Normative and Positive Approaches to Ranking Human Development

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Normative and Positive Approaches to Ranking Human Development

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Maki Michinaka

Supervised by Professor Takashi Kurosaki

Graduate School of Economics, Hitotsubashi University

Tokyo, Japan

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Abstract

This dissertation investigates how to rank the levels of human development for given observations such as individuals, villages, or countries. The term human development describes the process of enlarging people's choice of life, and ranking them is important to setting targets for various antipoverty policies.

Specifically, I focus on the following three questions:

(I) What kind of rules are DESIRABLE to rank the levels of human development?

(II) What kind of rules are USEFUL for practical usage?

(III) How do we EXTEND these rules to overcome limitations in the accuracy of data?

Chapter 1 introduces this dissertation. I begin by reviewing previous research on human development and multidimensional poverty measurement, and then, I describe the motivations of the dissertation, which involve the importance of constructing human development ranking rules.

Chapter 2 focuses on Question (I). I suggest two types of human development ranking rules, named the maximal order ranking (MAXOR) and the minimal order ranking (MINOR), and examine their features. For the purpose of eliminating inherent arbitrariness in existing typical ranking rules, the ranking rules I propose do not require any aggregation or indexation processes. Instead, I adopt the specific axioms and processes. Each of the MAXOR and MINOR is a partition of a set of observations; the ranking result of MAXOR is generated by recursive steps of making maximal sets in a set while that of MINOR is generated by recursive steps of making minimal sets in a set. The MAXOR satisfies the axiom named *superiority of non-dominated observations*: that is, if an observation is not dominated by any other observations, then the observation is ranked the first rank order. On the other hand, the MINOR satisfies the axiom named *inferiority of non-dominating observations*: if an observation does not dominate any other observations, then the observation is ranked to the bottom rank order. These rankings recognize the incomparability of one human development dimension to other dimensions.

Chapter 3 corresponds to Question (II). I examine the practical utility of the ranking rules proposed in Chapter 2 by using the ranking results derived from the balanced

and unbalanced cross-country panel datasets for the period from 1980 to 2007. As a means of illustration, I compare these ranking results with the ranking of the Human Development Index (HDI), one of the most prevalent multidimensional human development measurement tools. The MAXOR and MINOR have the relatively stable number of ranks and distributions of the observations in the MAXOR and the MINOR during this period. This fact means that a rank order in the MAXOR or the MINOR for a specific observation shows its relative position compared to all other observations in a stable way, regardless of the year or the total number of observations.

Chapter 4 focuses on Question (III). I extend the MAXOR and MINOR based on the following two purposes. One is to fit the MAXOR and MINOR to the limitation of the existing dataset. Another is to overcome the disadvantage that a nonnegligible number of observations are ranked at the same rank order. It seems reasonable to assume that all available datasets possibly include some measurement errors. In order to reduce the disadvantage of the MAXOR and MINOR, and to fit the ranking rules to the limitation of the accuracy of the existing dataset, I propose extended ranking rules that involve allowing the data to have a certain range of measurement errors. Regarding indicator values included in a certain range as indifferent, we can reduce the number of observations ranked in the same rank order. For the dataset of HDI 2006, when we allow data variation of approximately 5.37%, the practical utility is maximized, namely, the number of observations that have the same rank is minimized. As a secondary effect of this extension, the robustness of the ranking to measurement error is also enhanced, and that is shown by a simulation exercise.

Chapter 5 conclude the dissertation. It first summarizes the findings of the analysis and then provides directions for future research.

Contents

List of Figures

List of Tables

Chapter 1

Introduction: Why Do Ranking Rules Matter?

1.1 Multidimensional poverty and human development

Poverty reduction has been one of the most crucial challenges in the world. Although researchers, policymakers, institutions, and individuals have made a consistent effort to alleviate poverty, it remains an urgent global task.

Though the aim of poverty reduction has not changed, the concept of poverty itself changed over the course of the last few decades. Prior to these decades, poverty had been conceived as economic deficiency. Numerous studies on development economics discussed how to measure the level of poverty based only on income or consumption level. The pioneering work of Amartya Sen (1976) elaborated upon the research on poverty measurement. Sen (1976) axiomatically characterized a poverty index for measuring the level of poverty of a given society. He organized into two steps the procedure for generating the index. The first is identifying the individuals who are the poor among the total population in the given society. This step is regarded as the determination of the poverty line in that society. The second step is aggregating the shortfalls of the individuals who fall below a certain poverty line into a poverty index value. In this step, the issue is whether or not the aggregation rule that transforms the set of individual level poverty into an index value that represents the poverty level of the society satisfies reasonable assumptions. Kakwani (1980), Chakravarty (1983) and Foster et al. (1984), aimed to improve Sen's poverty index, and proposed new poverty indices that satisfy acceptable axioms. These studies were extended to the poverty ordering approach, which ranks two distinct income distributions (Atkinson, 1987; Foster and Shorrocks, 1988; Zheng, 1997). In this context, however, poverty was regarded as a mere unidimensional issue, because the poverty level was measured through only monetary dimension.

On the other hand, the literature advocating that human well-being or welfare is not merely a unidimensional monetary problem but a multidimensional phenomenon can be traced back to the 1970's. These studies assume that the quality of life relates to various non-monetary factors such as health, education, social exclusion, freedom, safety, and so on. According to this idea, they attempt to measure the level of human well-being with an index value that aggregates multiple indicators. There exist several early contributions such that the physical quality of life index by Morris (1979), which consists of life expectancy, infant mortality rate, and adult literacy rate. Meanwhile, the deprivation index by Townsend (1989) consists of the unemployment ratio, non-car ownership, non-home ownership, and household overcrowding, and the quality of life index by Dasgupta and Weale (1992) consists of per capita income, infant mortality rate, life expectancy, adult literacy rate, and political and civil rights indices. The majority of these contributions, however, tend to be constructed upon an inadequate theoretical foundation. Some of these indices do not provide adequate explanation of why they selected the indicators for their index or how they derived their aggregation methodologies.

The capability approach proposed by Amartya Sen (1985; 1992) developed the conceptual and methodological frameworks of both the poverty and well-being measurements, and relaxed the border between them. The essence of the capability approach is that the well-being of a person should be evaluated by what the person does rather than what the person has. This concept has earned widespread acceptance among researchers and policymakers. As the capability approach was accepted, the following idea entered the mainstream: The well-being of a person should be measured by how much choice the person has in life, and the poverty level of a person should be measured by how many choices are deprived from a person. More technically, although the poverty measurement approach and the well-being measurement approach share the common understanding that both poverty and well-being are multidimensional concepts, their bases of measurement differ. The former focuses on the degree of deprivation so that a certain poverty line or threshold is set on each dimension and the shortfalls to the poverty line in all dimensions are aggregated. Meanwhile, the latter focuses on the degree of attainment so that the achievements in all dimensions are simply aggregated. Poverty is no longer a unidimensional concept in the poverty measurement approach but a multidimensional one. The new term, multidimensional poverty, which explicitly distinguishes unidimensional poverty and multidimensional poverty, is now widely accepted. Kakwani and Silber (2008) defined multidimensional poverty as a human condition that reflects failure in many dimensions of human life, such as hunger, ill health, malnutrition, unemployment, inadequate shelter, lack of education, vulnerability, powerlessness, social exclusion, and so on.

During the last two decades, studies on multidimensional poverty measurement applied the accumulated theoretical foundations of measuring unidimensional poverty, and have made much progress. Tsui (2002), Bourguignon and Chakravarty (2003) and Duclos and Makdissi (2005) developed a multidimensional poverty ordering approach that axiomatically characterizes a multidimensional poverty index with an aggregation of the shortfalls of the poor falling to the poverty line of each dimension. The fuzzy set approach, which is another major approach to multidimensional poverty measurement, explicitly takes into account the vagueness of the border between the poor and the non-poor (Qizilbash, 2006; Betti et al., 2008). On the other hand, Nussbaum (2000) and Alkire (2005) attempted to identify appropriate indicators of well-being. Many types of statistical analyses investigating the causal relationship among different dimensions of well-being are also in development (Kuklys, 2005; Ranis et al., 2006; Krishnakumar and Ballon, 2008). The Multidimensional Poverty Index (MPI), which identifies multiple deprivations at the individual level in health, education and standard of living was proposed by Alkire and Foster (2009).[1] Fleurbaey (2009) gave a detailed survey on several approaches to the measurement of individual well-being and social welfare and examine the key to construction of altanatives to Gross Domestic Product (GDP) basis on the framework of social choice theory. Thus, the studies on multidimensional poverty and well-being measurement has developed with mutual impact.

Human development is another concept of human well-being based on the capability approach. It was created by Mahbub ul Haq (1996) and the United Nations

[1]The UNDP annually publishes the MPI values and its rankings in the HDR from 2010.

Development Programme (UNDP). The UNDP (1990) defined human development as a process of enlarging people's choices (UNDP 1990, p. 1). As a measure of human development, the UNDP launched an index named the Human Development Index (HDI) in 1990, a composite index describing the degree of human development at the national level. The HDI chose three fundamental aspects of human development: longevity, knowledge, and a decent standard of living (UNDP 1990, pp.11-12). To represent the attainment of these three aspects, the HDI has adopted four indicators: life expectancy at birth, adult literacy rate, combined gross enrolment ratio for primary, secondary and tertiary schools, and GDP per capita in purchasing power parity of US dollars (PPP$). The HDI is a combined index of these four indicators.[2] Every year, the UNDP publishes the HDI value of each country and its ranking in its annual report known as the Human Development Report (HDR). The HDI is the best-known and the oldest index for measuring the levels of human development by the UNDP, while the UNDP also provides three other types of indices: the Inequality-adjusted human development index (IHDI) that adjusts the HDI for inequality in the distribution of each dimension across the population, the Gender Inequality Index (GII) that reflects gender-based disadvantages in three dimensions; reproductive health, empowerment and the labor market, and the Multidimensional Poverty Index (MPI) that identifies the degree of multiple deprivations at the individual level in education, health and standards of living using microdata based on household surveys.[3]

The HDI values and rankings have drawn global attention. For each nation, the HDI value and ranking are one of the yardsticks for the attainment of their development policies, and the improvement of them becomes one of the goals of development policies. In the past year, 273 articles including the word 'Human Development Index'

[2]These indicators were adopted from 1995 to 2009. The indicators and aggregation methodology of the HDI have been modified over the past twenty years. For more details, see Appendix A.

[3]Before 2010, the Human Poverty Index (HPI) was used in place of the IHDI and the Gender-related Development Index (GDI) and the Gender Empowerment Measure (GEM) were used in place of the GII. The Human development report website (http://hdr.undp.org/en/humandev/) provides detailed explanations about indices made by the UNDP. For details of the HPI, see http://hdr.undp.org/en/statistics/indices/hpi/, and for the GDI and GEM, see http://hdr.undp.org/en/statistics/indices/gdi_gem/. Instructions for how to calculate the IHDI, GII and MPI are in the *technical notes*, http://hdr.undp.org/en/media/HDR%202013%20technical%20notes%20EN.pdf

were published in major newspapers in the world.[4] In particular, soon after publication of the HDR 2013 on March 14, 2013, a number of newspapers in developing and developed countries provided articles about the HDI values and rankings in 2013. In addition, some of them also provide policy perspectives for improving the HDI values and rankings. For example, *The Australian,* an Australian national newspaper reported the HDI ranking (the second out of 187 countries) of Australia and that of several other countries under the title of "We are second only to Norway."[5] *Agencia de Informacao de Mocambique*, a newspaper in Mozambique, reported that the HDI rank of Mozambique in 2013 is the second worst in the world but the value of that increased by 0.005 compared to 2012.[6] *Addis Fortune,* a weekly newspaper in Ethiopia provided an article titled "Human Development Must Top Economic Policy Agendas," claiming that enhancement of education and health care of mothers and children were the key to sustainable development[7]. A major Malaysian newspaper, *New Straits Times* reported that the HDI ranking of Malaysia is 64th in the world and 6th in Asian countries, and refers to agendas to reinforce human development such as enhancement of public health and education services.[8] *The Globe and Mail,* the newspaper with the largest circulation in Canada ran a column stating that the income inequality in Canada had been growing in recent years and the rank of the inequality-adjusted human development index (IHDI) of Canada in 2013 was behind Slovenia.[9]

The HDI is a breakthrough in the sense that it succeeds in quantifying the concept of the capability approach and human development in a simple index format. The indexation enables us to capture the level of human development intuitively and to compare quickly the human development levels of different countries. At the same time, however, it is criticized for its inherent arbitrariness in the following two angles. One is the arbitrariness of its selection of indicators that measure the levels of human development. The other is the arbitrariness of its calculation process that aggregates

[4] From September 1, 2012 to August 31, 2013. The data is based on the LexisNexis database. See http://www.lexisnexis.com/ap/academic/, accessed August 31, 2013.

[5] *The Australian,* March 15, 2013, p. 9

[6] "Human Development: Two interpretations of a Dodgy Report," *Agencia de Informacao de Mocambique,* March 19, 2013, online edition.

[7] *Addis Fortune,* March 24, 2013, online edition

[8] "Growth must be inclusive," *New Straits Times,* March 30, 2013 p. 18.

[9] "Inequality, yes but Canada's in a sweet spot," *The Globe and Mail*, March 18, 2013, p. 11.

four indicator values into one index value. The HDI is also subject to the criticism that there are no logical or statistical foundations for accepting the specific indicators or calculations. To search for such foundations, a number of modifications were proposed in previous works. McGillivray (1991) pointed out that there is a high correlation among the four indicators of the HDI so that the HDI cannot represent the breadth of human development. Paul (1996) suggested several modifications to the HDI, such as adding the infant mortality rate as an indicator. Noorbakhsh (1998a, 1998b) suggested several modifications to the HDI taking account for the diminishing returns to the education indicators and suggest an alternative income indicator having less restriction in the calculation process. Gormely (1995) suggested the use of distinct income indexation formulas depending on the level of GDP per capita in PPP$. Though Gormely's method was adopted by the HDI from 1995 to 1998, Luchters and Menkhoff (1996) pointed out the statistical artifacts of this alternative method, and suggested using a single, simple function type for the income transformation, such as a logarithmic or Atkinson-type function. After that, Anand and Sen (1999) proposed a logarithmic transformation formula that was adopted by the HDI from 1999 to 2009. The characterization of the HDI by Chakravarty (2003) provided an axiomatic characterization of the HDI. Chowdhury and Squire (2006) and Chershye et al. (2008) suggest alternative weighting methods for the aggregation process of the HDI.

As mentioned above, the advantages of the indexation of human development are understandability and comparability. However, when we try to represent the multi-dimensional concept of the HDI by an index value, we inevitably confront problems such that which indicators are chosen and how they are aggregated into an index value. Moreover, reducing multiple indicators to one index weakens the index's ability to capture the diverse nature of human development. A combined index does not give information about the level of each indicator. This lack of consideration for diversity somewhat contradicts the original concept of the HDI, for one of the aims of the HDI was to highlight several distinct aspects of human development.

This dissertation focuses on the aggregation problem and aims to suggest two types of methodologies for ranking human development that capture the diverse nature of human development. Unlike the HDI and other major development indices, I concentrate on the analyses of the relative levels of human development, not the absolute levels.

The methodologies I suggest never aggregate multiple indicator values into one index value, and never calculate the absolute value of individual observations that describes the level of human development of the observation. The next sections provide the reason why this dissertation is centered on the aggregation issue and the relative levels of human development.

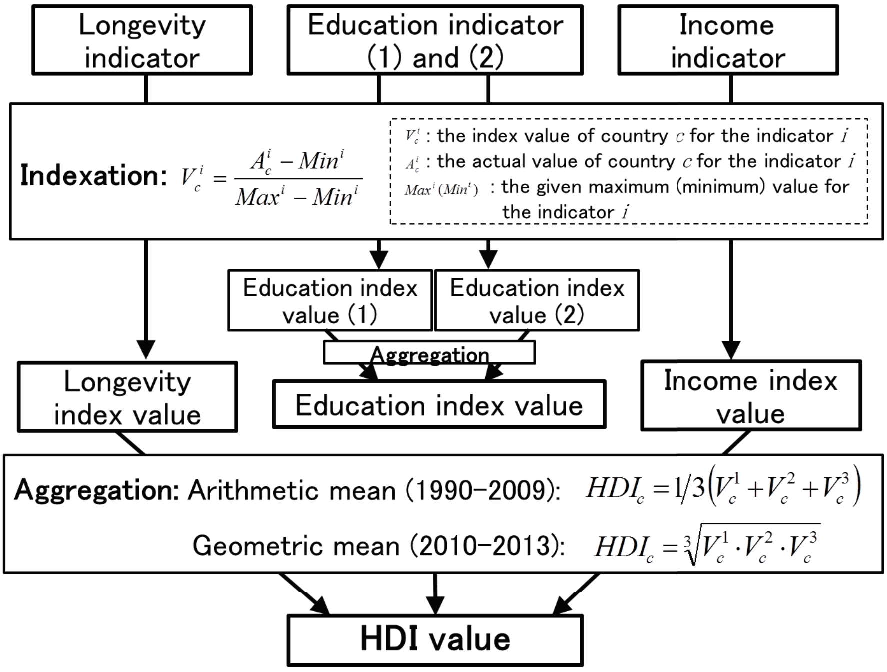
1.2 Main focus of this dissertation

When we try to rank the levels of human development for certain observations (individuals, households or countries), we will face two kinds of problems: which indicators are adopted as the representative indicators that appropriately describe the diverse nature of human development and how to aggregate or rank the levels of human development of the observation that consists of multiple indicators. In this dissertation, I focus on the latter problem. In addition, I emphasize the relative level of human development rather than the absolute level, so I suggest the methodologies just to rank the human development levels of observations, not to calculate the level of each individual observation. The following subsections are my focus.

