult to dominate other countries owing to the extremely low value of indicator two, and therefore, it is positioned relatively low in the MINOR. The following section examines this point in detail.

3 Ranking Results and Discussion

3.1 Data

This section discusses the MAXOR and MINOR ranking results for the period 1980 to 2007, using unbalanced and balanced cross-country panel datasets. The datasets are based on the statistics of the human development reports for the period 1990 to 2009. Here, countries are the observations to be ranked. I adopt four human development indicators identical to those used when calculating the HDI (life expectancy at birth, adult literacy rate, combined gross enrolment ratio, and GDP per capita). Owing to the lack of available data, the unbalanced panel dataset is collated using data for only 18 years for the period 1980 to 2007. The number

[4]The number of rank groups for the same set in the MAXOR and MINOR are always equal. See Michinaka (2009) for details.

Spearman's rank correlation (obs=182)							
	Life	Litercy	Enrolment	GDP	HDI	MAXOR	MINOR
Life expectancy	1.00						
Adult literacy rate	0.72	1.00					
Combined gross enrolment ratio	0.78	0.81	1.00				
GDP per capita (PPP$)	0.84	0.73	0.80	1.00			
HDI	0.93	0.83	0.87	0.95	1.00		
MAXOR	0.91	0.83	0.87	0.94	0.98	1.00	
MINOR	0.94	0.82	0.88	0.89	0.97	0.93	1.00

Table 2: Rank correlations among indicators and ranking results

of countries is at a minimum of 82 countries in 1980 and at a maximum of 182 countries in 2007. On the other hand, the balanced panel dataset is prepared using data from 166 identical countries for 14 years for the period 1992 to 2007.

3.2 Ranking Results

Table 6 shows the ranking results of the MAXOR and MINOR in 2007 using the unbalanced panel dataset. For the purpose of comparison, we assume that the raw value and rank for each indicator are based on the MAXOR and MINOR, and the HDI value and rank in 2007 are also inserted[5].

Table 6 displays the HDI rank order, and 182 countries are ordered in 18 groups, both based on the MAXOR and MINOR. Norway is ranked at the first position in the MAXOR, MINOR, and HDI. On the other hand, Niger is ranked last in all of them. In fact, as shown in Table 2, the rank correlation among the MAXOR, MINOR, and HDI is quite high.

However, as shown in Table 3, several countries have quite low rank correlations among the MAXOR, MINOR and HDI. For example, Hong Kong, China (Special Administrative Region: SAR), is ranked 1st in the MAXOR, 29th in the MINOR, and 24th in the HDI. Similarly, Botswana and Equatorial Guinea are ranked 84th and 46th in the MAXOR, 134th and 147th in the MINOR, and 125th and 118th in HDI. In fact, Hong Kong, China (SAR), has achieved a high level of GDP per capita (PPP$), 40,000[6], and it is ranked at the top among 182 countries. On the

[5]This HDI ranking result is different from the HDI ranking presented in HDR 2007. This is because the annual HDI ranking presented in the annual HDR is decided on the basis of the data that are a few years older than the title year. For example, the HDI ranking for 2009 compiled in HDR 2009 is decided on the basis of the four indicator values in 2007. However, I re-calculated the HDI value and ranking for each year from the data for the corresponding year. That is, the 2007 HDI in Table 6 is calculated on the basis of the four indicator values in 2007

[6]The actual value is 42,306, but the author applied the value 40,000 in accordance with the calculation method of the HDI.

	Life expectancy		Adult literacy rate		Combined gross enrolment ratio		GDP per capita		HDI		MAXOR		MINOR		Difference between (a) and (b)
	raw value (years)	rank	raw value (%)	rank	raw value (%)	rank	raw value (PPP$)	rank	index value	rank	rank	n-th group (a)	rank	n-th group (b)	
Norway	80.5	12	99.0	1	98	8	40000	1	0.971	1	1	1	1	1	0
Niger	50.8	166	28.7	179	27	181	627	177	0.339	182	182	18	171	18	0
Hong Kong, China (SAR)	82.2	2	94.6	76	74	84	40000	1	0.944	24	1	1	29	7	6
Botswana	53.4	160	82.9	122	70	110	13604	60	0.687	125	84	9	134	15	6
Equatorial Guinea	49.9	168	87.0	113	62	130	30627	28	0.709	118	46	7	147	16	9

Table 3: Extracts of ranking results in 2007

other hand, the enrolment ratio of 74 is ranked 88th and is not at a high level compared to GDP per capita (PPP$). Owing to its relatively high level of GDP per capita (PPP$), other countries find it difficult to dominate Hong Kong, China (SAR); however, it cannot easily dominate other countries because of its relatively low enrolment ratio. For the same reason, Botswana and Equatorial Guinea have differences between their MAXOR and MINOR rankings. It is difficult for other countries to dominate Botswana because of its relatively high level of GDP per capita, (PPP$) 13,604; however, it cannot easily dominate other countries because of its relatively low life expectancy value, 53.4 (160th among 182 countries). Equatorial Guinea is one of the more contrasting cases. Other countries find it difficult to dominate Equatorial Guinea because of its relatively high level of GDP per capita (PPP$), 30,627 (28th among 182 countries); however, it cannot easily dominate other countries because of its relatively low level of life expectancy, 49.9 (168th among 182 countries)[7].

As regards the time series results, as shown in Table 4 and Figure 2, the number of rank groups in the MAXOR and MINOR are relatively stable at around 15, regardless of whether the panel dataset is unbalanced or balanced. It is notable that the number of countries for the unbalanced panel more than doubled from a low of 82 (in 1980) to 182 (in 2007); however, the number of ranks in the MAXOR and MINOR did not experience such major growth. The lowest rank is 13 (in 1985 with 89 countries), and it rose to 18 (in 1993 and 2007 with 174 and 182 countries respectively).

On the other hand, as regards the ranking results of the balanced panel dataset, the distri-

[7]Botswana and Equatorial Guinea are typical mineral-rich countries. The former is a diamond-rich country and the latter is an oil-rich country. Owing to the countries' rich mineral resources and the proper utilization of the resources, these countries underwent rapid economic growth during the 1990s. See Poteete (2009) and Same (2008) for details.