1.2.1 Why aggregation rules are important?

The year 2010 was a sensational one for those who were interested in the HDI, because the aggregation process of the HDI was modified drastically.[10] The HDI is a composite index that aggregates the attainment of three essential dimensions of human development, that is, longevity, educational attainment, and income. Figure 1.1 shows the process of acquiring the HDI value. To obtain the HDI value, we first calculate the index value of each dimension by using the actual value of the indicators, such as life expectancy, adult literacy rate, enrolment ratio and GDP per capita, which represent the attainment of these three dimensions. Then, we aggregate these three index values into an HDI index value. From 1990 to 2009, the HDI value was a simple arithmetic mean of these three index values, but in 2010, a geometric mean was adopted for the first time.

[10]Several modifications were added not only to the aggregation process but also to the indicators that represent three fundamental dimensions. See Appendix A.



Source: Prepared by the author based on the Human Development Report 1990-2013.

Figure 1.1: How to calculate the HDI value

What does this change mean? By definition, for any pair of positive real numbers, the arithmetic mean is always larger than the geometric mean except in the case when the numbers are equal.[11] This condition indicates that the arithmetic mean does not pay attention to the balance of two numbers, whereas the geometric mean puts much value on the proximity of two numbers. For example, a distribution of two index values $(0.5, 0.5, 0.5)$ and another distribution $(0.1, 0.5, 0.9)$ are regarded as the same human development level according to the old HDI, because the arithmetic mean of these distributions are the same as 0.5.[12] On the other hand, the new HDI regards the former distribution as more desirable than the latter one, because the geometric mean of the former is 0.5 but that of the latter is approximately 0.36.[13] This means that the HDI changed its philosophy to be more appreciating of the extent of the balance among the three index values, whereas this balance was not appreciated previously. In fact, the changes in the aggregation process possibly have had some impact on the final

[11]In mathematics, the inequality of arithmetic and geometric shows, for any pair of positive real numbers $a > 0$ and $b > 0$, $\frac{a+b}{2} \geq \sqrt{ab}$ with equality if and only if $a = b$.

[12]$(0.5 + 0.5 + 0.5) \times \frac{1}{3} = (0.1 + 0.5 + 0.9) \times \frac{1}{3} = 0.5$

[13]$\sqrt[3]{0.5 \cdot 0.5 \cdot 0.5} = 0.5$, and $\sqrt[3]{0.1 \cdot 0.5 \cdot 0.9} \approx 0.36$.

Country	Longevity index	Education index		Income index	HDI value	
		old	new		old	new
Equatorial Guinea	0.42	0.79	0.78	0.96	0.719	0.675
Egypt	0.75	0.70	0.69	0.66	0.703	0.702

Source: Calculated by the author based on the data of 2007 conpiled in the Human Development Report 2009.

Table 1.1: The old and new HDI values

index values and the ranking of them.

Table 1.1 shows the three index values and the HDI values calculated by the old and new methods (i.e., arithmetic mean and geometric mean) for Equatorial Guinea and Egypt based on the dataset of 2007 compiled in the HDR 2009 (UNDP 2009).[14] [15] The three index values of Equatorial Guinea are quite different. The longevity index is 0.42, but the income index is more than twice of that at 0.96.[16] In contrast, the index values of Egypt are relatively well-balanced compared to those of Equatorial Guinea. The difference of the maximum and minimum value is within 0.1. Hence, the old HDI value, as calculated by the arithmetic mean for Equatorial Guinea, is bigger than the new HDI value calculated by the geometric mean (0.719 versus 0.675, respectively). Meanwhile, the old HDI value of Egypt, 0.703 is almost the same as the new HDI value, 0.702. As a result, the old HDI value of Equatorial Guinea is bigger than that of Egypt, but the new HDI value of the former is much smaller than that of the latter, which means that the levels of human development and rank relation of these countries reverses when the aggregation method of the HDI changed, namely, when the HDI philosophy changed.

This fact shows that we can obtain different index values and ranking results for

[14]The annual HDI values and ranking presented in the annual HDR is decided on the basis of the data that is a few years older than the title year.

[15]The year 2009 was the last year of the old HDI aggregation method. The reason the education index values are different is that the education index is the two to one weighted mean of adult literacy rate and combined gross enrolment ratio. Within the old HDI, the weight mean is an arithmetic mean, but, within the new HDI, it is a geometric mean.

[16]Equatorial Guinea is a typical oil-rich country in Sub-Saharan Africa. Owing to the country's rich mineral resources and the proper utilization of the resources, this country underwent rapid economic growth during the 1990s. See Same (2008) for details.

the same original data simply by changing the aggregation rule, which implies that we are possibly manipulating the index values and ranking results in an arbitrary manner. Thus, some policymakers might seek political advantage by manipulating the aggregation rules. However, it is difficult to eliminate this kind of arbitrariness entirely. Because every ranking rule always has a certain implicit arbitrariness in the sense that there are any criteria or philosophies for the selection of particular formulas or weights of the ranking rule. How can we address this problem? One of the possible solutions is choosing the rules based on acceptable criteria. If a rule is characterized based only on reasonable assumptions that appropriately represent unanimously acceptable criteria, then, consequently, the index values and ranking results based on the rule would be accepted unanimously. In other words, we can reduce the implicit arbitrariness of the index value and ranking results by constructing the aggregation rules based on acceptable criteria. This motivates me to build ranking rules that satisfy some acceptable axioms.

As acceptable axioms, I propose several axioms: *ordinalism:* **(O)**, *dominance principle:* **(DP)**, *superiority of non-dominated observations:* **(SNO)**, *inferiority of non-dominating observations:* **(INO)**, *non-existence of dominance relation in a same rank order:* **(NDR)** and *monotonicity* **(M)**. Dominance principle requires that if an observation achieves greater attainments in all human development dimensions to another observation, then the observation is ranked higher to another one. The axiom of superiority of non-dominated observations and inferiority of non-dominating observations are symmetrical. The former implies that if an observation is not dominated by any other observations, then the observation is ranked to the first rank order. On the other hand, the latter implies that if an observation cannnot dominate in all dimensions to any other observations, then the observation is ranked to the least rank order. Several axioms I introduce are based on the common criterion that we never aggregate the attainment of different human development dimensions, because distinct dimensions represent distinct aspects of human development respectively, so we should not aggregate them. In this dissertation, I provide two types of human development ranking rules that satisfies these axioms.

The ranking rules I suggest never need any indexation or aggregation process in generating the ranking results. Instead, I use three kinds of binary relations and certain recursive steps to generate them. Reducing multiple indicators' attainments to one index value weakens the index's ability to capture the diverse nature of human development. A combined index does not give information about the attainment level of each indicator that corresponds to each dimension of human development. A lack of consideration of diversity somewhat contradicts the multidimensional concept of human development. Hence, the ranking rules that I propose generate no scalar index of the human development level for each observation, but they do generate a ranking of the human development level for all observations. In short, my proposed rules are not meant to derive a scalar index of the level of a specific observation. Instead, they are rules for ranking all observations in order of the levels of human development.

Another feature of these rules is found in the binary relations used in the process of generating the ranking result. I allow incomparability to the binary relation of two observations. As a result, the ranking results derived from the rules are not complete top-to-bottom rankings like as the HDI, because several incomparable observations are placed to the same rank order. Although this feature seems like a practical disutility, it also can be regarded as an appreciation of the diversity of human development among different observations, in the sense that we never impose assigning different rank orders to incomparable observations.

1.2.2 Why not an absolute but a relative approach?

In the context of research on poverty, there are two contrasting concepts of poverty: absolute poverty and relative poverty. The former pays attention to the absolute poverty levels of individuals, households or nations in a society, but the latter discusses those of relative levels. In uni-dimensional (monetary) poverty approach, the absolute poverty line is set based on the cost, which is minimal standards of food, clothing, health care and shelter and so on, and individuals who fall below the poverty line are regarded as the poor. In 2008, the World Bank set the global poverty line at $1.25 a day in purchasing power parity of US dollars in 2005.[17] [18] A number of developing countries have their own national poverty line; moreover, some countries have several kinds of poverty lines such as food and non-food poverty lines, and rural and urban poverty

[17]See, http://data.worldbank.org/indicator/SI.POV.DDAY.

[18]Before 2010, one dollar a day was the global poverty line. It was defined in the *World Development Report 1990* (WDR) by the World Bank.

lines. By contrast, the relative poverty line is set at a constant proportion of current mean income or consumption in a society. One of the prevalent relative poverty lines is defined by the Organisation for Economic Co-operation and Development (OECD). It defines the poverty rate as the ratio of the number of people who fall below the poverty line and the total population; the poverty line is here taken as half the median household income.[19] If the income of all individuals in a society increases without change in income distribution but the income of some individuals changes from below to above the absolute poverty line, then the absolute poverty level of the society declines but the relative poverty level is not changed.

Regardless of whether on a national or global level, the main objectives of development policies are to decrease the absolute poverty level and increase the absolute human development level. On the other hand, the relative levels of poverty or human development, or in other words, the ranking of poverty or human development level in a certain society are also matters of world concern. As the above newspaper articles show, not only the value but also the rank of the HDI for each country is given attention and the improvement of them is one of the major goals of the development policy issues. In addition to that, a certain ranking is useful to determine a certain kind of priority, for example, when a government or an institution gives the Official Development Assistance (ODA) to the least developed country based on the level of human development. In such a case, we do not need to calculate the absolute values of human development levels for all countries but all we need to do is rank all countries based on some sort of ranking rules. It means that a relative approach possibly reduces the cost of an absolute approach.

For the above reasons, this dissertation adopt the relative approach. I never set any poverty lines but suggest the methodologies to rank observations (such as individuals, households and countries) in line with the levels of multidimensional human development.

[19] See http://www.oecd-ilibrary.org/sites/factbook-2010-en/11/02/02/index.html?itemId=/content/chapter/factbook-2010-89-en.

1.3 Organization of this dissertation

This paper discusses how the levels of human development can be ranked for individuals, households, villages, or countries. The selection of indicators that representing the various dimensions of human development is also an important problem, but in this dissertation, I focus on the aggregation problem of such indicators. Hence, I assume that the levels of human development for relevant observations such as individuals or countries are described by common multiple development indicators (for example, life expectancy, infant mortality ratio, GDP per capita and so on) and these indicators are given. I firstly provide two types of ranking rules to rank the levels of human development and then examine their practical usefulness by extending them to fit the limitation of reality. The rest of this dissertation is organized as follows:

Chapter 2 is devoted to the construction of desirable human development ranking rules based on reasonable and acceptable axioms. I firstly introduce several axioms and then suggest two types of ranking rules, named maximal order ranking (MAXOR) and minimal order ranking (MINOR). Then, I investigate the characteristics of these ranking rules.

Chapter 3 examines the practical usefulness of The MAXOR and MINOR with using ranking results derived from balanced and unbalanced cross-country panel datasets for the period 1980 to 2007. For the purpose of comparison with other existing ranking rules, I used the same dataset as that used to derive the HDI value and ranking during that period. I investigate the ranking result and discuss the advantage of the MAXOR and MINOR for applying unbalanced panel datasets.

Chapter 4 extends the MAXOR and MINOR to fit the limitation of the existing dataset. The available datasets possibly include some measurement errors. Taking this possibility into account, I attempt to extend the MAXOR and MINOR, which involves allowing the data to have a certain range of measurement errors. The result shows that this extension improves the usefulness of the MAXOR and MINOR ranking, in the sense that it decreases the number of countries with the same ranking.

This dissertation thus contributes to the literatures by combining normative and positive approaches to ranking human development. As an attempt based on a normative approach I provide the ranking rules satisfying several acceptable axioms, and as the attempt based on a positive approach, I examine and extend the practical usefulness of the rules by using existing datasets and suggest the way to extend the rules tanking account of the measurement errors in existing dataset.

Chapter 2

The Maximal Order Ranking and the Minimal Order Ranking

2.1 Introduction

It is important to rank the levels of human development among given observations such as countries or individuals in order to set targets for various antipoverty policies.[1] How can we rank the levels of development among observations if each observed development level is expressed by the data of multiple indicators? An approach is indexation of these data. Transforming multiple data into an index value enables us to rank them easily. However, any ranking results based on indexation are always at risk of being manipulated, for we can obtain different index values and ranking results from the same original data by changing the aggregation rule.

With the aim of alleviating the arbitrariness of the composite indices, I provide two types of ranking rules based on acceptable and reasonable assumptions. These ranking rules, namely, the maximal order ranking (MAXOR) and the minimal order ranking (MINOR) do not require any aggregation or indexation processes to generate their ranking results, but require certain binary relations and recursive steps satisfying several axioms. Some of them have implicit brief that we cannot compare the attain-

[1]This chapter is revision of Michinaka (2010). I am grateful for the useful comments and suggestions on the earlier version of this chapter that were made by Professor Shuji Kasajima and Professor Noriatsu Matsui. I am also thankful for the ideas that I gained through attending the 19th annual meeting of the Japan Society for International Development in November 2008.

ment of one human development dimension to that of another dimension, because the attainments of distinct dimensions should be evaluated distinctly.

The next section provides notations and definitions. Section 3 introduces axioms I apply to the ranking rules. Section 4 defines the MAXOR and MINOR, and an brief example is given in Section 5. Section 6 examines the characteristics of the rules. The final section gives a conclusion.

2.2 Notations and definitions

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 multidimensional human development, such as GDP per capita, density of physicians, and adult literacy rate. These indicators are common among all observations. I also assume that the data for each indicator are represented using real positive numbers. The greater the numbers, the better are the situations.

Let X be a finite set of observations, and I be a set of the human development indicators. The numbers of elements in X and I are denoted as $\sharp X$ and $\sharp I$ respectively. Let $\mathbf{R}_+$ denote a set of all positive real numbers, and $\mathbf{R}_+^I$ is the $\sharp I$-fold Cartesian product of $\mathbf{R}_+$. The level of human development for any observation in X is described as $f(x) = (f_x^i)_{i \in I}$, where f is a mapping from X to $\mathbf{R}_+^I$. In other words, f assigns the $\sharp I$-dimensional human development level to an observation x in X.

Assume that $\succeq$ denotes a binary relation on X means "at least as developed as." This binary relation is defined as $x \succeq y :\Leftrightarrow \forall x, y \in X \ \& \ \forall i \in I, \ f_x^i \geq f_y^i$. Corresponding to $\succeq$, I define three types of binary relation on X:

(I) $\succ$, which is interpreted as "strictly more developed than," is defined as

$$x \succ y : \Leftrightarrow \forall x, y \in X, \ \& \ f_x^i \geq f_y^i \ \forall i \in I, \ \& \ \exists j \in I \ \text{ such that } \ f_x^j > f_y^j$$

(II) $\sim$, which is interpreted as "as developed as," is defined as

$$x \sim y :\Leftrightarrow \forall x, y \in X \ \& \ \forall \ i \in I, \ f_x^i = f_y^i$$

(III) $\bowtie$, which is interpreted as "incomparable," is defined as

$$x \bowtie y :\Leftrightarrow \forall x, y \in X, \ \exists i \in I \text{ such that } f_x^i > f_y^i \ \& \ \exists j \in I \text{ such that } f_x^j < f_y^j.$$

Here $\succ$ and $\sim$ represent asymmetric and symmetric part of $\succeq$ respectively. (I) is well-known binary relation as the Pareto dominance. If $x \succ y$, we consider that y is Pareto dominated by x. Meanwhile, $\bowtie$ is an incomparable relation that corresponds to $\succeq$, namely, $x \bowtie y \Leftrightarrow \neg(x \succeq y)$ & $\neg(y \succeq x)$.[2] It is interpreted that the levels of human development for x and y are incomparable in the sense that the each observation achieves higher attainment in distinct dimension each other. This incomparability describes the criterion that we never aggregate the attainment of different human development dimensions because each dimension represents a distinct aspect of human development so that we cannot combine them.

2.3 Axioms

To examine the properties of the MAXOR and MINOR, I introduce the following axioms.

Ordinalism (O):

The ranking is generated based on not cardinal but ordinal information.

Dominance principle (DP):

$\forall x \in X$ & $\forall y \in X$, $f_x^i \geq f_y^i \; \forall i \in I$ & $\exists j \in I$ such that $f_x^j > f_y^j \Rightarrow x$ is ranked to the higher rank order than y.

Superiority of non-dominated observations (SNO):

$\forall x \in X$ & $\forall i \in I$, $\nexists f_y^i$ such that $f_y^i > f_x^i \Rightarrow x$ is ranked to the first rank order.

Inferiority of non-dominating observations (INO):

$\forall x \in X$ & $\forall i \in I$, $\nexists f_y^i$ such that $f_x^i > f_y^i \Rightarrow x$ is ranked to the bottom rank order.

Non-existence of dominance relation in a same rank order (NDR):

$\forall x \in X$ & $\forall y \in X$, x and y are ranked the same rank order $\Rightarrow f_x^i \sim f_y^i$ or $x \bowtie y$.

Monotonicity (M):

If $\forall x, y \in X$, x is ranked higher than y then f_x^j for $j \in I$ improves and $f_y^i \; \forall i \in I (i \neq \jmath)$ & $f_y^i \; \forall i \in I$ remain unchanged, $\Rightarrow$ the hierarchy of rank orders between x and y is unchanged.

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

Independence of irrelevant alternatives (IIA):

$\forall x, y \in X$, the hierarchy of rank orders between x and y is determined based only on the human development profile of x and y

Here I provide detailed explanations for each axiom.

Ordinalism **(O)** refers to the condition of the information used to generate a ranking. It requires that not using cardinal but ordinal information in generating a ranking. To rank human development, we rank each observation's human development profile, which is a bundle of values for the multiple indicators representing multidimensional human development, such as GDP per capita, density of physicians, enrolment ratio and adult literacy rate. The data for each indicator value are considered to be cardinal information in the sense that their quantities are represented by real positive numbers. However, if a ranking rule satisfies **(O)**, then not cardinality but ordinality only is considered in generating a ranking. To explain, cardinal information includes the size of data (e.g., in Japan, the life expectancy at birth is 83.6 years, while in Norway is 81.3 and, in Sierra Leone, 48.1) or the difference in the sizes of data (e.g., the size difference of life expectancy in Japan and Norway is only 2.3 years, but that in Japan and Sierra Leone is 35.5 years); meanwhile, ordinal information includes the rank order of observations (e.g., the rank order of life expectancy of the above three countries is first Japan, then Norway, and finally Sierra Leone). Though we often cannot specify accurate sizes for certain data, we do know the rank order of them. For example, we may not be able to pinpoint the accurate weight of an elephant or a rabbit, but we can easily judge an elephant is heavier than a rabbit. Thus even if we do not have cardinal information, we use can use ordinal information to generate a ranking.

Dominance principle **(DP)** requires that if an observation which achieves higher attainments for all indicator values compared to another observation should be ranked higher than the other one. In other words, if an observation dominates another observation, then the observation should be ranked higher than the other one.

Superiority of non-dominated observations **(SNO)** requires that if an observation is not dominated by any other observations, then the observation is ranked the first rank order. By definition, an observation that is never dominated by other any observation achieves the highest attainment for at least one indicator among all observations. By contrast, *Inferiority of non-dominating observations* **(INO)** requires that if an observation does not dominate any other observations, then the observation is ranked to the bottom rank order. By definition, an observation that does dominate any other observations never achieves strictly higher attainments for any indicators.

Non-existence of dominance relation in a same rank order **(NDR)** requires that the binary relations for any pair of observations ranked in the same order always correspond to indifference or incomparablity.

Monotonicity **(M)** and *Independence of irrelevant alternatives* **(IIA)** are major axioms in social choice theory. **(M)** requires that if an indicator value of an observation is improved while the observation is originally ranked higher than another observation, then the improvement does not reverse the hierarchy of these two observations. **(IIA)** requires that determining the hierarchy of rank order for any pair of observations are based only on the profiles of these two observations. In other words, the performance of any other observation does not influence the order of two observations. If a ranking rule satisfies **(IIA)**, we need not take account of the information about irrelevant observations (i.e. alternatives) when ranking two relevant observations. In this sense, **(IIA)** is the condition for reducing the cost of dealing with such a quantity of information.

2.4 Definitions of the MAXOR and MINOR

On the basis of the abovementioned binary relations and axioms, I now define two types of human development ranking rules.

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

$$\overline{M}(X, \succ) = \{x \mid x \in X \ \& \ \nexists y \in X \text{ such that } y \succ x\}$$

The maximal order ranking (MAXOR) over X is generated according to the following recursive steps:

1. Make the maximal set on X, and call it $\overline{M}_1$
2. Define $X \backslash \overline{M}_1 = X_1$
3. Again, make the maximal set $\overline{M}_2$ on X_1, namely,

$$\overline{M}_2(X_1, \succ) = \{x \mid x \in X_1 \ \& \ \nexists y \in X_1 \text{ such that } y \succ x\}$$

4. In like manner, consecutively make maximal sets $\overline{M}_i$ on X_{i-1} until $X_{i-1} \backslash \overline{M}_i = \emptyset$

5. These procedures make a sequence of maximal sets, that is, $\overline{M}_1$, $\overline{M}_2$, ..., $\overline{M}_i$, ..., $\overline{M}_m$. We regard $x \in \overline{M}_1$ as the observations ranked to the first rank order, $x \in \overline{M}_2$ as the observations ranked to the second rank order, ... $\overline{M}_m$ as the observations ranked to the bottom rank order.

The minimal order ranking (MINOR) over X is defined in a way reverse to that of the MAXOR. I firstly define a minimal set of a set X as follows:

$$\underline{M}(X, \succ) = \{x \mid x \in X \ \& \ \nexists y \in X \text{ such that } x \succ y\}$$

The MINOR over X is then generated according to the similar recursive way to MAXOR:

1. Make the minimal set on X, and call it $\underline{M}_m$

2. Define $X \backslash \underline{M}_m = X_m$

3. Again, make the minimal set $\underline{M}_{m-1}$ on X_m, namely,

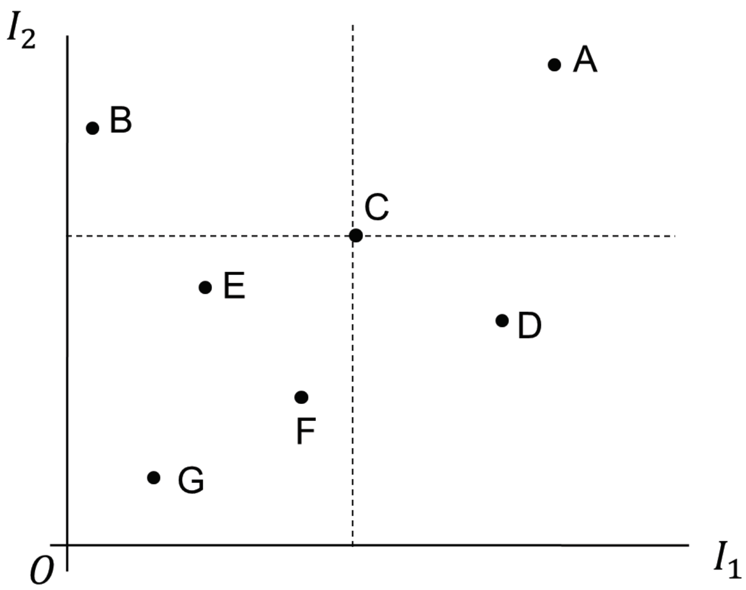
   $$\underline{M}_{m-1}(X_1, \succ) = \{x \mid x \in X_m \ \& \ \nexists y \in X_m \text{ such that } x \succ y\}$$

4. In like manner, consecutively make maximal sets $\underline{M}_{m-i}$ on X_{m-i+1} until $X_{m-i+1} \backslash \underline{M}_{m-i} = \emptyset$

5. These procedures make a sequence of minimal sets, that is, $\underline{M}_m$, $\underline{M}_{m-1}$, ..., $\underline{M}_{m-i}$, ..., $\underline{M}_1$. We regard $x \in \overline{M}_1$ as the observations ranked to the first rank order, $x \in \overline{M}_2$ as the observations ranked to the second rank order, ... $\overline{M}_m$ as the observations ranked to the bottom rank order.

2.5 Example

Here, I illustrate the abovementioned binary relations and ranking rules by a brief example. For simplification and to facilitate the understanding of the binary relations, let us assume that $X = \{A, B, C, D, E, F, G\}$ and $I = \{I_1, I_2\}$. Each point from A to G in Figure 2.1 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, I infer that A Pareto dominates C. Conversely, E, F, and G,



Source: Prepared by the author.

Figure 2.1: Illustration of the binary relations

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. 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, I infer that they are incomparable to C. In addition, if an observation has all indicator values that identical to those of C, we infer that the observation is indifferent to C.

Table 2.1 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 $\underline{M}_n$). 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.

Note that the rank order of B is second in the MAXOR, while it is the lowest in

	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

Source: The ranking results were generated by the author based on the processes introduced in Section 2.4.

Table 2.1: Ranking results of the example

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.

A *ranking* is defined as a linear ordering $\geq$ over 2^X. Each of the MAXOR and MINOR is regarded as a ranking. Note that the three types of binary relations defined in Section 2 are quasi-orderings.[3] The binary relations used to generate the MAXOR and MINOR are quasi-ordering, but the ranking results of both the MAXOR and MINOR are linear ordering.

In addition to that, note that the incomparable binary relations are not always hold in the final ranking results generated by the MAXOR and MINOR. For any $x, y \in X$, there possibly exists the case that despite $x \bowtie y$, x is ranked more highly than y in the final ranking results. This case happens if there exists $z \in X$ such that $x \bowtie z$ and $z \succ y$. The interpretation of this case is as follows: x and y are incomparable; moreover, x and z are incomparable, but z dominates y. Then, at least y has to be ranked lower than z in the final ranking result. With respect to x and z, they are incomparable; moreover, x and y are also incomparable, so we cannot judge which of x and z should be ranked lower in the final ranking result. In the end, we put them

[3] An ordering is a binary relation that satisfies reflexivity, completeness and transitivity. A quasi-ordering satisfies reflexivity and transitivity, but not completeness.

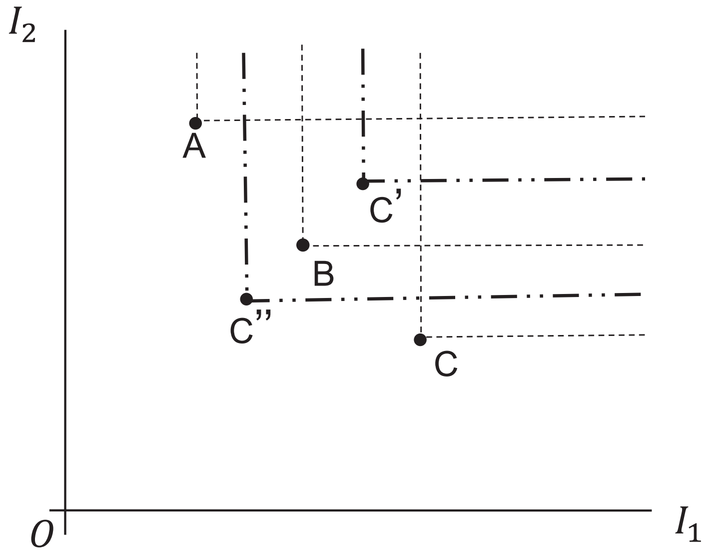


Figure 2.2: Counterexample of Independence of irrelevant alternatives (IIA)

in the same rank order. Finally, the rank order of x and z is the same, but y will be lower than them in the ranking result, despite the fact that $x \bowtie y$.

2.6 Characteristics of the ranking rules

In this section, I check the axioms satisfied by the MAXOR and MINOR.

The MAXOR satisfies **(O)**, **(M)**, **(DP)**, **(NDR)** and **(SNO)**.

As shown in the previous section, the MAXOR can be generated based only on ordinal information, then the MAXOR satisfies **(O)**.

If an observation dominates another one, the former is ranked higher than the latter in the MAXOR. Hence, the MAXOR satisfies **(DP)**.

(M) requires that if an observation ranked higher than another one improves an indicator value, then the improvement does not reverse the hierarchy of these two observations. By definition, if an observation is ranked higher than another one in the MAXOR, the former dominates the latter. The improvement in an indicator of the former keeps the dominance relation between these two observations. **(M)** is thus satisfied by the MAXOR

Regarding **(NDR)**, the contraposition shows that if $x \succ y$ or $y \succ x$ (because $\neg(x \sim y)$ and $\neg(x \bowtie y)$), then x and y are ranked differently. By the definition of the

MAXOR, if $x \succ y$ then x should be ranked higher than y, and if $y \succ x$ then y should be ranked higher than x. Hence, the MAXOR satisfies **(NDR)**.

As defined in the previous section, the MAXOR is generated by consecutively making of maximal sets. By the definition of a maximal set, the observations never dominated by any other observations should be included in a maximal set. Hence, the observations never dominated by any other ones are always ranked first. Thus, **(SNO)** is satisfied.

On the other hand, The MINOR satisfies **(O)**, **(M)**, **(DP)**, **(NDR)** and **(INO)**.

(O), **(M)**, **(DP)** and **(NDR)** are proved in the same manner as the MAXOR.

With respect to **(INO)**, the MINOR is generated by consecutively making of minimal sets. By the definition of a minimal set, the observations never dominate any other observations should be included in a minimal set. Hence, the observations never dominate any other ones are always ranked least. Thus, **(SNO)** is satisfied.

Unlike the HDI, the MAXOR and MINOR do not satisfy **(IIA)**. I show it using a simple counterexample. In Figure 2.2, $A \bowtie B$, $A \bowtie C$ and $B \bowtie C$, then all of these three observations are ranked to the first rank group in both the MAXOR and MINOR. However, if the human development profile of C changes into C', the binary relations change to $A \bowtie B$, $A \bowtie C'$ and $C' \succ B$. In turn, the rank orders also change to that; A and C' are ranked the first, while B is the second in the MAXOR. By the same token, if C changes into C'', the binary relations change to $A \bowtie B$, $A \bowtie C''$ and $B \succ C''$. Rank orders thus change as well; B is ranked the first, while A and C'' are ranked second.

2.7 Conclusion

In this chapter, I provided two types of ranking rules to rank the levels of human development of given observations based on acceptable assumptions and to examine the characteristics of these ranking rules. The notable feature of these ranking rules is recognition of the incomparability among distinct human development dimensions. However, even if a ranking rule is constructed based on reasonable assumptions, the ranking rule might not be used when it lacks practical usefulness. In the next chapter, I examine the practical usage of the MAXOR and MINOR by generating the ranking results using the existing datasets.

Chapter 3

The Practical Usefulness of Maximal Order Ranking and Minimal Order Ranking

3.1 Introduction

It is important not only that a ranking rule is based on reasonable and acceptable assumptions but also that the ranking rule is easily applied to practical usage.[1] Moreover, it is also important to check whether the ranking result provides useful information regarding the real situation. In addition, a ranking rule is not always used in one shot. It might be used regularly on a periodic basis. In this context, the relevance of the time-series variation of the rank order of each observation can be a yardstick for useful 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

[1]This chapter is revision of Michinaka (2011a). I am grateful for the useful comments and suggestions on the earlier version of this chapter that were made by Dr.Hiroki Nogami, Dr.Tatsufumi Yamagata and Professor Koji Yamazaki at the 21th annual meeting of the Japan Society for International Development in December 2010. I am also thankful for valuable comments and suggestion by Dr.Koji Takamiya and the participants of the Research Seminar on Economics at Nigata University in June 2012. In addition, I appreciate for valuable comments and suggestions by Dr.Tatsufumi Yamagata, Dr.Hiroki Nogami, Dr.Tomohiro Machikita, Dr.Satoshi Inomata, Dr.Jun Saito and the participants of the Research Workshop on Development Economics at the Development Studies Center of Institute of Developing Economy, JETORO in January 2012.

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, this chapter examines the practical usefulness of the MAXOR and MINOR by using the ranking results derived from existing cross-country panel datasets. The datasets are balanced and unbalanced panel datasets for the period 1980 to 2007. The unbalanced panel dataset is the one used to derive the values and rankings of the Human Development Index (HDI) reported in the Human Development Reports (HDRs) and the balanced panel dataset is extracted from the unbalanced one. The HDI is one of the most prevalent human development measurement tools. It is a composite index of four kinds of development indicators, that is, life expectancy at birth; adult literacy rate; combined gross enrollment ratio for primary, secondary and tertiary; and gross domestic products (GDP) per capita.[2]

In the rest of this chapter, I firstly derive the ranking as a means of illustration. Then I compare these ranking results with those of the HDI. In comparison, I regard it better that a rank order is robust against changes in 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.

3.2 Data

I use unbalanced and balanced cross-country panel datasets of human development indicators. The unit of observation is a country. I adopt four human development indicators identical to those used when calculating the HDI, that is, life expectancy at birth, adult literacy rate, combined gross enrolment ratio, and GDP per capita.

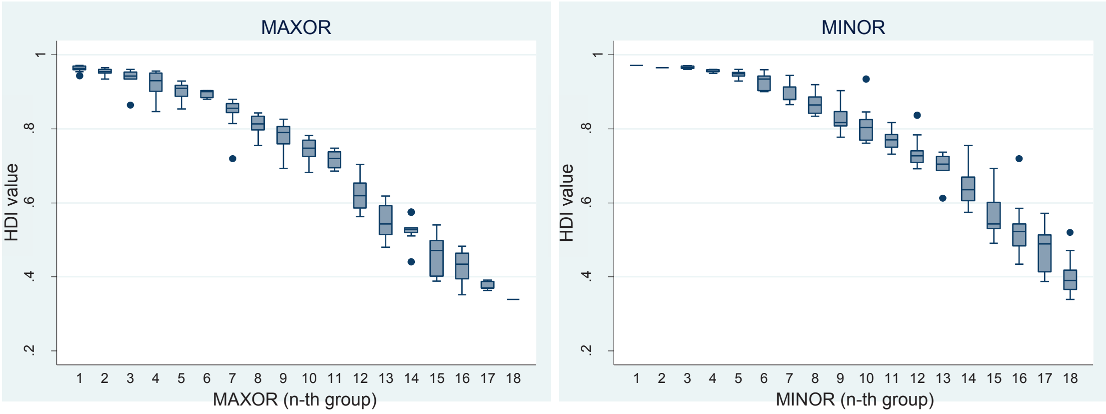
The data source is the HDRs for the period 1990 to 2009. Not all of these reports provide the information for these four variables in a consistent and comparable manner. I, therefore, compiled an unbalanced panel dataset of these four variables that are reported in a consistent and comparable manner. This compilation resulted in the unbalanced panel covering 18 data points (years 1980, 1985, 1990, and 1992-2007 except

[2]In 2010, the following four indicators replace those listed: life expectancy at birth, mean years of schooling, expected years of schooling and gross national income (GNI) per capita. See Appendix A for a more detailed explanation.