Unbalanced panel

	1980	1985	1990	1992	1993	1994	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total number of countries	82	89	115	174	174	175	174	174	174	162	173	175	177	177	177	177	179	182
Number of rank groups	14	13	16	15	18	16	14	16	17	16	17	15	16	16	16	15	17	18

Balanced panel (Total number of countries=166)

	1992	1993	1994	1995	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007
Number of rank groups	14	18	16	14	15	16	16	15	15	15	16	14	16	17

Table 4: Transitions in the total number of countries and rank groups

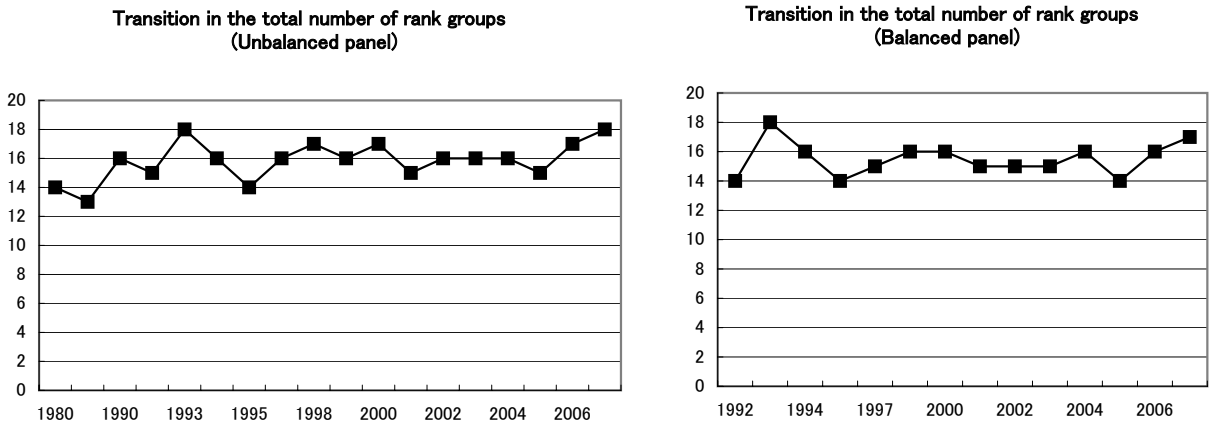

Figure 2: Transitions in the total number of countries and rank groups

bution of countries among the ranks in the MAXOR and MINOR are relatively stable. This implies that most of the countries have followed a similar developmental trajectory during this period. Figure 3 shows the transitions in the distributions of countries among the ranks in the MAXOR and MINOR for the period 1994 to 2006. I used the data of the years 1994, 1998, 2000, 2004, and 2006 to arrive at the rank group number for these years, which is 16.

In both the MAXOR and MINOR, a number of countries are positioned at middle-level ranks through the relevant years. With respect to the MAXOR, the peaks are around the 7th or 8th rank; however, for the MINOR the peaks are positioned slightly to right side compared to the MAXOR; that is, the peaks for the MINOR are around the 8th or 9th rank. Moreover, less than five countries are positioned in the bottom rank group in the MAXOR; however, in the MINOR, this number is larger, that is, a minimum of four and a maximum of 16.

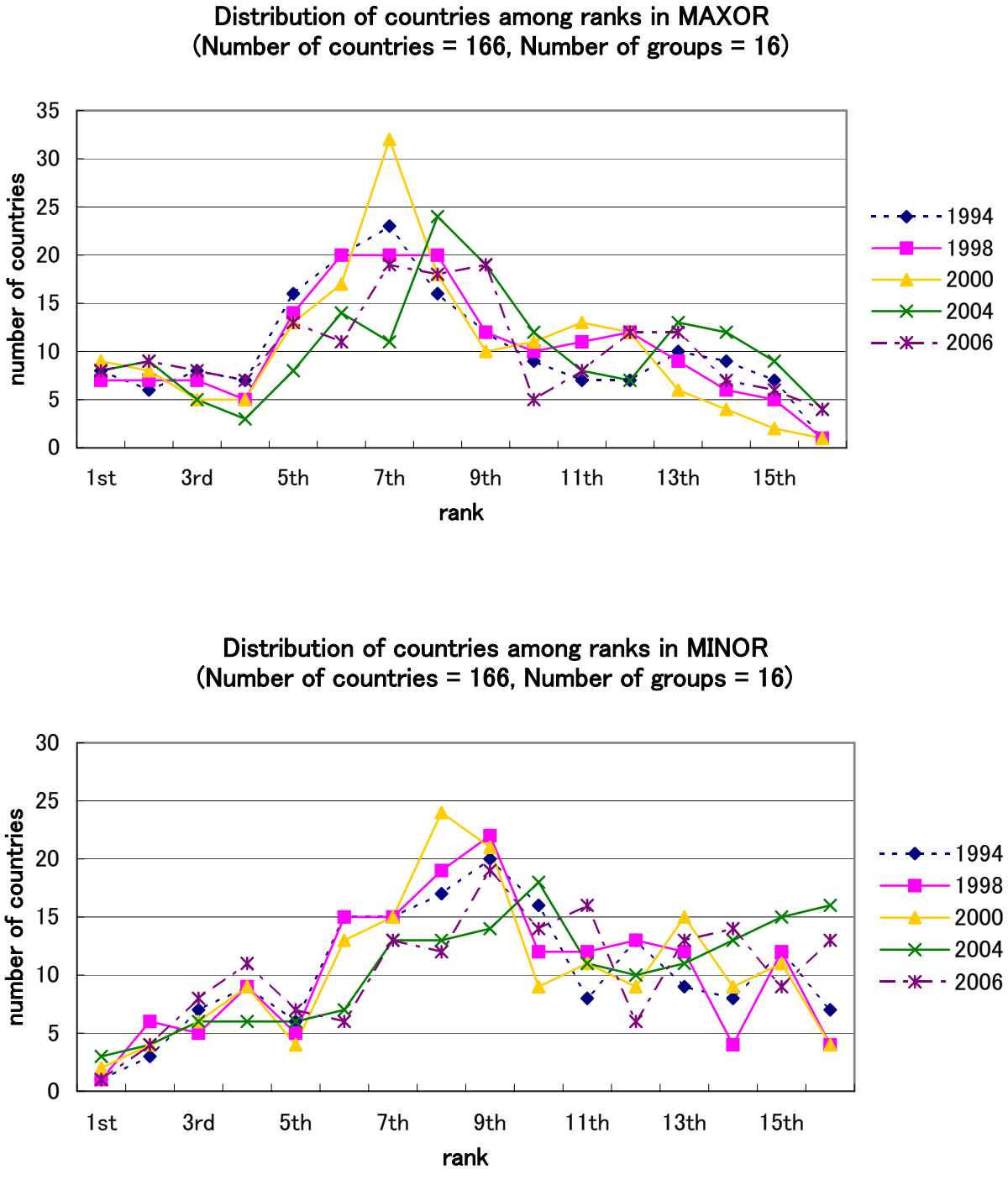

Figure 3: Distributions of countries in MAXOR and MINOR

3.3 Discussion

Certain specific characteristics of the MAXOR and MINOR are revealed on the basis of the above results.

The first characteristic is the acceptance of incomparability. Unlike the HDI, the MAXOR and MINOR accept the incomparability of one human development indicator to another. Consequentially, incomparable countries are positioned at the same rank. As regards the HDI, one country usually corresponds to a specific rank. Multiple countries will be positioned at the same rank only on rare occasions. For example, a maximum of 21 countries are assigned to the same rank group (8th group) in the MAXOR in the unbalanced panel data for 2007. On an average, 10 countries are positioned at the same rank. In this sense, the ranking results of the MAXOR and MINOR tend to be much coarser than those of the HDI[8].

However, this incomparability also presents the possibility that these rankings will be accepted widely. The HDI is subject to the criticism that the formulas used for its calculation are arbitrary in that they subjectively weight distinct aspects of human development. Consequently, those who do not agree with the weighting cannot accept the HDI ranking result. On the other hand, the MAXOR and MINOR never weight or aggregate distinct aspects, and therefore, they leave room for a broad consensus. As Sen (1985, pp.36-37; 1992, pp.46-48) suggests in his intersection approach, we should not forcibly order alternatives when we cannot judge which is better. Even if the information obtained is incomplete, obtaining some sure information is more desirable than obtaining nothing or intuitively unacceptable results owing to the insistence of acquiring a complete ordering. With regard to the intersection approach, the first characteristic of the MAXOR and MINOR are that they are regarded as minimum rankings that are commonly acceptable because they never insist on completeness among observations that cannot absolutely be judged as being better.

The second characteristic is what the ranking emphasizes. As shown by the ranking method, the MAXOR is a ranking that demonstrates how it is difficult for one country to be dominated by others. Conversely, the MINOR demonstrates how it is easy for one country to dominate others; that is, the MINOR presents the inverse order of how it is difficult for one country to dominate other countries. As mentioned in the previous section, a country that has at least

[8]As an attempt to reduce the number of countries assigned to the same rank, Michinaka and Ito (2010) extended the ranking methods proposed in this paper, by allowing a certain range of measurement error in the dataset used to derive rankings.

one relatively high indicator value tends to be ranked relatively high in the MAXOR, since it is difficult for other coutries to dominate it. Contrastingly, a country that has at least one relatively low indicator value tends to be ranked relatively low in the MINOR, since it is difficult for the country to dominate other countries. Therefore, the MAXOR and MINOR highlight the "development" and "non-deprivation" aspects of each country respectively.

Furthermore, the MAXOR can be regarded as a "specialist" ranking, while the MINOR can be regarded as an "all-round" ranking. This is because a country can be ranked high in the MAXOR with at least only one high indicator value; however, a country can never be ranked high in the MINOR if there exists just one low indicator value. In this sense, it is tougher to be ranked higher in the MINOR than in the MAXOR. This is consistent with the fact that the peaks of the distributions of the MINOR are located more on the right side than those of the MAXOR in Figure 3.

The third characteristic relates to the difference in ranks between the MAXOR and MINOR with regard to a particular country. This highlights useful information regarding whether the development of a country is well balanced. If one indicator of a country has an extremely high value, while others have extremely low values, it may be ranked high in the MAXOR owing to the single high indicator value, but its ranking in the MINOR will continue to be low owing to other low indicator values. For a country, the smaller the difference in rank is, the better balanced is its development. However, the HDI ranking does not capture such differences in the development process of each country. The HDI aggregates the values of indicators into one combined index so that the differences of values among indicators are canceled out.

For instance, Equatorial Guinea and Uzbekistan are separated by just one position in the HDI for 2007 (See Table 6). The HDI ranking of Equatorial Guinea was 118 with an HDI value of 0.719, and the HDI ranking of Uzbekistan was 119 with an HDI value of 0.709. The difference in the HDI index is only 0.01. According to the HDI, both countries have an almost equal level of development though the former is slightly better than the latter. However, the values of each indicator for these countries are quite different. The human development profile of Equatorial Guinea, $(f^i_{EG})_{i\in I}$, is (49.9, 87.0, 62, 30627), while that of Uzbekistan, $(f^i_{UZ})_{i\in I}$, is (67.6, 96.9, 72, 2425). Except for the GDP per capita value, (PPP$), all other values of the indicators for Uzbekistan are higher than those of Equatorial Guinea. However, Equatorial Guinea's value of GDP per capita (PPP$) is much higher than that of Uzbekistan. In such

cases, how do we judge which country has reached a better human development level? The HDI is forced to rank these countries uniquely, but its comparison with the MAXOR and MINOR offers a better perspective on this issue. The difference in rank between the MAXOR and MINOR for Equatorial Guinea is 11 positions (7th in the MAXOR and 16th in the MINOR), but for Uzbekistan, the difference is only three positions (10th in the MAXOR and 13th in the MINOR). This means that the values of Equatorial Guinea's indicators vary widely, while those of Uzbekistan are relatively balanced.