	N	Life expectancy (years)				Adult literacy rate (%)				Combined gross enrollment ratio (%)				GDP per capita (PPP$)			
		Mean	S.D.	Min	Max	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
Unbalanced panel																	
1980	82	63.3	10.1	40.0	76.5	68.6	28.7	8.6	99.0	56.8	17.5	8.0	81.0	10490	10237	456	40000
1985	89	64.8	9.7	41.5	77.7	69.8	27.6	8.6	99.0	59.2	17.6	12.0	90.0	10169	10213	330	40000
1990	115	65.7	9.8	32.6	79.0	74.7	25.2	9.4	99.0	61.6	18.1	15.0	99.0	6064	5861	524	21449
1992	174	64.9	10.2	39.0	79.5	75.7	24.1	12.4	99.0	60.5	19.5	7.0	100.0	6100	6269	330	23760
1993	174	65.1	10.2	39.2	79.6	75.8	23.5	12.8	99.0	61.3	19.5	7.0	100.0	6376	6887	300	34131
1994	175	65.1	10.9	22.6	79.8	77.2	22.8	13.1	99.0	62.8	18.8	15.0	100.0	6690	7050	352	34155
1995	174	65.6	10.4	34.7	79.9	78.4	22.1	13.6	99.0	63.3	18.7	15.0	100.0	6950	7285	355	34004
1997	174	65.6	10.9	37.2	80.0	78.9	21.6	14.3	99.0	64.8	19.8	12.0	100.0	7220	7667	410	30863
1998	174	65.8	11.0	37.9	80.0	79.2	21.0	14.7	99.0	65.4	19.9	15.0	100.0	7299	7617	458	33505
1999	162	65.0	11.7	38.3	80.8	79.5	21.1	15.3	99.0	66.1	20.5	16.0	100.0	7992	8390	448	40000
2000	173	65.5	11.6	38.9	81.0	80.6	20.6	15.9	99.0	65.9	20.0	16.0	100.0	8425	8706	490	40000
2001	175	65.4	12.4	33.4	81.3	81.3	20.4	16.5	99.0	67.6	19.1	17.0	100.0	8534	8700	470	40000
2002	177	65.4	12.6	32.7	81.5	81.3	20.5	12.8	99.0	68.9	18.9	19.0	100.0	8982	9451	478	40000
2003	177	65.8	12.3	32.5	82.0	81.4	20.4	12.8	99.0	70.4	18.7	21.0	100.0	9224	9572	548	40000
2004	177	66.0	12.4	31.3	82.2	81.9	20.0	19.0	99.0	70.3	18.2	21.0	100.0	9940	10205	561	40000
2005	177	67.4	10.9	40.5	82.3	82.3	19.7	23.6	99.0	70.6	18.1	22.0	100.0	10575	10816	667	40000
2006	179	67.7	10.8	40.2	82.4	83.5	18.9	22.9	99.0	71.0	17.6	25.0	100.0	11598	12227	281	40000
2007	182	68.5	10.2	43.6	82.7	83.7	19.0	26.2	99.0	71.7	17.1	25.0	100.0	12438	12771	298	40000
Balanced panel																	
1992	166	65.4	10.0	39.0	79.5	76.6	23.7	12.4	99.0	61.4	18.7	14.0	100.0	6284	6330	330	23760
1993	166	65.5	10.0	39.2	79.6	76.7	23.0	12.8	99.0	62.2	18.8	15.0	100.0	6390	6623	300	25390
1994	166	65.5	10.5	33.6	79.8	77.2	22.8	13.1	99.0	63.2	18.8	15.0	100.0	6875	7161	427	34155
1995	166	65.7	10.4	34.7	79.9	78.4	22.0	13.6	99.0	63.5	18.8	15.0	100.0	7108	7394	455	34004
1997	166	65.9	10.7	37.2	80.0	79.1	21.5	14.3	99.0	65.2	19.8	12.0	100.0	7400	7768	410	30863
1998	166	66.1	10.8	37.9	80.0	79.4	21.1	14.7	99.0	65.9	19.9	15.0	100.0	7449	7710	458	33505
2000	166	65.7	11.3	38.9	81.0	80.6	20.7	15.9	99.0	66.4	19.9	16.0	100.0	8565	8786	490	40000
2001	166	65.7	12.0	33.4	81.3	81.2	20.6	16.5	99.0	68.1	19.1	17.0	100.0	8718	8820	470	40000
2002	166	65.8	12.3	32.7	81.5	81.2	20.7	12.8	99.0	69.2	18.9	19.0	100.0	9239	9611	520	40000
2003	166	66.1	12.1	32.5	82.0	81.2	20.9	1.9	99.0	70.8	18.6	21.0	100.0	9482	9730	548	40000
2004	166	66.3	12.2	31.3	82.2	81.8	20.2	19.0	99.0	70.7	18.0	21.0	100.0	10219	10365	561	40000
2005	166	67.7	10.7	40.5	82.3	82.2	19.9	23.6	99.0	71.0	17.9	22.0	100.0	10879	10980	667	40000
2006	166	67.9	10.6	40.2	82.4	83.5	18.9	22.9	99.0	71.4	17.6	25.0	100.0	12017	12451	333	40000
2007	166	68.6	10.0	44.5	82.7	83.9	18.7	26.2	99.0	72.2	17.2	25.0	100.0	12604	12728	341	40000

Source: Calculated by the author based on the Human Development Report 1990-2009.

Table 3.1: Summary statistics of data



Notes: Box-and-whisker plots show the distribution of the HDI values across rank groups in the MAXOR and MINOR in 2007 (n=182).
Source: Prepared by the author. The calculation is based on the dataset in the Human Development Report 2009.

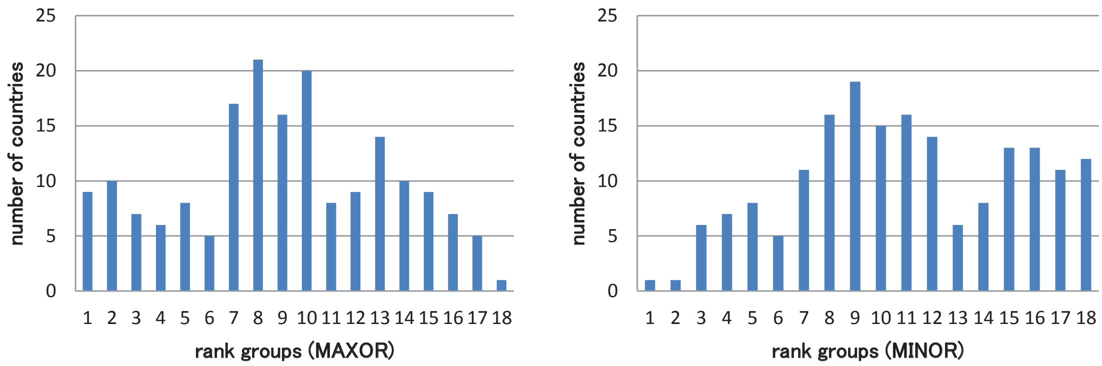
Figure 3.1: The MAXOR, MINOR and the HDI values

for 1996). As shown in Table 3.1, the number of countries gradually increased from 82 in 1980 to 182 in 2007. The table also reports the means and standard deviations of the four human development indicators. Over the period from 1980 to 2007, all four measures increased gradually.

From this unbalanced panel, I compiled a balanced panel dataset. I have deleted countries for which data are missing in some years and countries that experienced division or merger in their national boundaries. I have also discarded the first three data points and the year 1999 as the number of countries was small in these four years. This compilation resulted in the balanced panel of 166 identical countries covering 14 data points (years 1992-2007 except for 1996 and 1999). From the balanced panel dataset as well, we observe gradual increases in all four human development indicators.

3.3 Ranking results

The MAXOR and MINOR procedures described in Chapter 2 were applied to the unbalanced and balanced panel datasets. This section discusses the MAXOR and MINOR ranking results for the period 1980 to 2007.



Notes: Year 2007, the number of country is 182.
Source: Prepared by the author. The calculation is based on the dataset in the Human Development Report 2009.

Figure 3.2: Distribution of countries across rank groups in the MAXOR and MINOR

3.3.1 Results for 2007

Table B.1 in Appendix B shows the ranking results of the MAXOR and MINOR in 2007 using the unbalanced panel dataset.[3] The 182 countries are ordered in eighteen 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.

The box-and-whisker plots (Figure 3.1) show the distribution of the HDI value for countries across rank-groups in the MAXOR and MINOR.[4] All of the graphs shape downward sloping curves. The fact substantiates the ranking result generated by the MAXOR and MINOR correlate with the HDI values and its ranking. The further explanation about the whiskers and outliers are given in following section.

Figure 3.2 shows the distribution of countries across rank groups in the MAXOR

[3]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 is 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. 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 B.1 is calculated on the basis of the four indicator values in 2007.

[4]These box-whisker plots show the distribution of HDI value for countries across rank groups. The lower "whisker" corresponds to the lower quartile and the upper corresponds to the upper quartile. The "box" covers the middle half of the data. The central line of each box means the median. The value that is far from the end of whisker by time and a half-length of a box is called "outlier." The outliers are denoted by dots on the graphs.

	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

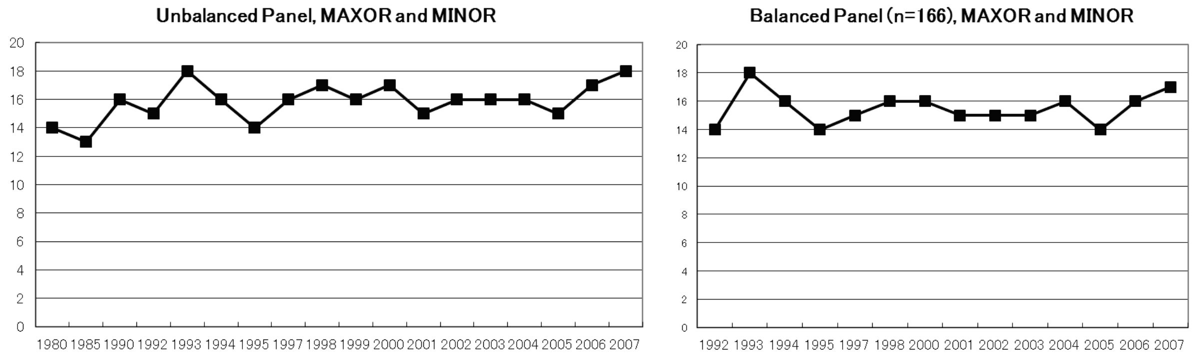
Source: The data of life expectancy, adult literacy rate, combined gross enrolment ratio and GDP per capita were in the Human Development Report 2009. The HDI rank and vlalue, the MAXOR and MINOR and the rank difference between them were calculated by the author.

Table 3.2: Extracts of ranking results in 2007

and MINOR in 2007. The MAXOR and MINOR manage to rank the 182 countries into eighteen rank groups from first to last place. In the MAXOR, 21 countries are ranked into the same rank order at the most (the eighth rank group), and at the least, a sole country (the 18th, the bottom rank group). With respect to the MINOR, 19 countries are ranked into the same at the most (the ninth rank group), and at the least, a sole country (the first and second rank groups). For any country, to be ranked high in the MAXOR is easier than that in the MINOR, because the MAXOR requires at least one indicator's high attainment while the MINOR requires well-balanced attainments among four indicators. As a result, the number of countries ranked relatively high rank order (from the first to fourth rank groups) of the MAXOR is greater than that of the MINOR. On the contrary, the number of countries ranked relatively low rank order (from the bottom to 15th rank groups) of the MINOR is greater than that of the MAXOR.

For example using six countries, Table 3.2 shows that the rankings highly differ depending on the aggregation rules. Namely, 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,[5] and it is

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



Source: Prepared by the author. The calculation is based on the data of the Human Development Report 1990-2009.

Figure 3.3: Changes in the total number of rank groups

ranked at the top among 182 countries. On the 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$) 13,604; however, it cannot easily dominate other countries because of its relatively low life expectancy value, 53.4 (160th among 182 countries). Equatorial Guinea is one of the more extreme cases. Other countries find it difficult to dominate Equatorial Guinea because of its relatively high level of GDP per capita, (PPP$) 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).

3.3.2 Changes over time

As regards the time series results, as shown in Figure 3.3, 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. As the number of rank groups is the same for the MAXOR and MINOR in a specific year, Figure 3.3 is the same for the MAXOR and MINOR. 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

		Standard Deviation			
	N	Mean	S.D.	Min	Max
MAXOR	166	0.85	0.45	0.00	2.19
MINOR	166	0.91	0.50	0.00	3.00

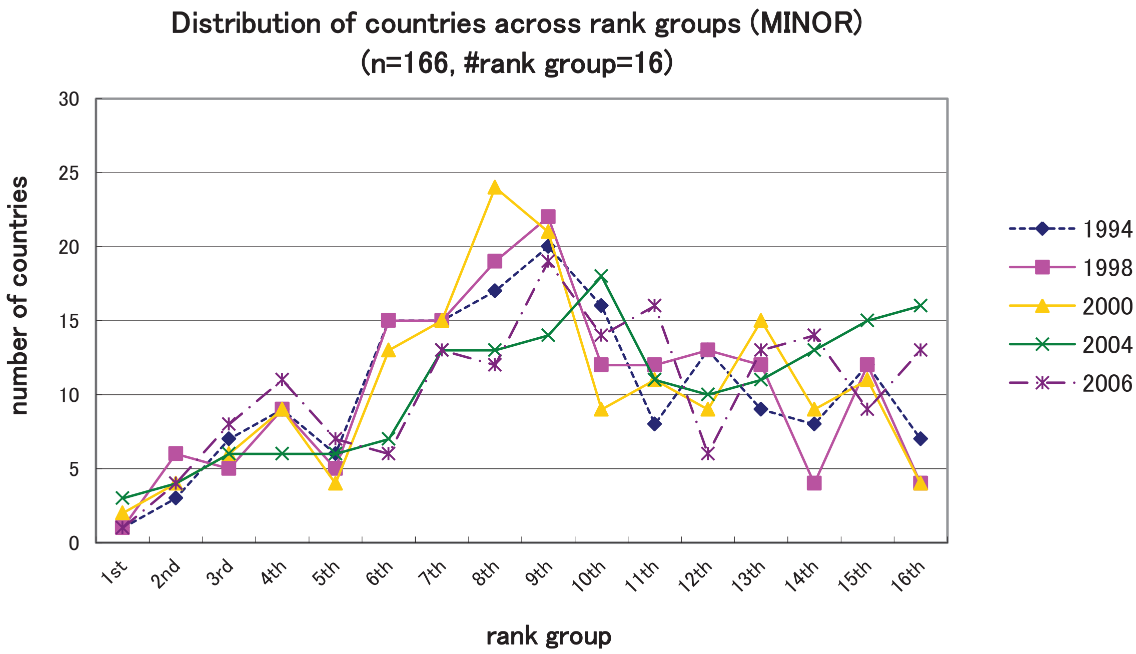
Notes: This table reports summary statistics of the standard deviation (S.D.) of the rank order over time for each country. The raw data of S.D. for all countries (balanced panel dataset: t=1994, 1998, 2000, 2004, 2006; n=166; the number of rank groups = 16) are shown in Appendix Table B.3. For instance, if a country was ranked at the same rank order in all of these five years, its S.D. becomes zero.
Source: Calculated by the athor based on the datasets in the Human Development Report 1996, 1998, 2002, 2006 and 2008.

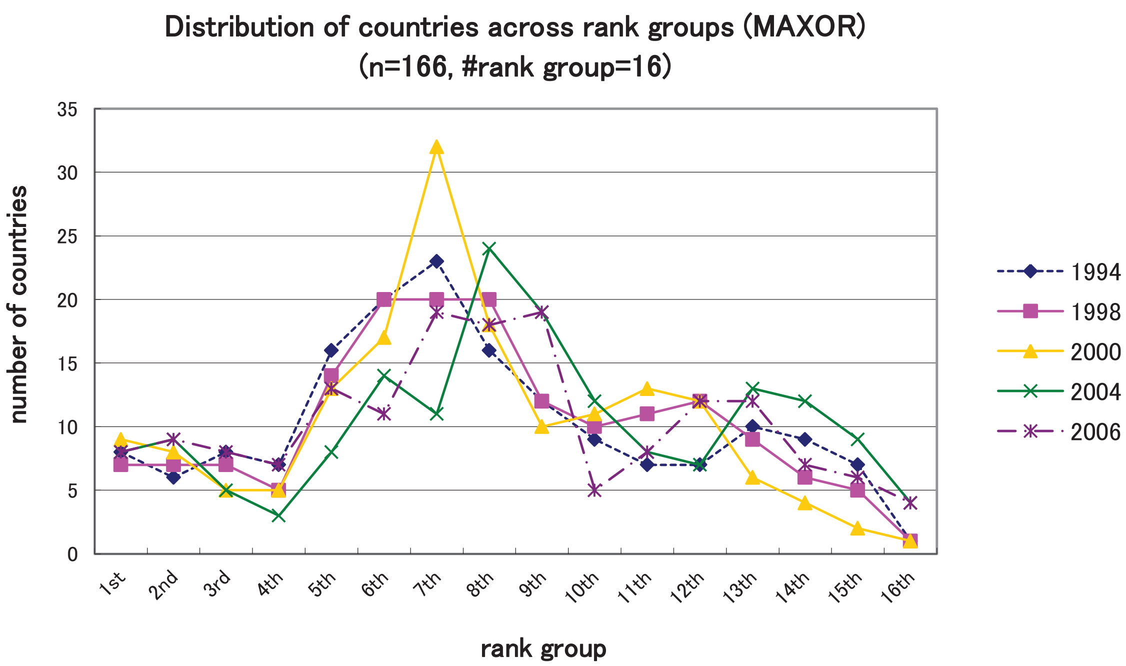
Table 3.3: Stability of ranks for each country over 1994-2006 (I)

		Distribution of #max(n-th group) − #min(n-th group)						
	N	0	1	2	3	4	5	6
MAXOR	166	7	59	60	24	11	4	1
MINOR	166	4	57	57	26	11	9	2

Notes: This table reports the distribution of #max(n-th group) − #min(n-th group), where #max(n-th group) and #min(n-th group) are calculated over time for each country. The raw data of n-th group for all countries (balanced panel dataset: t=1994, 1998, 2000, 2004, 2006; n=166; the number of rank groups = 16) are shown in Appendix Table B.3. For instance, if a country was ranked at the same rank order in all five years, its value of #max(n-th group) − #min(n-th group) becomes zero; if another country was ranked at the fifth group in some years and at the fourth group in the other years, its value of #max(n-th group) − #min(n-th group) becomes one.
Source: Calculated by the athor based on the datasets in the Human Development Report 1996, 1998, 2002, 2006 and 2008.