The final characteristic concerns a longitudinal aspect. Whether the transition of the rank order for a observation provides some useful information in a time series is important for a particular ranking. However, for country-based rankings that accept only a single correspondence between a particular rank and a particular country, such as the HDI ranking, the total number of countries or the performances of other countries strongly affect the rank of a specific country because these rankings generally do not satisfy the condition of independence of irrelevant alternatives (IIA). If the total number of countries has increased as time passes, the rank of a certain country might have dropped even if the development performance of the country has not been inferior to that of other countries.

Though the MAXOR and MINOR also do not satisfy the condition of IIA, however, they succeed in alleviating this problem, since they accept the case that multiple countries are positioned at the same rank. As shown in Figures 2 and 3, the total number of rank groups and the distributions of countries are stable throughout the considered period. This means that a group rank order for a specific country in the MAXOR or MINOR shows its relative position against all other countries, regardless of the total number of countries, unlike the HDI ranking.

For example, as shown in Table 5, India's HDI ranking was 68 in 1980, 92 in 1990, and 134 in 2007, suggesting that its relative human development level is worsening (See Table 5). However, the number of countries considered for the HDI ranking in 1980 was only 82, as opposed to 115 in 1990 and 182 and 2007. Therefore, the question, which of the two is better, the 68th rank among 82 countries or the 134th rank among 182 countries, is important. In the case of the dataset, for which the number of countries varies on a yearly basis, a simple comparison of the rank order is not fruitful. Conversely, the rank group orders assigned by the MAXOR and MINOR are relatively robust to changes in the number of countries. India was positioned in the 11th rank group in the MAXOR and in 12th rank group in the MINOR in 1980. It was

	1980	1985	1990	1995	2000	2005	2007
Total number of countries	82	89	115	174	173	177	182
Total number of rank groups	14	13	16	14	17	15	18
India							
Life expectancy	55.1	56.8	58.1	61.6	63.3	63.7	63.4
Adult literacy rate (%)	40.7	40.7	48.2	52.0	57.2	61.0	66.0
Combined gross enrolment ratio (%)	41	48	49	55	55	63	61
GDP per capita (PPP$)	921	1063	1279	1422	2358	3452	2753
HDI							
value	0.427	0.452	0.487	0.528	0.577	0.618	0.612
rank	68	73	92	138	124	128	134
MAXOR							
rank	64	69	93	129	133	126	137
n-th group	11	10	13	10	12	11	13
MINOR							
rank	63	68	93	130	111	111	120
n-th group	12	11	14	11	12	11	13
Rank difference between MAXOR and MINOR	1	1	1	1	0	0	0

Table 5: Transitions in the rankings for India

positioned in the 13th rank group in the MAXOR and the 14th rank group in the MINOR in 1990, and it was positioned in the 13th rank order in both the MAXOR and MINOR in 2007. This result shows us that India's relative position against all other countries has gotten slightly worse during this period, while its development has been well balanced.

The change in the total number of countries is mainly attributed to the independence of or upheavals in the countries. For example, a number of countries gained independence after the disintegration of the Soviet Union in 1991. Therefore, the number of countries considered in the HDR statistics drastically increased from 115 to 174. In the case of the breaking down a country to multiple countries, the human development levels of the new countries appear to be similar. In the MAXOR and MINOR, countries that achieve similar performances tend to be positioned in the same rank group, unlike complete rankings that assign one rank order to one country. Hence, a rank order as a group in the MAXOR or MINOR for a specific country can signify its relative position against all other countries, regardless of the total number of countries. In this sense, the MAXOR and MINOR are more suited for observing the variations in the level of human development for each country over time, unlike other typical rankings that accept only a single correspondence between a particular rank and a particular country.

4 Conclusion

In this paper, I have suggested two types of rankings to rank the levels of human development among observations such as individuals, households, or countries. In addition, I have examined the characteristics of these rankings by using their ranking results. By applying certain binary relations based on the concept of the Pareto dominance, instead of applying aggregation or indexation, these rankings succeed in eliminating some arbitrariness that are implicit in some existing combined, multidimensional human development indices such as the HDI.

One of the rankings, the MAXOR, is a ranking that evaluates the "development" aspect of human development for each observation. Contrastingly, another ranking, the MINOR, highlights the "deprivation" aspect of development. One advantage of these rankings is that they may possibly be more widely accepted than the HDI, since they never subjectively weight among distinct human development indicators.

Another advantage is that the MAXOR and MINOR can capture how the development with regard to the observations is well balanced. This is because the MAXOR rank order for specific observations strongly reflects the superior aspects of the observations, while the MINOR rank order strongly reflects the observations' inferior aspects.

In addition, I showed that the MAXOR and MINOR are robust to changes in the total number of observations. Unlike other general rankings, a MAXOR or MINOR rank order for a specific observation can show its relative position against all other observations, regardless of the total number of observations. In this sense, the MAXOR and MINOR are useful in their application to certain time series datasets with a varying number of observations.

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Appendix

An Overview of the Human Development Index

The Human Development Index (HDI) is a composite index describing the level of human development in each country. The United Nations Development Programme (UNDP) launched the HDI in 1990, and publishes it and its rankings annually in the Human Development Report (HDR). In the first HDR, the UNDP (1990, p. 10) defined human development as a process of enlarging people's choices. This concept is rooted in Sen's capability approach; thus the HDI has been regarded as embodying the capability approach for the practical realization of human development measurement.

The HDI chose three fundamental aspects of human development, longevity, knowledge and a decent standard of living, as essential human development aspects (UNDP 1990, pp. 11-12). To represent these three aspects, the HDI has adopted four indicators; life expectancy at birth, the adult literacy rate, the combined gross enrolment ratio for primary, secondly and tertiary schools[9], and GDP per capita in purchasing power parity of US dollars (PPP$). The HDI is a combined index of these four indicators.