Table 3.4: Stability of ranks for each country over 1994-2006 (II)





Notes: Balanced panel dataset: t=1994, 1998, 2000, 2004, 2006; n=166; the number of rank groups = 16.
Source: Prepared by the author. The calculation is based on the datasets in the Human Development Report 1996, 1998, 2002, 2006 and 2008.

Figure 3.4: Distribution of countries across rank groups in the MAXOR and MINOR

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 for 166 countries, Figure 3.4 shows the changes in the distribution 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. Table B.3 in Appendix B shows the ranking results in the MAXOR and MINOR, and the standard deviation of them for these 166 countries in these data points. As summarized in Table 3.3, the mean and standard deviation of the standard deviations of the number of difference between the highest and lowest rank orders of the rank groups that an observation belonging for this period are less than one in both the MAXOR and MINOR. It shows that the distributions of countries among the ranks groups are relatively stable both in the MAXOR and MINOR. That is confirmed in Table 3.4. This table shows the distributions of the range of difference between the highest and lowest rank groups during this period. The numbers of row (from zero to six) describe the difference of the maximum number and minimum number of the rank order that is experienced by a country in these data points. In short, the range of changes for a country which remained the same rank in these time points is regarded as zero. As this table shows, approximately two-thirds of the 166 countries experienced changes in rank order within the range of two. This fact means that the MAXOR and MINOR are the ranking that keep observations' relative places in the ranking results over time. In addition, this fact implies that most of the countries have followed a similar developmental trajectory during this period.

In both the MAXOR and MINOR, countries tend to concentrate around middle-level ranks. 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.

3.4 Discussion

In the previous section, I showed the ranking results of the MAXOR and MINOR. The dataset used to generate the rankings have three notable features: (1) the levels of all indicator values among all observations (namely, the average for each indicator value) have been increasing year by year, (2) the total number of observations have increased year by year, and (3) the levels of all indicator values are relatively close for the most of countries (namely, the normalized indicator values for all indicators are close). In the case of two dimensions, the most of countries are located around a 45-degree line. In this section, I examine several characteristics of the MAXOR and MINOR derived from data including these features.

Acceptance of incomparability among distinct dimensions of human development

The first characteristic is the acceptance of incomparability among distinct dimensions of human development, that is, the binary relation such as $x \bowtie y$. Unlike the other usual ranking rules, the MAXOR and MINOR accept this kind of incomparability in the process of generating ranking results. As a result of this acceptance, incomparable countries are possibly positioned at the same 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 ranking rules. 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 that ignore incomparability or diversity among different dimensions.

The MAXOR and MINOR assume the incomparability of one human development indicator to another. Consequentially, incomparable countries are positioned at the same rank. In the ranking result derived from unbalanced panel data for 2007, for example, a maximum of 21 countries are assigned to the same rank group (eighth group) in the MAXOR. 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.

Emphasizing development and deprivation aspects

In the second characteristic emphasized by the ranking, 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 observation to dominate other observations. As mentioned in the previous section, an observation that has at least one relatively high indicator value tends to be ranked relatively high in the MAXOR, since it is difficult for other observations to dominate it. Contrastingly, an observation that has at least one relatively low indicator value tends to be ranked relatively low in the MINOR, since it is difficult for the observation 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 one high indicator value; however, an observation 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.

For instance, Homg Kong, China (SAR), $(f^i_{HK})_{i \in I} = (82.2,\ 94.6,\ 74,\ 40000)$ is ranked to the first in the MAXOR though it is ranked to 24th and 29th in the HDI and the MINOR respectably. The reason is that the MAXOR is a "specialist" ranking, which ranks high a country with at least one high indicator value. The value 40000 in the fourth indicator (GDP per capita) is the highest among all countries, then any other countries cannot dominate Hong Kong, China (SAR). Hence, it is ranked the first in the MAXOR. On the other hand, the MINOR is an "all-round" ranking, for if there is just one low indicator value. The value 74 in the third indicator (enrolment ratio) is ranked to 84th among all countries. Hong Kong, China (SAR) has difficulty in dominating other country due to relatively low value of enrolment ratio. Hence, the rank order of this country in the MINOR (7th) is relatively lower than that in the MAXOR. It shows that Hong Kong, China (SAR) is a specialist of income dimension, but not an allrounder.

This characteristics is shown in Figure 3.1. This figure captures distinct feature of the MAXOR, MINOR and the HDI. In the MAXOR, if a country achieves high attainment in at least one dimension, then the country tends to be ranked relatively high rank order, for the reason that such countries are difficult to be dominated. However, the HDI values of such countries tend to be not so high, because the HDI value is an weighted arithmetic mean of four indicators. The downward whiskers and outliers in the left figure (The MAXOR and the HDI value) shows this tendency. These whiskers and outliers correspond to the countries ranked high rank order relative to their HDI value, because of extremely high attainment in at least one indicator. By contrast, in the MINOR, if a country achieve well-balanced attainment in all four indicators, then the country tends to be ranked relatively high rank order, for the reason that such countries are difficult to be dominated., while the HDI does not pay attention to the balance of attainment among these four indicators. Hence, countries that have high HDI values are not always ranked high rank order in the MAXOR. The upward whiskers and outliers in the right figure (the MINOR and the HDI value) correspond to the countries that have relatively high HDI values but ranked relatively low rank in the MINOR because of ill-balanced development.

Highlighting the difference in development processes

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 all indicators for a country is well balanced. If one indicator of an observation 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 between the ranking result of the MAXOR and the MINOR , the better balanced is its development. However, typical ranking rules do not capture such differences in the development process of each observation, because they aggregate 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 3.1). 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.

	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

Source: The data of totalnumber of countries, life expectancy, adult literacy rate, combined gross enrolment ratio and GDP per capita were cited from the dataset in the Human Development Report 2009. The HDI rank and vlalue, the MAXOR and MINOR and the rank difference between them were calculated by the author.

Table 3.5: Changes in the rankings for India

Usefulness in unbalanced-panel dataset

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 such as the HDI ranking, changes in the total number of countries or changes in other countries' performances strongly affect the rank of a specific country. 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.

The MAXOR and MINOR are less subject to this problem than the HDI ranking. As shown in Figures 3.3, 3.4 and Table 3.4, the total number of rank groups and the distributions of countries across rank groups 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 3.5, India's HDI ranking was 68 in 1980, 92 in 1990, and 134 in 2007, suggesting that its relative human development level is worsening. 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 observations 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 observations. India was positioned in the 11th rank group in the MAXOR and in 12th rank group in the MINOR in 1980. It was 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 either attributed to division or mergers of countries, or data unavailability possibly due to 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 division of a country into 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 changes in the total number of countries due to country divisions. 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 observation.

3.5 Conclusion

This chapter showed that the MAXOR and MINOR are robust to changes in the total number of observations. Unlike other general country-based rankings such as the HDI, a rank order derived from the MAXOR or MINOR for a specific country can show its relative position against all other countries, regardless of changes in the total number of countries. In this sense, the MAXOR and MINOR are useful in panel analysis applied to unbalanced panel.

On the other hand, the MAXOR and MINOR confront a practical disadvantage that multiple observations are frequently categorized to the same ranking, while one observation corresponds to a unique rank order in typical ranking rules. The next chapter further examines how disadvantaged are they when the ranking rules are extended to allow measurement error.

Chapter 4

The Extended Maximal Order Ranking and Minimal Order Ranking

4.1 Introduction

In previous chapters, I implicitly assumed that the data values we use are measured accurately.[1] Hence, the binary relation for the two countries $a, b \in X$ such as $(f_a^i)_{i\in I} = (100,\ 100,\ 100), (f_a^i)_{i\in I} = (10,\ 10,\ 101)$ is regarded as incomparable, that is, $a \bowtie b$. In a real situation, however, measurement error exists in any dataset. If we allow a $\pm 1\%$ error to the original data value, then, the binary relation of this example changes to $a \succ b$. This is because we can regard the value 100 as indifferent to the value 101 while the value 100 is obviously superior to the value of 10. With allowance for measurement error, we may be able to conclude that a Pareto dominates b. It shows that the binary relations and the ranking rules I define over X are somewhat vulnerable to the error of data values.

As another feature, the MAXOR and MINOR have a disadvantage of "tie-full ten-

[1]Some of the contents in this chapter are taken from Michinaka and Ito (2010). I am grateful for the useful comments and suggestions on the earlier version of this chapter that were made by Professor Nobuyuki Kitamura, Professor Noriatsu Matsui and Mr.Yoichiro Kimata. I am also thankful for the ideas that I gained through attending the 20th annual meeting of the Japan Society for International Development in November 2009.

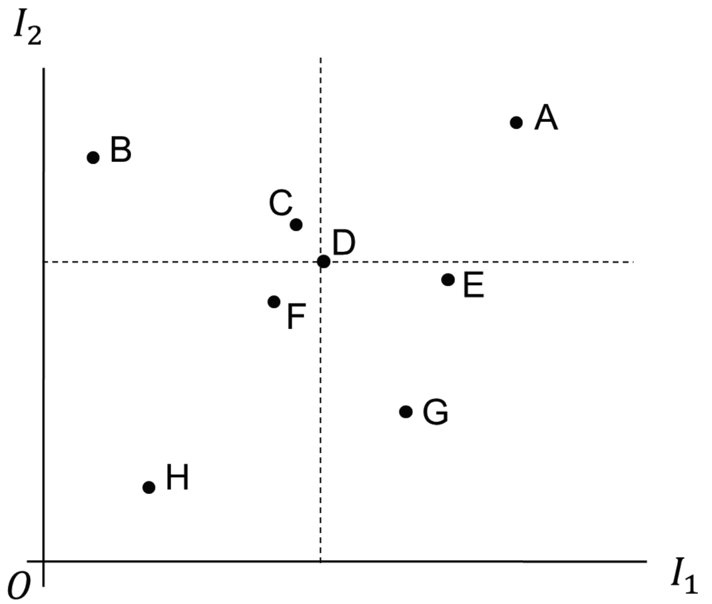
dency," means many countries are ranked at the same rank order. Things will worsen as the number of human development indicators ($\sharp I$) increases, for the number of incomparable binary relation will increase.

Due to this disadvantage, the MAXOR and MINOR might be subject to the criticism that it lacks practical utility even though it is intuitively understandable and less arbitrary than the HDI ranking rule. As an attempt to solve this problem and to improve practical utility of the ranking, I take into account the measurement error in human development indicators. It seems reasonable to assume that all datasets have some degree of measurement error, which may be bigger, especially in datasets collected in developing countries.

The rest of this chapter shows that as an interesting tendency in the MAXOR and MINOR, the number of observations with the same rank order decreases after slight difference among data is ignored. The reason for this reduction is the fact that the binary relations on certain observations turn to comparable from incomparable when the difference is neglected. Applying this feature, I propose to extend the MAXOR allowing the bandwidth of binary comparison in order to maximize the practical utility of the MAXOR and MINOR (Section 2 in this chapter). In my example, when we allow data variation of approximately 5.37%, the practical utility is maximized, namely, the number of objectives that have the same rank is minimized. This is shown in the third section. As a secondary effect of this extension, the robustness of the ranking to measurement error is also enhanced. The fourth section of this chapter shows it through a simulation exercise.

4.2 Allowing a bandwidth of data

For simplicity's sake, consider a case where there are only two human development indicators and only eight observations in X, then, $I = \{I_1, I_2\}$ and $X = \{A, B, C, D, E, F, G, H\}$. Figure 4.1 depicts the distribution of observations. Focusing on country D, the tie-full tendency is related to the areas lying to the northwest and southeast of D. We refer to these areas as 'incomparable areas' of D, since countries B, C, E and G in these areas are incomparable to D. The tie-full tendency is mainly attributed to these incomparable areas, and consequently, reducing the area is largely equivalent to weakening the



Source: Prepared by the author.

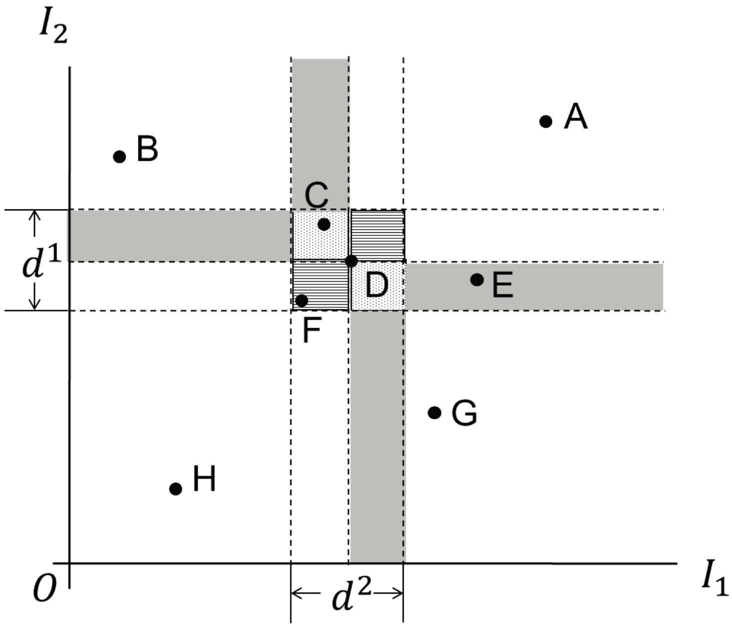
Figure 4.1: Introduction of a bandwidth (I)

tie-full tendency.

In fact, there are several ways to reduce the area. For instance, approaches admitting a cardinality among values of multiple indicators, like the Human Development Index (HDI), mean arbitrary weights are placed on each indicator. Consequently, any pairs of $f(x) = (f_x^i)_{i\in I}$ and $f(y) = (f_y^i)_{i\in I}$ for all $x, y \in X$ are comparable since $f(x) = (f_x^i)_{i\in I}$ for all $x \in X$ can be a scalar as an aggregated index value (in short, there is no incomparable area).

Another way to decrease the incomparable areas, while maintaining the advantage of the MAXOR is to allow the data of the indicators to have a certain range of bandwidth. The bandwidth in each dimension is denoted as d_1 and d_2 in Figure 4.2. The bandwidth is also interpretable as neglecting a certain range of differences between the values of indicators, or equivalent to presuming that the data have measurement errors so that the confident interval of the observed data point has the size similar to d_1 or d_2 on average. Considering the fact that a data such as country-level data potentially contain a certain level of measurement errors, allowing data to have a bandwidth can be justified to some extent and is also plausible from a practical perspective.

As the figure shows, allowing a certain range of bandwidth makes the incomparable



Source: Prepared by the author.

Figure 4.2: Introduction of a bandwidth (II)

area decreased. The gray-shaded four rectangle areas in Figure 4.2 describe the areas that changed from incomparable to comparable. Before allowing the bandwidth, $D \bowtie E$ but after allowing, it changed to $E \succ D$. The dot-shaded square areas lying to the northwest and southeast of D describe the areas that changed from incomparable to indifferent. $D \bowtie C$ changed to $D \sim C$. At the same time, however, this approach also has a weakness: the existence of the bandwidth also reduce the comparable area. The horizontally-shaded square areas lying to the northeast and southwest of D describes the area that changed from comparable to indifferent. $D \succ F$ changed to $D \sim F$ by allowing the bandwidth.

Thus, the introduction of a bandwidth has an advantage and disadvantage: whereas the number of observations reclassified from the category of incomparable (i.e. $x \bowtie y$) to comparable (i.e. $x \succ y$ or $y \succ x$) for an observation $x \in X$, denoted by $\sharp COM_x$, increases, the same applies to that moving from comparable to indifferent (i.e. $x \sim y$), as denoted by $\sharp IND_x$. Regarding $\sum_{x \in X} \sharp COM_x$ and $\sum_{x \in X} \sharp IND_x$ as the benefit and cost of introducing a bandwidth, the net benefit of introducing a bandwidth is defined as

$$W^i(d^i) = \sum_{x \in X} \big(\sharp COM_x(d^i) - \sharp IND_x(d^i)\big).$$

The shape of function W^i with respect to d^i is an empirical question, dependent on the joint distribution of f_x^i and f_x^j over $\mathbf{R}_+^I$.

Therefore, to maximize the practical utility of the extended MAXOR and MINOR, I choose d^i that maximizes the net benefit, $W^i(d^i)$.In other words, I obtain an optimal bandwidth for index i as the solution of the following maximization problem:

$$\widehat{d^i} = \arg\max\{\sum_{x \in X} \big(\sharp COM_x(d^i) - \sharp IND_x(d^i)\big)\}$$

In this chapter I allow the bandwidth to vary among observations by setting $d_x^i = f_x^i \times r_i$ (but r_i is common for all countries), and choose an optimal r_i in the same manner. Subsequently, for all $x,\ y \in X$ and $i \in I$, f_x^i and f_y^i are regarded as equivalent if $|f_x^i - f_y^i| \leq d_x^i$. In other words, if $|f_c^i - f_y^i| \leq d_x^i$, then the development level of x and that of y are regarded as indifferent. In the next section, I show the ranking result derived through this procedure and compared with the result of the original MAXOR.

4.3 Extended ranking results

In this section, I show the ranking results derived from the original and extended MAXOR and MINOR. I adopt the data used to calculate the HDI in Chapter 3; life expectancy at birth, the adult literacy rate, the combined gross enrolment ratio for primary, secondary and tertiary schools and GDP per capita (PPP$). The data of these indicators for 179 countries were used to calculate the HDI in 2006.[2]

Using this HDI 2006 data, I show four ranking results generated by the ranking methodologies proposed in the previous section, namely, the original and extended methods of the MAXOR and MINOR. Table B.2 in Appendix B shows the extended ranking where the value of r is set at 0.1074, which is found optimal in the sense that the number of comparable pair of countries are maximized. The value of r is the same at the MAXOR and MINOR, because the binary relations are common between the MAXOR and MINOR. While the HDI ranking in 2007 for 179 countries is a complete

[2]To obtain the HDI value in 2006, I used the data in the HDR 2008.

top-to-bottom ranking from the first (Iceland) to the 179th (Sierra Leone), multiple countries are ranked to the same rank in both the original and extended MAXOR and MINOR. Consequently, the original MAXOR and MINOR manages to rank the 179 countries into only seventeen rank groups from first to last place. In the MAXOR, 22 countries are ranked into the same rank order at the most (the eighth rank group), and at the least, four countries (the 17th, namely the bottom rank group). With regard to the MINOR, twenty countries are ranked into the same order at the most (the 10th rank group), and at least, one country (the first group) in the original rule. While the extended MAXOR and MINOR still see several countries ranked the same, it decrease the number of countries in each rank group. The extended MAXOR and MINOR rank 179 countries to 36 rank groups. In the extended MAXOR, only eleven countries are ranked at the most (the second rank group) and at the opposite end, a sole country (the fifth rank group). With respect to the MINOR, nine countries are ranked into the same rank order at the most (the 34th rank group), and at the least, two observation (the eleventh rank group). In short, the extended ranking rules improve the practical utility of the original rules in the sense that it alleviates the coarseness of the ranking results derived from the original rules.

As stated in the previous section, this extension brings both benefit and cost to the original ranking. The benefit is the fact that neglecting of slight difference among data values possibly changes some binary relations incomparable to comparable. Conversely, the cost of this neglect also possibly changes some binary relations from comparable to indifferent. For an example of the former case, see the Turkey and Syrian Arab Republic ranked ninth rank group in the MAXOR. The human development profile of the former is $(f^i_{TUR})_{i \in I} = (71.6,\ 88.1,\ 71,\ 11535)$ while that of the latter is $(f^i_{SYR})_{i \in I} = (73.9,\ 82.5,\ 65,\ 4225)$. These countries are ranked the same due to only a slight difference in the value of life expectancy with 2.3. The introduction of bandwidth will mean this slight difference can be neglected, while the ranks of these countries in extended ranking are quite different from each other (14th and 23rd rank group, respectably). Likewise, for an instance of the latter, see Malaysia ranked eighth rank group in the MAXOR with $(f^i_{MAL})_{i \in I} = (73.9,\ 91.5,\ 71,\ 12536)$ dominates Turkey so that the former is ranked prior to the latter. Meanwhile, the introduction of bandwidth changes the binary relation on these countries from comparable to indifferent. Consequently, the ranks of these countries are the same (14th rank group) in the extended ranking.

These results show that when we allow approximately a 5% difference in data value, the practical utility of the MAXOR and MINOR are maximized, namely, the number of observations that have the same rank is minimized. It seems natural that we assume the existence of measurement error in any dataset. In particular, it is difficult to collect precise datasets in developing countries. With this in mind, acceptance of an error range of plus or minus 5% does not seem a quite unreasonable assumption.

4.4 A simulation exercise

In the previous section, I proposed an extension of the MAXOR in which a bandwidth was introduced in comparing the value of a human development indicator for a pair of countries. I showed that the extension resulted in finer rankings (i.e., a smaller number of countries in each rank group) than the original MAXOR. In this section, I show that this extension has a secondary effect that the extended MAXOR is more robust to measurement error than the original MAXOR. To see this, a hypothetical simulation exercise is implemented since there is no reliable information on the actual size of measurement error in human development indicators.

4.4.1 Simulation strategy

Let f_x^i be the observed value of the human development indicator i for country x. For the simulation analysis, I use the set of 179 countries in 2006. As before, i is one of the four human development indicators of life expectancy at birth, adult literacy rate, combined gross enrolment ratio for primary, secondary and tertiary, and GDP per capita. From this dataset, I calculated the HDI ranking, the original MAXOR and MINOR ranking, and the extended MAXOR and MINOR ranking for the 179 countries. The results are reported in Table B.2 in Appendix B.

If the observed values are subject to measurement error, slightly different values are expected to realize depending on the random draw of the measurement error. As information on the true value is not available by definition, I run a hypothetical simulation in which the observed value f_x^i is replaced by $z_{x,t}^i = f_x^i + u_{x,t}^i$, where t means the t-th trial of the simulation and $u^i_{x,t}$ is a random draw representing the measurement error. For example, for $t = 1$, I created a hypothetical set of $z^i_{x,1}$ for the 179 countries for the four human development indicators. From this set, I calculated the HDI ranking, the original MAXOR ranking, and the extended MAXOR ranking. I then compared the HDI ranking from the observed values and that from the hypothetical set $t = 1$ by calculating Spearman's and Kendall's rank correlation coefficients.[3] I repeated this exercise for the original MAXOR ranking and the extended MAXOR ranking.

I repeated this exercise for 100 times ($t = 1, \ldots, 100$) and calculated the average of the rank correlation coefficients. This series of simulation runs was implemented for a particular value of the variance of measurement error, $u^i_{x,t}$. A similar series was repeated for different values of the variance of $u^i_{x,t}$. When the variance becomes small, the rank correlation coefficient becomes closer to one by construction. What I will examine is how three rules of ranking (the HDI, the original MAXOR, and the extended MAXOR) are associated with different levels of rank correlation for a given level of the variance of $u^i_{x,t}$. This will be examined graphically.

4.4.2 Detail of simulation parameters

I adopted a specification for measurement error, $u^i_{x,t}$, based on a log-normal model. Namely, suppose that $\ln f^i_x = \mu^i_x + \epsilon^i_x$, where μ^i_x is the true (and unobservable) value of the natural logarithm of f^i_x and ϵ^i_x is a random error. I assume that the random error is distributed as i.i.d. $N(0, \sigma^2_i)$. Then $\ln f^i_x$ becomes a log-normal random variable with mean $\exp(\mu^i_x + \frac{\sigma^2_i}{2})$ and variance $\exp(2\mu^i_x + \sigma^2_i)\{\exp(\sigma^2_i) - 1\}$.

We now introduce the key parameter ρ that indicates the extent to which the true value explains the observed value $\ln f^i_x = \mu^i_x + \epsilon^i_x$. This measure, which is similar to the

[3] A rank correlation coefficient shows the correlation between two distinct rank orders for the same set of observations; for example, correlation between the rank order of students' body height and that of body weight for the students in a class. Spearman's rank correlation coefficient (Spearman's rho) is defined as $S_\rho = \frac{r_s(n^2-1)}{1-6\sum(d_i)^2}$ where n is the number of observations, d_i is the difference between the ranks of a rank order X and another rank order Y for an observation i, $r_s = 1$, if there is a perfect agreement between the two sets of ranks, and $r_s = -1$, if there is a perfect disagreement between the two sets of ranks two sets of rank. Kendall's rank correlation coefficient (Kendall's tau) is defined as $K_\tau = \frac{C-D}{\frac{1}{2}n(n-1)}$ where n is the number of observations, C is the number of pairs that are concordant between two rank orders, and D is the number of pairs that are disconcordant.

coefficient of determination (regression R^2) when regressing $\ln f_x^i$ on μ_x^i, ranges between zero and one, and as it assumes a larger value, the error ϵ_x^i has less influence on the observed value $\ln f_x^i$. Subsequently, an unbiased and consistent estimator of σ_i^2 for each ρ is calculated by:

$$\widehat{\sigma}_i^2 = \frac{\sum(\ln f_x^i - \mu_x^i)^2}{N} = \frac{\sum[(\ln f_x^i - \bar{\mu}^i) - (\mu_x^i - \bar{\mu}^i)]^2}{N} = \frac{(1-\rho)\sum(\ln f_x^i - \bar{\mu}^i)^2}{N}, \ \forall i \in I \text{ and } \forall \rho$$

where $\bar{\mu}^i$ is the sample mean of $\ln f_x^i$ over the 188 countries. Using this $\widehat{\sigma}_i^2$, the error term $u_{x,t}^i$ is specified as:

$$u_{x,t}^i = \exp(-\epsilon_{x,t}^i + \frac{\hat{\sigma}_{i,\rho}^2}{2})$$

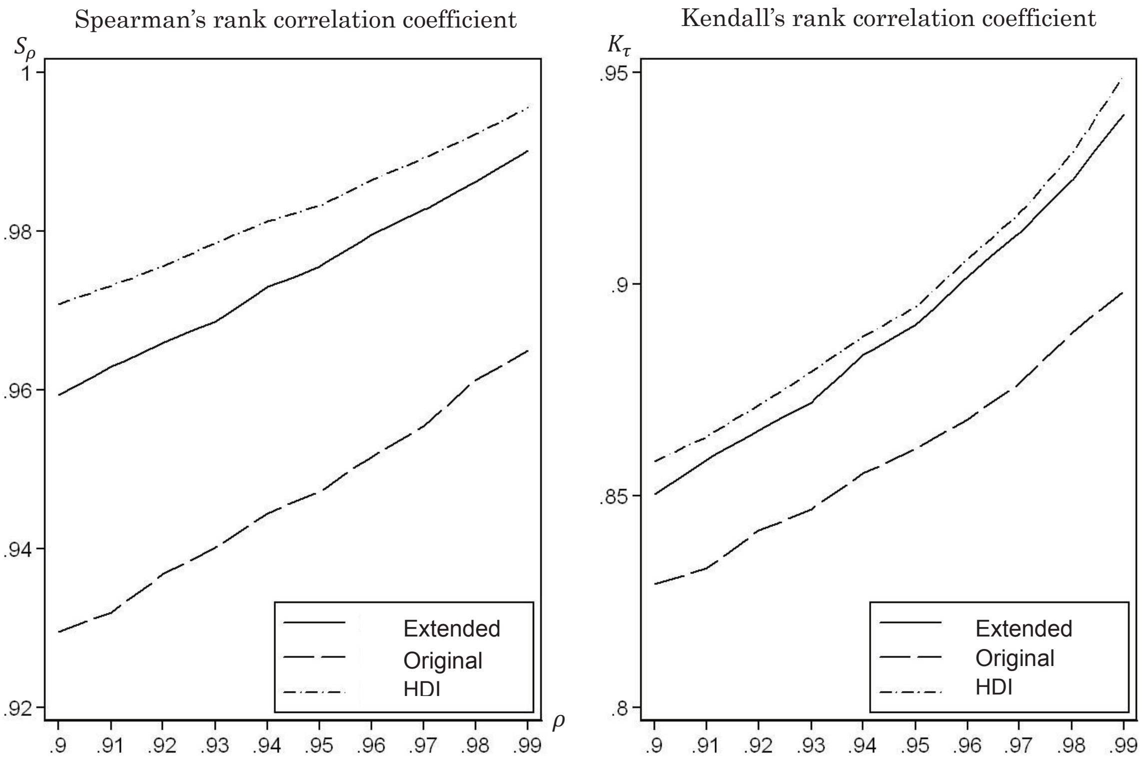
In other words, a hypothetical draw for country x for the indicator i in the t-th simulation run is given by:

$$z_{x,t}^i = \exp\left(\mu_{x,t}^i + \frac{\widehat{\sigma}_{i,\rho}^2}{2}\right) = \exp\{(\ln f_x^i - \epsilon_{x,t}^i + \frac{\widehat{\sigma}_{i,\rho}^2}{2})\} = f_x^i + \exp(-\epsilon_{x,t}^i + \frac{\hat{\sigma}_{i,\rho}^2}{2}),$$

In the simulation, I parametrically changed ρ from 0.90 (large measurement error case) to 0.99 (small measurement error case). For each value of ρ, I ran 100 simulations and calculated the average of the rank correlation coefficients.

4.4.3 Simulation results

Figure 4.3 shows the results of the simulation exercise for the MAXOR. The horizontal axis is the value of ρ. The vertical axis shows either Spearman's or Kendall's rank correlation coefficient between the ranking result based on the observed data and that based on hypothetical data. The figure shows that the extended MAXOR remarkably performs better than the original MAXOR. Because the HDI ranking is a complete ranking, its rank coefficients are higher than both the original and extended MAXOR. What is remarkable in the figure is that the extended MAXOR shows the robustness against measurement error to the extent comparable to the robustness of the HDI ranking in spite of the fact that the extended MAXOR is an incomplete ranking in which only the rank groups are identified. A qualitatively similar figure was obtained from the original and extended MINOR.



Source: Calculated by the author based on the dataset in the Human Development Report 2008.

Figure 4.3: Results of a simulation exercise, MAXOR

4.5 Conclusion

This chapter extended the MAXOR and MINOR to fit them to the presumption that any existing datasets are subject to measurement error. As a means of extension, I allowed a certain range of bandwidth to the original dataset in calculating the MAXOR ranking. The advantage of adopting bandwidth is to reduce incomparable areas for observation, whereas the disadvantage is to increase indifferent areas. I calculated the best range of bandwidth in the sense of maximize the sum of number of observations categorized to comparable area. According to the calculation used the same data of the HDI 2006, approximately $\pm 5.37\%$ range of bandwidth is the best one. A simulation exercise showed that this extension also enhanced the robustness of the MAXOR and MINOR ranking to perturbation in data and is shown by a simulation exercise.

I therefore conclude that the extended MAXOR enhanced the practical utility in the sense of not only tanking account of error in data, but also being robust to error, and increasing the number of comparable observations.

Chapter 5

Conclusion

This dissertation investigated how to rank the levels of human development of individuals, villages, or countries when indicators composing various human development dimensions are given. I firstly provided two types of ranking rules, the maximal order ranking (MAXOR) and the minimal order ranking (MINOR). I then examined the practical usefulness of these rules and extended the rules to fit the limitation of the accuracy of existing data.

I took a normative approach in building these ranking rules to eliminate the possibilities of manipulation of ranking results. We can always obtain different ranking results from the same data simply by changing the rule. To gain wide acceptance, any rule needs to be characterized by reasonable assumptions. As reasonable axioms, I adopted *ordinalism:* **(O)**, *dominance principle:* **(DP)**, *superiority of non-dominated observations:* **(SNO)**, *inferiority of non-dominating observations:* **(INO)**, *non-existence of dominance relation in a same rank order:* **(NDR)** and *monotonicity* **(M)**. The MAXOR satisfies **(O)**, **(M)**, **(DP)**, **(NDR)** and **(SNO)**, while the MINOR satisfies **(O)**, **(M)**, **(DP)**, **(NDR)** and **(INO)**. Unlike the HDI, the MAXOR and MINOR do not satisfies the axiom of *independence of irrelevant alternatives:* **(IIA)**, which is major axioms in social choice theory. Another remarkable feature of the MAXOR and MINOR is that they recognize the incomparability of one human development dimension with another dimension. By this recognition, the MAXOR and MINOR capture the diverse nature of human development.

On the other hand, I took positive approaches in examining and extending the MAXOR and MINOR. For the purpose of examining their practical usage, I used the ranking results derived from the balanced and unbalanced cross-country panel datasets for the period from 1980 to 2007. As a result, I found that a rank order in the MAXOR or the MINOR for a specific country shows its relative position compared to all other observations in a stable way, regardless of the changes in the total number of observations. This means that the MAXOR and MINOR are useful in panel analysis applied to unbalanced panel datasets.

Although the MAXOR and MINOR successfully exclude implicit arbitrariness inherent in existing ranking rules, they confront a disadvantage of having a nonnegligible number of observations ranked in the same rank group. On the other hand, the available datasets possibly include measurement errors. In order to reduce the disadvantage, I proposed an extended ranking rule that involves allowing the data to have a certain range of measurement error. This extension improves the usefulness of our ranking in the sense that it decreases the number of countries in each rank group.

Not only for ranking human development but also other alternatives, the MAXOR and MINOR have versatility. For example, the ranking of comfortable cities may be achieved by taking account of various factors such as traffic convenience, security, infrastructure, and health services. By the same token, the Olympic host city is selected by considering of various factors such as public support, public security, accommodation facilities, and climate . MAXOR and MINOR can thus also be applied to other cases. In cases of ranking certain alternatives by taking account of multiple factors, MAXOR and MINOR have broad applicability.

As an attempt to develop ranking rules, there are a few remaining tasks. As regards Chapter 2, axiomatic characterization of the MAXOR and MINOR is an open question. In order to characterize these ranking rules axiomatically, several axioms should be added. Previous studies on the field of ranking opportunity sets (e.g. Bossert, Pattanaik and Xu; 1994, Dutta and Sen; 1996), the union and intersection approaches for multidimensional poverty measurements (e.g. Bourguignon and Chakravarty; 2003), Alkire and Foster; 2009), and a survey on measurement of social welfare by Fleurbaey (2009) may provide beneficial suggestions for my further examination. As regards Chapter 3, the robustness check of these ranking rules is required. The practical utility of the MAXOR and MINOR shown in this dissertation might be specific to the HDI datasets I used. I have to check whether the same results are obtained when I apply these rules to other datasets. As regards Chapter 4, the selection of the bandwidth should be further discussed. In this dissertation, I applied the bandwidth that maximizes the utility of the ranking rules. However, there might be a certain "reasonable" range of measurement error. How to estimate measurement error in the existing dataset for developing countries is the next issue.

Despite of above remaining tasks, this dissertation thus showed the advantage of combining normative and positive approaches to rank human development. By taking a normative approach, the acceptance of the ranking rules has been enhanced. By taking positive approaches, the practical utility of the ranking rules has been demonstrated empirically. The use of MAXOR and MINOR will enhance our further understanding of multidimensional human development.

Appendix A

The History of the Human Development Index

A.1 Introduction

To rank countries or individuals by their levels of human development is important in order to set targets for various antipoverty policies.[1] One of the prevalent human development rankings based on indexation is the Human Development Index (HDI). It is a composite index of four kinds of development indicators, that is, life expectancy at birth, mean years of schooling, expected years of schooling and gross national income (GNI) per capita[2]. The United Nations Development Programme (UNDP) annually releases the value of HDI for each country and ranks them from the best to the worst. As mentioned in Chapter 1, the HDI was launched by the UNDP in 1990. Though the basic concept and calculation methodology for the HDI have not changed significantly since its beginning, slight modifications have been added over the past twenty years. Especially, in 2010, the 20th anniversary year for the HDI and the HDR, rather large modifications were added in the indicators and the calculation method of the HDI. Why were these modifications added? Are the characteristics of the new calculation methodology appropriate for the measure of human development? This appendix

[1] This chapter is revision of Michinaka (2011b).