The process of calculating the HDI value is introduced annually in the HDR. Though the basic concept and the calculation methodology for the HDI have not changed since the beginning, slight modifications have been added over the past seventeen years. The following calculation methodology was adopted in the period from 1999 to 2009.

To obtain the HDI value, we first calculate the index value of each indicator. Then, we combine the literacy index value and the enrolment index value to get the gross education index value. Thus we have three index values; the life expectancy index, education index and GDP index values. The HDI value is a simple average of these three values. The formula to calculate an index value of each indicator is as follows:

$$V_c^i = \frac{A_c^i - Min^i}{Max^i - Min^i}$$

[9]This indicator was added to the HDI in 1991. The original HDI published in 1990 consisted of three indicators, that is, the life expectancy at birth, the adult literacy rate and GDP per capita (PPP$).

Let V_c^i be an index value, where subscript c means a country and the superscript i means a development indicator such as the adult literacy rate. Hence V_c^i denotes an index value of an indicator i for country c and A_c^i denotes the actual value of an indicator i for country c. Let Max^i and Min^i be the fixed maximum and minimum values corresponding to each i respectively.

With respect to the GDP index value, a logarithmically transformation is applied. The reason given by the HDR is that achieving a respectable level of human development does not require unlimited income (See the technical note of the HDR 2009). Then, the formula to calculate GDP index value of country c, namely V_c^G, is

$$V_c^G = \frac{\log\{A_c^G\} - \log\{Min^G\}}{\log\{Max^G\} - \log\{Min^G\}}.$$

The fixed maximum and minimum values of each indicator, in respective order, are as follows: for life expectancy at birth, 85 and 25; for the adult literacy rate, 100 and 0; for the combined gross enrolment ratio, 100 and 25; for GDP per capita (PPP$), 40,000 and 100. Occasionally, the actual value goes beyond the fixed maximum value.

Now we have four index values, that is, the life expectancy index value V_c^L, the literacy index value V_c^{LT}, the enrolment index value $V_c^{EN}$and GDP index value V_c^G. Next, we combine the literacy index and the enrolment index to get the gross education index V_c^E. The formula is

$$V_c^E = \frac{2}{3}\{V_c^{LT}\} + \frac{1}{3}\{V_c^{EN}\}.$$

Finally, we combine these three index values, that is, life expectancy index, education index and GDP index values. The HDI value is a simple average of these three index values. The formula is as follows:[10]

$$HDI_c = \frac{1}{3}\{V_c^L + V_c^E + V_c^G\}$$

[10]In the HDR 2010, the geometric mean is adopted for aggregating these three index values.

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Table 6: Ranking results in 2007 (n=182)

	Life expectancy		Adult literacy rate		Combined gross enrolment ratio		GDP per capita		HDI		MAXOR		MINOR		Difference between (a) and (b)
	raw value (years)	rank	raw value (%)	rank	raw value (%)	rank	raw value (PPP$)	rank	index value	rank	rank	n-th group (a)	rank	n-th group (b)	
Norway	80.5	12	99.0	1	98	8	40000	1	0.971	1	1	1	1	1	0
Australia	81.4	5	99.0	1	100	1	34923	22	0.970	2	1	1	3	3	2
Iceland	81.7	3	99.0	1	96	12	35742	19	0.969	3	1	1	3	3	2
Canada	80.6	11	99.0	1	99	7	35812	18	0.966	4	1	1	3	3	2
Ireland	79.7	19	99.0	1	97	10	40000	1	0.965	5	10	2	2	2	0
Netherlands	79.8	17	99.0	1	97	10	38694	14	0.964	6	10	2	3	3	1
Sweden	80.8	8	99.0	1	94	16	36712	16	0.963	7	1	1	3	3	2
France	81.0	7	99.0	1	95	14	33674	25	0.960	8	10	2	9	4	2
Luxembourg	79.4	24	99.0	1	94	16	40000	1	0.960	9	20	3	3	3	0
Japan	82.7	1	99.0	1	86	41	33632	26	0.960	10	1	1	16	5	4
Switzerland	81.7	3	99.0	1	82	49	40000	1	0.959	11	1	1	24	6	5
Finland	79.5	22	99.0	1	100	1	34526	23	0.959	12	10	2	9	4	2
United States	79.1	28	99.0	1	92	19	40000	1	0.956	13	27	4	9	4	0
Austria	79.9	16	99.0	1	90	26	37370	15	0.955	14	10	2	9	4	2
Denmark	78.2	34	99.0	1	100	1	36130	17	0.954	15	1	1	9	4	3
Spain	80.7	9	97.9	53	96	12	31560	27	0.954	16	10	2	16	5	3
Belgium	79.5	22	99.0	1	94	16	34935	21	0.953	17	20	3	9	4	1
Italy	81.1	6	98.9	47	91	23	30353	29	0.951	18	10	2	16	5	3
Liechtenstein	79.2	26	99.0	1	86	41	40000	1	0.950	19	27	4	16	5	1
New Zealand	80.1	15	99.0	1	100	1	27336	32	0.949	20	10	2	9	4	2
Germany	79.8	17	99.0	1	88	35	34401	24	0.947	21	20	3	16	5	2
United Kingdom	79.3	25	99.0	1	89	33	35130	20	0.947	22	27	4	16	5	1
Singapore	80.2	14	94.4	79	85	44	40000	1	0.944	23	10	2	29	7	5
Hong Kong, China (SAR)	82.2	2	94.6	76	74	84	40000	1	0.944	24	1	1	29	7	6
Greece	79.1	28	97.1	60	100	1	28517	31	0.942	25	20	3	24	6	3
Korea (Republic of)	79.2	26	99.0	1	98	8	24801	35	0.937	26	20	3	16	5	2
Israel	80.7	9	97.1	60	89	33	26315	34	0.934	27	20	3	24	6	3
Andorra	80.5	12	99.0	1	65	125	40000	1	0.934	28	10	2	75	10	8
Slovenia	78.2	34	99.0	1	92	19	26753	33	0.929	29	33	5	16	5	0
Brunei Darussalam	77.0	38	94.9	73	77	73	40000	1	0.919	30	33	5	40	8	3
Kuwait	77.5	36	94.5	78	72	99	40000	1	0.915	31	33	5	40	8	3
Cyprus	79.6	20	97.7	56	77	73	24789	36	0.913	32	27	4	29	7	3
Qatar	75.5	48	93.1	86	80	55	40000	1	0.910	33	33	5	40	8	3
Portugal	78.6	31	94.9	73	88	35	22765	42	0.908	34	33	5	29	7	2
Czech Republic	76.4	42	99.0	1	83	47	24144	37	0.903	35	41	6	24	6	0
United Arab Emirates	77.3	37	90.0	99	71	103	40000	1	0.903	36	41	6	56	9	3
Malta	79.6	20	92.4	89	81	53	23080	39	0.901	37	27	4	40	8	4
Barbados	77.0	38	99.0	1	92	19	17956	48	0.900	38	41	6	24	6	0
Bahrain	75.6	47	88.8	105	90	26	29723	30	0.895	39	33	5	56	9	4
Estonia	72.9	74	99.0	1	91	23	20361	43	0.883	40	41	6	29	7	1
Poland	75.5	48	99.0	1	87	39	15987	53	0.880	41	46	7	29	7	0
Slovakia	74.6	56	99.0	1	80	55	20076	45	0.879	42	46	7	29	7	0
Hungary	73.3	69	98.9	47	90	26	18755	46	0.879	43	41	6	29	7	1
Chile	78.5	32	96.5	66	82	49	13880	59	0.877	44	33	5	29	7	2
Croatia	76.0	44	98.7	49	77	73	16027	52	0.871	45	46	7	29	7	0
Lithuania	71.8	91	99.0	1	92	19	17575	49	0.870	46	46	7	40	8	1
Antigua and Barbuda	72.2	84	99.0	1	85	44	18691	47	0.868	47	46	7	40	8	1
Latvia	72.3	83	99.0	1	90	26	16377	51	0.866	48	46	7	40	8	1
Argentina	75.2	53	97.6	57	88	35	13238	62	0.865	49	46	7	29	7	0
Uruguay	76.1	43	97.9	53	90	26	11216	70	0.864	50	46	7	40	8	1
Cuba	78.5	32	99.0	1	100	1	6876	95	0.864	51	20	3	40	8	5
Bahamas	73.2	71	95.8	71	71	103	20253	44	0.855	52	46	7	56	9	2
Mexico	76.0	44	92.8	87	80	55	14104	58	0.854	53	46	7	40	8	1
Costa Rica	78.7	30	95.9	70	73	92	10842	73	0.853	54	33	5	56	9	4
Libyan Arab Jamahiriya	73.8	64	86.8	114	95	14	14364	57	0.846	55	27	4	56	9	5