[2] These four indicators were introduced in 2010. Until 2009, the life expectancy at birth, the adult literacy rate, combined gross enrolment ratio for primary, secondly and tertiary, and gross domestic product (GDP) per capita were used.

reviews the history of the HDI and examines the characteristics of the new HDI calculation methodology.

A.2 The concept of the HDI

The UNDP publishes the HDI values and its rankings annually in the Human Development Report. The annual HDR report is an independent publication commissioned by the UNDP. Every report presents an agenda such as 'Overcoming barriers: Human mobility and development (2009),' 'Beyond scarcity: Power, poverty and the global water crisis (2006),' and 'Human Rights and Human Development (2000).' Every HDR calls international attention to issues and policy options that put people at the center of strategies to meet the challenges of development.

In the first HDR (the HDR 1990), the UNDP defined human development as a process of enlarging people's choices and launched the HDI. The definition of human development and the concept of the HDI are rooted in Sen's capability approach; thus, the HDI has been regarded as embodying the capability approach for the practical realization of the measurement of human development.

The HDI chose as essential aspects of human development three fundamental dimensions: a long, healthy life, educational attainment, and a decent standard of living. These fundamental dimensions have remained, however, specific indicators that describe these dimensions and the calculation methodologies for measuring the achievement of these aspects changed over the years. Table A.1 summarizes the changes.

A.3 Changes in how to calculate the HDI value

A.3.1 Changes in indicators

This subsection reviews the changes in the indicators adopted by the HDI. To describe the three fundamental dimensions, the first HDI in 1990 adopted three indicators; life expectancy at birth, the adult literacy rate and gross domestic product (GDP) per capita in purchasing power parity of US dollars. The long, healthy life indicator has been fixed during these past twenty years. On the other hand, the indicators describing educational attainment and standard of living have been modified in this period.

Year of the HDR edition	Longevity		Educational attainment (1)		Educational attainment (2)		Per capita income	
	Max	Min	Max	Min	Max	Min	Max	Min
1990	Life expectancy at birth (year)		Adult literacy rate (%)		—		Log of GDP per capita (PPP$)	
	Actual observed value		Actual observed value				Actual observed value	
1991–1993	Life expectancy at birth (year)		Adult literacy rate (%)		Mean years of schooling (years)		Adjusted GDP per capita (PPP$)	
	Actual observed value		Actual observed value		Actual observed value		Actual observed value	
1994	Life expectancy at birth (year)		Adult literacy rate (%)		Mean years of schooling (years)		Adjusted GDP per capita (PPP$)	
	85	25	100	0	15	0	40000	200
1995–1998	Life expectancy at birth (year)		Adult literacy rate (%)		Combined gross enrolment ratio (%)		Adjusted GDP per capita (PPP$)	
	85	25	100	0	100	0	40000	100
1999–2009	Life expectancy at birth (year)		Adult literacy rate (%)		Combined gross enrolment ratio (%)		Log of GDP per capita (PPP$)	
	85	25	100	0	100	0	40000	100
2010–2013	Life expectancy at birth (year)		Mean years of schooling (years)		Expected years of schooling (years)		GNI per capita (PPP$)	
	Actual observed maximum value during 1980–2013	20	Actual observed maximum value during 1980–2013	0	Actual observed maximum value during 1980–2013	0	Actual observed maximum value during 1980–2013	Actual observed minimum value during 1980–2013

Source: prepared by the author based on the Human Development Report 1990-2013.

Table A.1: Changes in indicators, maximum and minimum values in the HDI

With respect to the indicators of educational attainment, in the second year of the HDI, namely in 1991, mean years of schooling was added as an indicator describing educational attainment.[3] The indicator describing educational attainment was a combined index of adult literacy rate and the mean value of years of schooling. The weight of the former was two thirds, and that of the latter was one third. From 1995 to 2009, the mean years of schooling was replaced with the combined gross enrollment ratio for primary, secondary, and tertiary schools. It was mainly because the formula for calculating mean years of schooling is complex and has enormous data requirements. Data on mean years of schooling is not provided by any UN agency or international organization. As a result, estimates must sometimes be used, which are not always acceptable. The combined enrollment ratio overcomes both these problems (UNDP 1995, p. 134). However, in 2010, mean years of schooling was adopted again, and this time, the indicator of expected years of schooling was also adopted.[4]

With respect to the indicator of income, the logarithm of GDP per capita or the adjusted GDP per capita has been adopted from 1990 to 2009. In 2010, the GDP per capita indicator was replaced with gross national income (GNI) per capita.[5] This is because the ongoing surge of globalization in the world often effects large differences between the income of a country's residents and its domestic production. To capture the real economic situation of a country, GNI seems a more appropriate indicator than GDP.

[3]Average number of years of education received by people aged 25 and older in their lifetimes based on education attainment levels of the population converted into years of schooling based on theoretical durations of each level of education attended

[4]Number of years of schooling that a child of school entrance age can expect to receive if prevailing patterns of age-specific enrolment rates were to stay the same throughout the child's life.

[5]The adjusted GDP is calculated by $W(y) = \frac{1}{1-\varepsilon} \times y^{1-\varepsilon}$ where y denotes the GDP per capita. When y^* denotes the poverty line, if $y \leq y^*$, then $\varepsilon = 0$ is applied and if $y > y^*$, then $\varepsilon = 0.5$ is applied. See the HDR 1991 (UNDP 1991) for more detail. The definition of GNI per capita is as follows: Sum of value added by all resident producers in the economy plus any product taxes (less subsidies) not included in the valuation of output plus net receipts of primary income (compensation of employees and property income) from abroad, divided by midyear population. GNI minus net receipts of primary income from abroad is GDP.

A.3.2 Changes in the calculation methodologies

The methodology for calculating the HDI value is introduced annually in the Technical Note in the HDR. The basis of calculation has not changed from the beginning. To obtain the HDI value, we first calculate the index value of each indicator. Then, we combine the two index values for educational attainment into one education index value. Finally, we aggregate three index values, the life expectancy index, education index, and income index value, into an HDI index value.

The formula to calculate the index value of each indicator is as follows:

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

Let V_c^i be an index value, where subscript c denotes a country and the superscript i denotes 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 maximum and minimum values corresponding to each i respectively.

With respect to education index, we need to combine two index values into one. The weight of the index value for educational attainment (1) is two thirds and for (2) is one third.[6]

Finally, we combine these three index values; that is, we combine the life expectancy index, education index, and income index values. From 1990 to 2009, the HDI value was a simple arithmetic mean of these three index values. However, in the HDR 2010, geometric mean was adopted for the first time. The characteristics of geometric mean are much different from those of arithmetic mean. How does this affect the HDI values and rankings? The next section makes a comparison of the new HDI produced by geometric mean and the old HDI produced by arithmetic mean using the data of the HDR 2010.

A.3.3 Changes in the maximum and minimum value

The maximum values and the minimum values of each indicator that are used to convert the raw number of each human development indicator into a normalized index

[6] in 2010, geometric mean was applied to get the combined education index. That is, $V_c^i = \frac{\{edu_1 \times edu_2\}^{0.5} - Min^i}{Max^i - Min^i}$.

value have also been changed. From 1990 to 1994, the actual observed maximum and minimum values of each indicator in the year had been applied. However, if the maximum and minimum values change every year, then the HDI value of a country possibly changes even if the performance of the country has not changed at all. From this viewpoint, the fixed maximum and minimum values had been applied from 1994 to 2009. However, the change in maximum value does not affect the relative comparison (in percentage terms) between any two countries or periods of time as to the HDI ranking. Therefore, in the HDR 2010 the maximum values were set to the actual observed maximum values of the indicators from the countries during 1980–2010. The minimum values will affect comparisons as to the HDI ranking, so values that can be appropriately conceived of as subsistence values or "natural" zeros are used. Progress is thus measured against minimum levels that a society needs to survive over time. The minimum values are set at twenty years for life expectancy, at zero years for both education variables and at $163 for per capita gross national income (GNI). According to the HDR 2010, the life expectancy minimum is based on long-run historical evidence from Maddison (2010) and Riley (2005) and the income minimum $163 is based on the lowest value attained by any country in recorded history (in Zimbabwe in 2008) that is regarded as necessity to ensure survival.

A.4 Characteristics of the new HDI

The new aggregation method, namely the use of geometric mean, results in substantial changes in the value and rank of the HDI for each country. Table B.4 in Appendix B shows a comparison of the new and old aggregation methods, geometric mean and arithmetic mean, respectively. The table includes the values of each indicator, the HDI 2010 values and ranks produced by the new and old methods, and the differences of the HDI values and ranks between the new and old methods for 169 countries. The data source is the HDR 2010 and the indicators are life expectancy at birth, mean years of schooling, expected years of schooling and gross national income (GNI) per capita.

First of all, geometric mean is sensitive to the balance of variable size, and poor performance in any dimension is now directly reflected in the HDI. In addition, there is no longer perfect substitutability across dimensions. This method captures how well

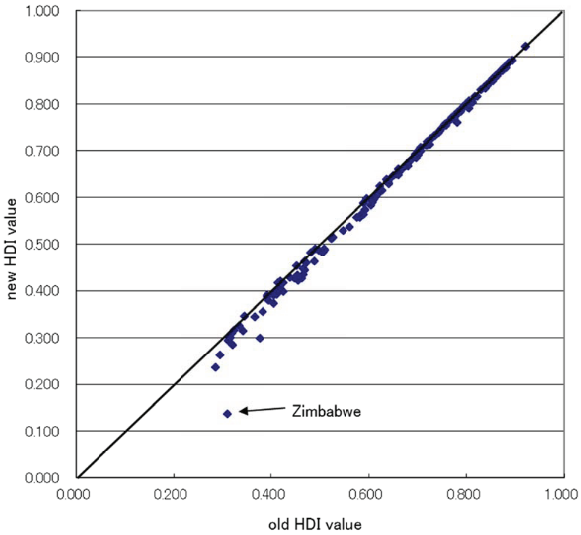


Figure A.1: The new and old HDI in 2010

balanced a country's performance is across the three dimensions.

By definition, all countries achieve lower values by the new method compared to those of the old one because the value of geometric mean is always less than or equal to that of arithmetic mean. The worse the balance among indicator values for a country, the larger the gap between the value of geometric mean and that of arithmetic mean. This is also caused by the properties of geometric and arithmetic mean.

As a whole, the difference between the new and old methodologies is small. With respect to the value difference in the HDI value, the smallest one is recorded by Norway at a value of 0.000 and the largest one is recorded by Zimbabwe at 0.176. Countries that achieve worse balanced development across dimensions have larger differences between new and old HDI values. With respect to the difference in rank, the smallest value is -8 by Liberia (ranked at 164th in the new HDI but 156th in the old), and the biggest value is 7 by Cameroon (ranked at 131st in the new HDI but 138th in the old). The performance of Liberia is ill-balanced compared to other countries (Life expectancy, Mean years of schooling, Expected years of schooling, GNI)=(59.1, 3.9, 11.0, 320), while that of Cameroon is quite well-balanced (51.7, 5.9, 9.8, 2197). 46 countries out of 169 stay the same rank in both of the new and old HDI.

Figure A.1 shows the scatter plots for the new and old HDI values. As mentioned, geometric mean always produces the same or lower index values compared to those

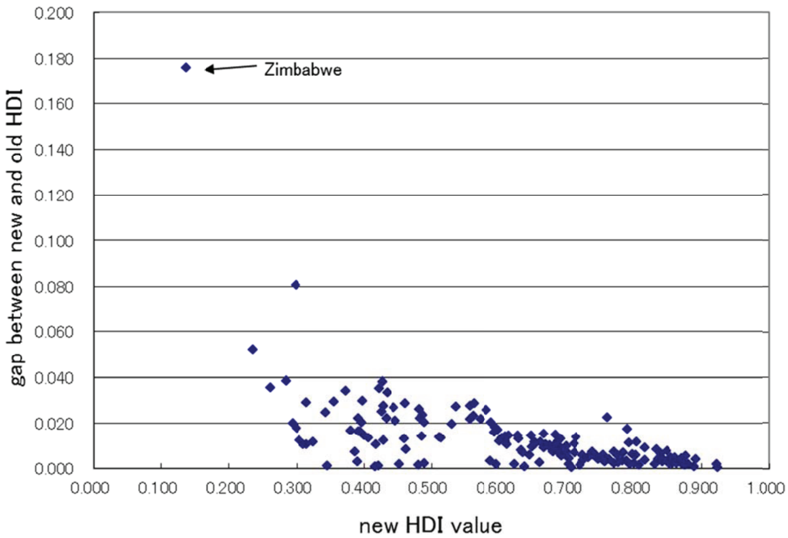


Figure A.2: Gap between the new and old HDI in 2010

produced by arithmetic mean, and all plots are located below the 45-degree line. Relatively unbalanced countries tend to have large gaps between the new and old HDI value, so they are located far below from the 45-degree line. For example, Zimbabwe, (Life expectancy, Mean years of schooling, Expected years of schooling, GNI)=(47.0, 7.2, 9.2, 176) has the largest gap 0.176, and it is located far below the 45-degree line.

Figure A.2 shows the scatter plots for the new HDI value and the gap of the new and old HDI values in 2010. There exists slightly negative correlation between these two variables. This means that as the new HDI value gets greater, the gap tends to get smaller. This phenomenon is interpreted as follows. In general, developed countries have already achieved high values in all indicators, so these countries inevitably ended well-balanced among the indicators. On the other hand, developing countries have not achieved high values yet, so the indicator values of these countries tend to be spread and unbalanced. From this viewpoint, the new HDI which evaluates the balance among indicators seems more severe for less developed countries. Is this characteristic appropriate for a human development measure?

The processes of human development depend on countries. Some countries may achieve a well-balanced development, but other countries may not. If a country once experienced an unbalanced development, there is a possibility that the first developed dimension will lead the development of other dimensions. From this viewpoint, to highly value a good balance in development is not always appropriate. Further modification to evaluate unbalanced development as well is required.

Appendix B

Statistical Annex

Table B.1: Ranking results in 2007 (n=182, unbalanced)

	Life expectancy		Adult literacy rate		Combined gross enrolment ratio		GDP per capita		HDI (old method)		HDI (new method)		Gap between the new and old HDI (old minus new)		MAXOR		MINOR		Difference between (a) and (b)
	raw value (years)	rank	raw value (%)	rank	raw value (%)	rank	raw value (PPP$)	rank	value	rank	value	rank	value	rank	n-th group (a)	rank	n-th group (b)	rank	[(b)-(a)]
Norway	80.5	12	99.0	1	98	8	40000	1	0.971	1	0.970	1	0.001	0	1	1	1	1	0
Australia	81.4	5	99.0	1	100	1	34923	22	0.970	2	0.970	2	0.000	0	1	1	3	3	2
Iceland	81.7	3	99.0	1	96	12	35742	19	0.969	3	0.969	3	0.000	0	1	1	3	3	2
Canada	80.6	11	99.0	1	99	7	35812	18	0.966	4	0.966	4	0.000	0	1	1	3	3	2
Ireland	79.7	19	99.0	1	97	10	40000	1	0.965	5	0.964	5	0.001	0	2	10	2	2	0
Netherlands	79.8	17	99.0	1	97	10	38694	14	0.964	6	0.963	6	0.001	0	2	10	3	3	1
Sweden	80.8	8	99.0	1	94	16	36712	16	0.963	7	0.963	7	0.000	0	1	1	3	3	2
France	81.0	7	99.0	1	95	14	33674	25	0.960	8	0.960	8	0.000	0	2	10	4	9	2
Luxembourg	79.4	24	99.0	1	94	16	40000	1	0.960	9	0.959	9	0.001	0	3	20	3	3	0
Japan	82.7	1	99.0	1	86	41	33632	26	0.960	10	0.959	10	0.001	0	1	1	5	16	4
Switzerland	81.7	3	99.0	1	82	49	40000	1	0.959	11	0.958	12	0.001	−1	1	1	6	24	5
Finland	79.5	22	99.0	1	100	1	34526	23	0.959	12	0.958	11	0.001	1	2	10	4	9	2
United States	79.1	28	99.0	1	92	19	40000	1	0.956	13	0.955	13	0.001	0	4	27	4	9	0
Austria	79.9	16	99.0	1	90	26	37370	15	0.955	14	0.954	14	0.001	0	2	10	4	9	2
Denmark	78.2	34	99.0	1	100	1	36130	17	0.954	15	0.953	16	0.001	−1	1	1	4	9	3
Spain	80.7	9	97.9	53	96	12	31560	27	0.954	16	0.954	15	0.000	1	2	10	5	16	3
Belgium	79.5	22	99.0	1	94	16	34935	21	0.953	17	0.952	17	0.001	0	3	20	4	9	1
Italy	81.1	6	98.9	47	91	23	30353	29	0.951	18	0.950	18	0.001	0	2	10	5	16	3
Liechtenstein	79.2	26	99.0	1	86	41	40000	1	0.950	19	0.948	20	0.002	−1	4	27	5	16	1
New Zealand	80.1	15	99.0	1	100	1	27336	32	0.949	20	0.949	19	0.000	1	2	10	4	9	2
Germany	79.8	17	99.0	1	88	35	34401	24	0.947	21	0.946	21	0.001	0	3	20	5	16	2
United Kingdom	79.3	25	99.0	1	89	33	35130	20	0.947	22	0.946	22	0.001	0	4	27	5	16	1
Singapore	80.2	14	94.4	79	85	44	40000	1	0.944	23	0.943	23	0.001	0	2	10	7	29	5
Hong Kong, China (SAR)	82.2	2	94.6	76	74	84	40000	1	0.944	24	0.940	25	0.004	−1	1	1	7	29	6
Greece	79.1	28	97.1	60	100	1	28517	31	0.942	25	0.941	24	0.001	1	3	20	6	24	3
Korea (Republic of)	79.2	26	99.0	1	98	8	24801	35	0.937	26	0.936	26	0.001	0	3	20	5	16	2
Israel	80.7	9	97.1	60	89	33	26315	34	0.934	27	0.934	27	0.000	0	3	20	6	24	3
Andorra	80.5	12	99.0	1	65	125	40000	1	0.934	28	0.927	29	0.007	−1	2	10	10	75	8
Slovenia	78.2	34	99.0	1	92	19	26753	33	0.929	29	0.928	28	0.001	1	5	33	5	16	0
Brunei Darussalam	77.0	38	94.9	73	77	73	40000	1	0.919	30	0.915	30	0.004	0	5	33	8	40	3
Kuwait	77.5	36	94.5	78	72	99	40000	1	0.915	31	0.911	32	0.004	−1	5	33	8	40	3
Cyprus	79.6	20	97.7	56	77	73	24789	36	0.913	32	0.911	31	0.002	1	4	27	7	29	3
Qatar	75.5	48	93.1	86	80	55	40000	1	0.910	33	0.907	34	0.003	−1	5	33	8	40	3
Portugal	78.6	31	94.9	73	88	35	22765	42	0.908	34	0.908	33	0.000	1	5	33	7	29	2
Czech Republic	76.4	42	99.0	1	83	47	24144	37	0.903	35	0.901	35	0.002	0	6	41	6	24	0
United Arab Emirates	77.3	37	90.0	99	71	103	40000	1	0.903	36	0.898	38	0.005	−2	6	41	9	56	3
Malta	79.6	20	92.4	89	81	53	23080	39	0.901	37	0.901	36	0.000	1	4	27	8	40	4
Barbados	77.0	38	99.0	1	92	19	17956	48	0.900	38	0.898	37	0.002	1	6	41	6	24	0
Bahrain	75.6	47	88.8	105	90	26	29723	30	0.895	39	0.894	39	0.001	0	5	33	9	56	4
Estonia	72.9	74	99.0	1	91	23	20361	43	0.883	40	0.880	40	0.003	0	6	41	7	29	1
Poland	75.5	48	99.0	1	87	39	15987	53	0.880	41	0.878	41	0.002	0	7	46	7	29	0