Table 6: Ranking results in 2007 (n=182) (continued)

	Life expectancy		Adult literacy rate		Combined gross enrolment ratio		GDP per capita		HDI		MAXOR		MINOR		Difference between (a) and (b)
	raw value (years)	rank	raw value (%)	rank	raw value (%)	rank	raw value (PPP$)	rank	index value	rank	rank	n-th group (a)	rank	n-th group (b)	
Oman	75.5	48	84.4	118	68	115	22816	41	0.846	56	46	7	75	10	3
Seychelles	72.8	76	91.8	92	82	49	16394	50	0.844	57	46	7	40	8	1
Venezuela (Bolivarian Republic of)	73.6	66	95.2	72	85	44	12156	65	0.843	58	63	8	40	8	0
Saudi Arabia	72.7	77	85.0	117	78	64	22935	40	0.843	59	46	7	75	10	3
Bulgaria	73.1	72	98.3	52	82	49	11222	69	0.839	60	63	8	40	8	0
Panama	75.5	48	93.4	83	79	59	11391	67	0.839	61	63	8	40	8	0
Saint Kitts and Nevis	72.2	84	97.8	55	73	92	14481	56	0.837	62	63	8	56	9	1
Romania	72.5	80	97.6	57	79	59	12369	64	0.837	63	63	8	40	8	0
Trinidad and Tobago	69.2	110	98.7	49	61	134	23507	38	0.836	64	46	7	106	12	5
Montenegro	74.0	61	96.4	67	74	84	11699	66	0.834	65	63	8	40	8	0
Malaysia	74.1	58	91.9	91	71	103	13518	61	0.829	66	63	8	56	9	1
Serbia	73.9	63	96.4	67	74	84	10248	75	0.826	67	84	9	56	9	0
Belarus	69.0	111	99.0	1	90	26	10841	74	0.825	68	63	8	75	10	2
Saint Lucia	73.6	66	94.8	75	77	73	9786	77	0.821	69	84	9	56	9	0
Albania	76.5	41	99.0	1	67	122	7041	93	0.817	70	46	7	75	10	3
Macedonia (the Former Yugoslav Rep.	74.1	58	97.0	62	70	110	9096	80	0.817	71	63	8	56	9	1
Russian Federation	66.2	122	99.0	1	81	53	14690	55	0.816	72	63	8	90	11	3
Dominica	76.9	40	88.0	108	78	64	7893	83	0.814	73	46	7	56	9	2
Grenada	75.3	52	96.0	69	73	92	7344	92	0.813	74	63	8	56	9	1
Brazil	72.2	84	90.0	99	87	39	9567	79	0.813	75	63	8	56	9	1
Bosnia and Herzegovina	75.1	54	96.7	65	69	114	7764	87	0.812	76	63	8	56	9	1
Colombia	72.7	77	92.7	88	79	59	8587	81	0.807	77	84	9	56	9	0
Peru	73.0	73	89.6	102	88	35	7836	85	0.806	78	63	8	56	9	1
Turkey	71.7	92	88.7	106	71	103	12955	63	0.806	79	84	9	75	10	1
Ecuador	75.0	55	91.0	94	77	73	7449	91	0.805	80	84	9	75	10	1
Kazakhstan	64.9	130	99.0	1	91	23	10863	72	0.804	81	63	8	90	11	3
Mauritius	72.1	88	87.4	112	76	79	11296	68	0.803	82	84	9	75	10	1
Lebanon	71.9	90	89.6	102	78	64	10109	76	0.803	83	84	9	56	9	0
Armenia	73.6	66	99.0	1	74	84	5693	100	0.797	84	63	8	56	9	1
Ukraine	68.2	116	99.0	1	90	26	6914	94	0.796	85	84	9	90	11	2
Azerbaijan	70.0	107	99.0	1	66	124	7851	84	0.786	86	63	8	90	11	3
Thailand	68.7	113	94.1	81	78	64	8135	82	0.783	87	84	9	106	12	3
Iran (Islamic Republic of)	71.2	101	82.3	123	73	92	10955	71	0.782	88	100	10	90	11	1
Georgia	71.6	96	99.0	1	76	79	4662	110	0.777	89	63	8	56	9	1
Dominican Republic	72.4	81	89.1	104	73	92	6706	97	0.776	90	100	10	90	11	1
Belize	76.0	44	75.1	134	78	64	6734	96	0.771	91	63	8	90	11	3
China	72.9	74	93.3	85	68	115	5383	102	0.771	92	100	10	75	10	0
Saint Vincent and the Grenadines	71.4	98	88.1	107	68	115	7691	89	0.771	93	100	10	90	11	1
Samoa	71.4	98	98.7	49	74	84	4467	113	0.771	94	84	9	75	10	1
Maldives	71.1	102	97.0	62	71	103	5196	104	0.770	95	84	9	75	10	1
Jordan	72.4	81	91.1	93	78	64	4901	107	0.769	96	100	10	75	10	0
Suriname	68.8	112	90.4	97	74	84	7813	86	0.769	97	100	10	106	12	2
Tunisia	73.8	64	77.7	130	76	79	7520	90	0.769	98	84	9	90	11	2
Tonga	71.7	92	99.0	1	78	64	3748	120	0.768	99	63	8	75	10	2
Jamaica	71.7	92	86.0	116	78	64	6079	98	0.766	100	100	10	75	10	0
Paraguay	71.7	92	94.6	76	72	99	4433	114	0.761	101	100	10	75	10	0
Sri Lanka	74.0	61	90.8	95	68	115	4243	116	0.758	102	100	10	90	11	1
Gabon	60.1	144	86.2	115	80	55	15167	54	0.755	103	63	8	126	14	6
Algeria	72.2	84	75.4	133	73	92	7740	88	0.753	104	100	10	90	11	1
Philippines	71.6	96	93.4	83	79	59	3406	124	0.751	105	84	9	90	11	2

Table 6: Ranking results in 2007 (n=182) (continued)

	Life expectancy		Adult literacy rate		Combined gross enrolment ratio		GDP per capita		HDI		MAXOR		MINOR		Difference between (a) and (b)
	raw value (years)	rank	raw value (%)	rank	raw value (%)	rank	raw value (PPP$)	rank	index value	rank	rank	n-th group (a)	rank	n-th group (b)	
El Salvador	71.3	100	82.0	125	74	84	5804	99	0.748	106	120	11	90	11	0
Syrian Arab Republic	74.1	58	83.1	121	65	125	4511	112	0.742	107	100	10	90	11	1
Fiji	68.7	113	94.4	79	71	103	4304	115	0.741	108	120	11	106	12	1
Turkmenistan	64.6	132	99.0	1	73	92	4953	106	0.738	109	100	10	106	12	2
Occupied Palestinian Territories	73.3	69	93.8	82	78	64	2243	135	0.736	110	84	9	120	13	4
Indonesia	70.5	105	92.0	90	68	115	3712	121	0.734	111	120	11	90	11	0
Honduras	72.0	89	83.6	120	74	84	3796	119	0.731	112	120	11	90	11	0
Bolivia	65.4	128	90.7	96	86	41	4206	117	0.730	113	100	10	106	12	2
Guyana	66.5	119	99.0	1	83	47	2782	127	0.728	114	100	10	106	12	2
Mongolia	66.2	122	97.3	59	79	59	3236	125	0.726	115	100	10	106	12	2
Viet Nam	74.3	57	90.3	98	62	130	2600	129	0.725	116	100	10	120	13	3
Moldova	68.3	115	99.0	1	71	103	2551	131	0.720	117	84	9	106	12	3
Equatorial Guinea	49.9	168	87.0	113	62	130	30627	28	0.719	118	46	7	147	16	9
Uzbekistan	67.6	117	96.9	64	72	99	2425	133	0.709	119	100	10	120	13	3
Kyrgyzstan	67.6	117	99.0	1	77	73	2006	141	0.709	120	100	10	106	12	2
Cape Verde	71.1	102	83.8	119	68	115	3041	126	0.708	121	120	11	106	12	1
Guatemala	70.1	106	73.2	138	70	110	4562	111	0.704	122	128	12	106	12	0
Egypt	69.9	108	66.4	149	76	79	5349	103	0.703	123	120	11	106	12	1
Nicaragua	72.7	77	78.0	129	72	99	2570	130	0.699	124	100	10	120	13	3
Botswana	53.4	160	82.9	122	70	110	13604	60	0.693	125	84	9	134	15	6
Vanuatu	69.9	108	78.1	128	62	130	3666	122	0.692	126	128	12	106	12	0
Tajikistan	66.4	120	99.0	1	70	110	1753	145	0.687	127	120	11	120	13	2
Namibia	60.4	143	88.0	108	67	122	5155	105	0.686	128	120	11	126	14	3
South Africa	51.5	164	88.0	108	76	79	9757	78	0.682	129	100	10	134	15	5
Morocco	71.0	104	55.6	162	61	134	4108	118	0.654	130	128	12	126	14	2
Sao Tome and Principe	65.4	128	87.9	111	68	115	1638	149	0.651	131	128	12	126	14	2
Bhutan	65.7	126	52.8	167	54	150	4837	108	0.619	132	128	12	126	14	2
Lao People's Democratic Republic	64.6	132	72.7	139	59	142	2165	136	0.618	133	137	13	126	14	1
India	63.4	134	66.0	150	61	134	2753	128	0.612	134	137	13	120	13	0
Solomon	65.8	125	76.6	131	49	162	1725	146	0.610	135	137	13	134	15	2
Congo	53.5	159	81.1	126	58	144	3511	123	0.601	136	128	12	134	15	3
Cambodia	60.6	142	76.3	132	58	144	1802	144	0.593	137	137	13	126	14	1
Myanmar	61.2	137	89.9	101	56	148	904	168	0.586	138	128	12	147	16	4
Comoros	64.9	130	75.1	134	46	167	1143	160	0.575	139	151	14	147	16	2
Yemen	62.5	135	58.9	158	54	150	2335	134	0.575	140	151	14	126	14	0
Pakistan	66.2	122	54.2	164	39	173	2496	132	0.572	141	137	13	134	15	2
Swaziland	45.3	179	79.6	127	60	140	4789	109	0.572	142	128	12	160	17	5
Angola	46.5	178	67.4	147	65	125	5385	101	0.563	143	128	12	160	17	5
Nepal	66.3	121	56.5	160	60	140	1049	166	0.552	144	137	13	134	15	2
Madagascar	59.9	145	70.7	143	61	134	932	167	0.543	145	137	13	147	16	3
Bangladesh	65.7	126	53.5	165	52	155	1241	156	0.543	146	137	13	134	15	2
Kenya	53.6	158	73.6	136	59	142	1542	150	0.540	147	137	13	147	16	3
Papua New Guinea	60.7	140	57.8	159	40	172	2084	139	0.540	148	161	15	134	15	0
Haiti	61.0	138	62.1	155	52	155	1155	159	0.532	149	151	14	134	15	1
Sudan	57.9	147	60.9	156	39	173	2086	138	0.530	150	151	14	134	15	1
Tanzania (United	55.0	156	72.3	140	57	146	1208	158	0.529	151	151	14	147	16	2
Ghana	56.5	152	65.0	151	56	148	1334	154	0.526	152	151	14	134	15	1
Cameroon	50.9	165	67.9	146	52	155	2128	137	0.523	153	151	14	147	16	2
Mauritania	56.6	151	55.8	161	50	160	1927	143	0.520	154	161	15	134	15	0
Djibouti	55.1	155	70.3	145	25	182	2061	140	0.520	155	151	14	171	18	4
Uganda	51.9	163	73.6	136	62	130	1059	164	0.513	156	137	13	147	16	3
Lesotho	44.9	180	82.2	124	61	134	1541	151	0.513	157	137	13	160	17	4

Table 6: Ranking results in 2007 (n=182) (continued)

	Life expectancy		Adult literacy rate		Combined gross enrolment ratio		GDP per capita		HDI		MAXOR		MINOR		Difference between (a) and (b)
	raw value (years)	rank	raw value (%)	rank	raw value (%)	rank	raw value (PPP$)	rank	index value	rank	rank	n-th group (a)	rank	n-th group (b)	
Nigeria	47.7	173	72.0	141	53	153	1969	142	0.511	158	151	14	160	17	3
Togo	62.2	136	53.2	166	53	153	788	171	0.499	159	161	15	147	16	1
Malawi	52.4	162	71.8	142	61	134	761	173	0.492	160	137	13	160	17	4
Benin	61.0	138	40.5	174	52	155	1312	155	0.491	161	161	15	134	15	0
Timor-Leste	60.7	140	50.1	168	63	128	717	174	0.489	162	137	13	160	17	4
Cote d'Ivoire	56.8	150	48.7	169	37	175	1690	147	0.483	163	170	16	147	16	0
Zambia	44.5	181	70.6	144	63	128	1358	153	0.480	164	137	13	160	17	4
Eritrea	59.2	146	64.2	154	33	178	626	178	0.471	165	161	15	171	18	3
Senegal	55.4	154	41.9	173	41	171	1666	148	0.464	166	170	16	147	16	0
Rwanda	49.7	169	64.9	152	52	155	866	169	0.459	167	161	15	160	17	2
Gambia	55.7	153	42.5	172	46	167	1225	157	0.456	168	170	16	147	16	0
Liberia	57.9	147	55.5	163	57	146	362	180	0.441	169	151	14	171	18	4
Guinea	57.3	149	29.5	178	49	162	1140	161	0.435	170	170	16	147	16	0
Ethiopia	54.7	157	35.9	176	49	162	779	172	0.413	171	170	16	160	17	1
Mozambique	47.8	172	44.4	171	54	150	802	170	0.401	172	161	15	160	17	2
Guinea-Bissau	47.5	175	64.6	153	36	176	477	179	0.395	173	170	16	171	18	2
Burundi	50.1	167	59.3	157	49	162	341	181	0.394	174	161	15	171	18	3
Chad	48.6	170	31.8	177	36	176	1477	152	0.392	175	177	17	171	18	1
Congo	47.6	174	67.2	148	48	166	298	182	0.389	176	161	15	171	18	3
Burkina Faso	52.7	161	28.7	179	32	179	1124	162	0.388	177	177	17	160	17	0
Mali	48.1	171	26.2	182	46	167	1083	163	0.370	178	177	17	171	18	1
Central African Republic	46.7	177	48.6	170	28	180	713	175	0.369	179	177	17	171	18	1
Sierra Leone	47.3	176	38.1	175	44	170	679	176	0.364	180	177	17	171	18	1
Afghanistan	43.6	182	28.0	181	50	160	1054	165	0.352	181	170	16	171	18	2
Niger	50.8	166	28.7	179	27	181	627	177	0.339	182	182	18	171	18	0

Notes:
1. This table was made by the author based on the data of the Human Development Report 2009.
2. The HDI rank is determined using HDI values to the sixth decimal point.
3. Though the value of adult literacy rate of some developing countries are over 99.0, the author applied 99.0 to these countries in order to keep consistency of data arrangement with other developed countries.
4. Though the value of GDP (PPP$) of some developing countries are over 40,000, the author applied 40,000 to these countries in order to keep consistency of the calculation of the HDI.