Table B.1: Ranking results in 2007

Table B.1: Ranking results in 2007 (n=182, unbalanced) (continued)

	Life expectancy		Adult literacy rate		Combined gross enrolment ratio		GDP per capita		HDI (old method)		HDI (new method)		Gap between the new and old HDI (old minus new)		MAXOR		MINOR		Difference between (a) and (b) [(b)−(a)]
	raw value (years)	rank	raw value (%)	rank	raw value (%)	rank	raw value (PPP$)	rank	value	rank	value	rank	value	rank	n−th group (a)	rank	n−th group (b)	rank	
Slovakia	74.6	56	99.0	1	80	55	20076	45	0.879	42	0.877	42	0.002	0	7	46	7	29	0
Hungary	73.3	69	98.9	47	90	26	18755	46	0.879	43	0.877	43	0.002	0	6	41	7	29	1
Chile	78.5	32	96.5	66	82	49	13880	59	0.877	44	0.875	44	0.002	0	5	33	7	29	2
Croatia	76.0	44	98.7	49	77	73	16027	52	0.871	45	0.868	45	0.003	0	7	46	7	29	0
Lithuania	71.8	91	99.0	1	92	19	17575	49	0.870	46	0.866	46	0.004	0	7	46	8	40	1
Antigua and Barbuda	72.2	84	99.0	1	85	44	18691	47	0.868	47	0.865	47	0.003	0	7	46	8	40	1
Latvia	72.3	83	99.0	1	90	26	16377	51	0.866	48	0.863	48	0.003	0	7	46	8	40	1
Argentina	75.2	53	97.6	57	88	35	13238	62	0.865	49	0.863	49	0.002	0	7	46	7	29	0
Uruguay	76.1	43	97.9	53	90	26	11216	70	0.864	50	0.861	50	0.003	0	7	46	8	40	1
Cuba	78.5	32	99.0	1	100	1	6876	95	0.864	51	0.855	51	0.009	0	3	20	8	40	5
Bahamas	73.2	71	95.8	71	71	103	20253	44	0.855	52	0.851	53	0.004	−1	7	46	9	56	2
Mexico	76.0	44	92.8	87	80	55	14104	58	0.854	53	0.853	52	0.001	1	7	46	8	40	1
Costa Rica	78.7	30	95.9	70	73	92	10842	73	0.853	54	0.849	54	0.004	0	5	33	9	56	4
Libyan Arab Jamahiriya	73.8	64	86.8	114	95	14	14364	57	0.846	55	0.845	55	0.001	0	4	27	9	56	5
Oman	75.5	48	84.4	118	68	115	22816	41	0.846	56	0.843	57	0.003	−1	7	46	10	75	3
Seychelles	72.8	76	91.8	92	82	49	16394	50	0.844	57	0.843	56	0.001	1	7	46	8	40	1
Venezuela (Bolivarian Republic of)	73.6	66	95.2	72	85	44	12156	65	0.843	58	0.841	59	0.002	−1	8	63	8	40	0
Saudi Arabia	72.7	77	85.0	117	78	64	22935	40	0.843	59	0.841	58	0.002	1	7	46	10	75	3
Bulgaria	73.1	72	98.3	52	82	49	11222	69	0.839	60	0.836	61	0.003	−1	8	63	8	40	0
Panama	75.5	48	93.4	83	79	59	11391	67	0.839	61	0.838	60	0.001	1	8	63	8	40	0
Saint Kitts and Nevis	72.2	84	97.8	55	73	92	14481	56	0.837	62	0.834	62	0.003	0	8	63	9	56	1
Romania	72.5	80	97.6	57	79	59	12369	64	0.837	63	0.833	63	0.004	0	8	63	8	40	0
Trinidad and Tobago	69.2	110	98.7	49	61	134	23507	38	0.836	64	0.826	66	0.010	−2	7	46	12	106	5
Montenegro	74.0	61	96.4	67	74	84	11699	66	0.834	65	0.831	64	0.003	1	8	63	8	40	0
Malaysia	74.1	58	91.9	91	71	103	13518	61	0.829	66	0.827	65	0.002	1	8	63	9	56	1
Serbia	73.9	63	96.4	67	74	84	10248	75	0.826	67	0.822	67	0.004	0	9	84	9	56	0
Belarus	69.0	111	99.0	1	90	26	10841	74	0.825	68	0.819	68	0.006	0	8	63	10	75	2
Saint Lucia	73.6	66	94.8	75	77	73	9786	77	0.821	69	0.818	69	0.003	0	9	84	9	56	0
Albania	76.5	41	99.0	1	67	122	7041	93	0.817	70	0.809	73	0.008	−3	7	46	10	75	3
Macedonia (the Former Yugoslav Rep.	74.1	58	97.0	62	70	110	9096	80	0.817	71	0.812	70	0.005	1	8	63	9	56	1
Russian Federation	66.2	122	99.0	1	81	53	14690	55	0.816	72	0.809	74	0.007	−2	8	63	11	90	3
Dominica	76.9	40	88.0	108	78	64	7893	83	0.814	73	0.811	71	0.003	2	7	46	9	56	2
Grenada	75.3	52	96.0	69	73	92	7344	92	0.813	74	0.808	75	0.005	−1	8	63	9	56	1
Brazil	72.2	84	90.0	99	87	39	9567	79	0.813	75	0.811	72	0.002	3	8	63	9	56	1
Bosnia and Herzegovina	75.1	54	96.7	65	69	114	7764	87	0.812	76	0.806	76	0.006	0	8	63	9	56	1

Table B.1: Ranking results in 2007 (n=182, unbalanced) (continued)

	Life expectancy		Adult literacy rate		Combined gross enrolment ratio		GDP per capita		HDI (old method)		HDI (new method)		Gap between the new and old HDI (old minus new)		MAXOR		MINOR		Difference between (a) and (b) [(b)−(a)]
	raw value (years)	rank	raw value (%)	rank	raw value (%)	rank	raw value (PPP$)	rank	value	rank	value	rank	value	rank	n−th group (a)	rank	n−th group (b)	rank	
Colombia	72.7	77	92.7	88	79	59	8587	81	0.807	77	0.804	78	0.003	−1	9	84	9	56	0
Peru	73.0	73	89.6	102	88	35	7836	85	0.806	78	0.803	79	0.003	−1	8	63	9	56	1
Turkey	71.7	92	88.7	106	71	103	12955	63	0.806	79	0.804	77	0.002	2	9	84	10	75	1
Ecuador	75.0	55	91.0	94	77	73	7449	91	0.805	80	0.802	81	0.003	−1	9	84	10	75	1
Kazakhstan	64.9	130	99.0	1	91	23	10863	72	0.804	81	0.794	83	0.010	−2	8	63	11	90	3
Mauritius	72.1	88	87.4	112	76	79	11296	68	0.803	82	0.802	80	0.001	2	9	84	10	75	1
Lebanon	71.9	90	89.6	102	78	64	10109	76	0.803	83	0.802	82	0.001	1	9	84	9	56	0
Armenia	73.6	66	99.0	1	74	84	5693	100	0.797	84	0.789	84	0.008	0	8	63	9	56	1
Ukraine	68.2	116	99.0	1	90	26	6914	94	0.796	85	0.787	85	0.009	0	9	84	11	90	2
Azerbaijan	70.0	107	99.0	1	66	124	7851	84	0.786	86	0.779	88	0.007	−2	8	63	11	90	3
Thailand	68.7	113	94.1	81	78	64	8135	82	0.783	87	0.779	87	0.004	0	9	84	12	106	3
Iran (Islamic Republic of)	71.2	101	82.3	123	73	92	10955	71	0.782	88	0.781	86	0.001	2	10	100	11	90	1
Georgia	71.6	96	99.0	1	76	79	4662	110	0.777	89	0.767	93	0.010	−4	8	63	9	56	1
Dominican Republic	72.4	81	89.1	104	73	92	6706	97	0.776	90	0.773	89	0.003	1	10	100	11	90	1
Belize	76.0	44	75.1	134	78	64	6734	96	0.771	91	0.769	90	0.002	1	8	63	11	90	3
China	72.9	74	93.3	85	68	115	5383	102	0.771	92	0.764	95	0.007	−3	10	100	10	75	0
Saint Vincent and the Grenadines	71.4	98	88.1	107	68	115	7691	89	0.771	93	0.768	91	0.003	2	10	100	11	90	1
Samoa	71.4	98	98.7	49	74	84	4467	113	0.771	94	0.760	99	0.011	−5	9	84	10	75	1
Maldives	71.1	102	97.0	62	71	103	5196	104	0.770	95	0.762	98	0.008	−3	9	84	10	75	1
Jordan	72.4	81	91.1	93	78	64	4901	107	0.769	96	0.763	97	0.006	−1	10	100	10	75	0
Suriname	68.8	112	90.4	97	74	84	7813	86	0.769	97	0.766	94	0.003	3	10	100	12	106	2
Tunisia	73.8	64	77.7	130	76	79	7520	90	0.769	98	0.768	92	0.001	6	9	84	11	90	2
Tonga	71.7	92	99.0	1	78	64	3748	120	0.768	99	0.755	100	0.013	−1	8	63	10	75	2
Jamaica	71.7	92	86.0	116	78	64	6079	98	0.766	100	0.763	96	0.003	4	10	100	10	75	0
Paraguay	71.7	92	94.6	76	72	99	4433	114	0.761	101	0.752	102	0.009	−1	10	100	10	75	0
Sri Lanka	74.0	61	90.8	95	68	115	4243	116	0.758	102	0.750	103	0.008	−1	10	100	11	90	1
Gabon	60.1	144	86.2	115	80	55	15167	54	0.755	103	0.744	105	0.011	−2	8	63	14	126	6
Algeria	72.2	84	75.4	133	73	92	7740	88	0.753	104	0.752	101	0.001	3	10	100	11	90	1
Philippines	71.6	96	93.4	83	79	59	3406	124	0.751	105	0.739	106	0.012	−1	9	84	11	90	2
El Salvador	71.3	100	82.0	125	74	84	5804	99	0.748	106	0.746	104	0.002	2	11	120	11	90	0
Syrian Arab Republic	74.1	58	83.1	121	65	125	4511	112	0.742	107	0.736	107	0.006	0	10	100	11	90	1
Fiji	68.7	113	94.4	79	71	103	4304	115	0.741	108	0.732	108	0.009	0	11	120	12	106	1
Turkmenistan	64.6	132	99.0	1	73	92	4953	106	0.738	109	0.727	109	0.011	0	10	100	12	106	2
Occupied Palestinian Territories	73.3	69	93.8	82	78	64	2243	135	0.736	110	0.717	113	0.019	−3	9	84	13	120	4
Indonesia	70.5	105	92.0	90	68	115	3712	121	0.734	111	0.725	111	0.009	0	11	120	11	90	0
Honduras	72.0	89	83.6	120	74	84	3796	119	0.731	112	0.725	110	0.006	2	11	120	11	90	0
Bolivia	65.4	128	90.7	96	86	41	4206	117	0.730	113	0.721	112	0.009	1	10	100	12	106	2
Guyana	66.5	119	99.0	1	83	47	2782	127	0.728	114	0.710	115	0.018	−1	10	100	12	106	2

Table B.1: Ranking results in 2007 (n=182, unbalanced) (continued)

	Life expectancy		Adult literacy rate		Combined gross enrolment ratio		GDP per capita		HDI (old method)		HDI (new method)		Gap between the new and old HDI (old minus new)		MAXOR		MINOR		Difference between (a) and (b) [(b)−(a)]
	raw value (years)	rank	raw value (%)	rank	raw value (%)	rank	raw value (PPP$)	rank	value	rank	value	rank	value	rank	n−th group (a)	rank	n−th group (b)	rank	
Mongolia	66.2	122	97.3	59	79	59	3236	125	0.726	115	0.713	114	0.013	1	10	100	12	106	2
Viet Nam	74.3	57	90.3	98	62	130	2600	129	0.725	116	0.709	116	0.016	0	10	100	13	120	3
Moldova	68.3	115	99.0	1	71	103	2551	131	0.720	117	0.702	117	0.018	0	9	84	12	106	3
Equatorial Guinea	49.9	168	87.0	113	62	130	30627	28	0.719	118	0.675	126	0.044	−8	7	46	16	147	9
Uzbekistan	67.6	117	96.9	64	72	99	2425	133	0.709	119	0.692	121	0.017	−2	10	100	13	120	3
Kyrgyzstan	67.6	117	99.0	1	77	73	2006	141	0.709	120	0.686	124	0.023	−4	10	100	12	106	2
Cape Verde	71.1	102	83.8	119	68	115	3041	126	0.708	121	0.700	120	0.008	1	11	120	12	106	1
Guatemala	70.1	106	73.2	138	70	110	4562	111	0.704	122	0.702	118	0.002	4	12	128	12	106	0
Egypt	69.9	108	66.4	149	76	79	5349	103	0.703	123	0.702	119	0.001	4	11	120	12	106	1
Nicaragua	72.7	77	78.0	129	72	99	2570	130	0.699	124	0.689	122	0.010	2	10	100	13	120	3
Botswana	53.4	160	82.9	122	70	110	13604	60	0.693	125	0.672	127	0.021	−2	9	84	15	134	6
Vanuatu	69.9	108	78.1	128	62	130	3666	122	0.692	126	0.688	123	0.004	3	12	128	12	106	0
Tajikistan	66.4	120	99.0	1	70	110	1753	145	0.687	127	0.663	128	0.024	−1	11	120	13	120	2
Namibia	60.4	143	88.0	108	67	122	5155	105	0.686	128	0.678	125	0.008	3	11	120	14	126	3
South Africa	51.5	164	88.0	108	76	79	9757	78	0.682	129	0.657	129	0.025	0	10	100	15	134	5
Morocco	71.0	104	55.6	162	61	134	4108	118	0.654	130	0.648	130	0.006	0	12	128	14	126	2
Sao Tome and Principe	65.4	128	87.9	111	68	115	1638	149	0.651	131	0.633	131	0.018	0	12	128	14	126	2
Bhutan	65.7	126	52.8	167	54	150	4837	108	0.619	132	0.616	132	0.003	0	12	128	14	126	2
Lao People's Democratic Republic	64.6	132	72.7	139	59	142	2165	136	0.618	133	0.612	133	0.006	0	13	137	14	126	1
India	63.4	134	66.0	150	61	134	2753	128	0.612	134	0.611	134	0.001	0	13	137	13	120	0
Solomon	65.8	125	76.6	131	49	162	1725	146	0.610	135	0.598	135	0.012	0	13	137	15	134	2
Congo	53.5	159	81.1	126	58	144	3511	123	0.601	136	0.589	136	0.012	0	12	128	15	134	3
Cambodia	60.6	142	76.3	132	58	144	1802	144	0.593	137	0.584	137	0.009	0	13	137	14	126	1
Myanmar	61.2	137	89.9	101	56	148	904	168	0.586	138	0.554	141	0.032	−3	12	128	16	147	4
Comoros	64.9	130	75.1	134	46	167	1143	160	0.575	139	0.557	140	0.018	−1	14	151	16	147	2
Yemen	62.5	135	58.9	158	54	150	2335	134	0.575	140	0.573	138	0.002	2	14	151	14	126	0
Pakistan	66.2	122	54.2	164	39	173	2496	132	0.572	141	0.564	139	0.008	2	13	137	15	134	2
Swaziland	45.3	179	79.6	127	60	140	4789	109	0.572	142	0.541	143	0.031	−1	12	128	17	160	5
Angola	46.5	178	67.4	147	65	125	5385	101	0.563	143	0.541	142	0.022	1	12	128	17	160	5
Nepal	66.3	121	56.5	160	60	140	1049	166	0.552	144	0.538	144	0.014	0	13	137	15	134	2
Madagascar	59.9	145	70.7	143	61	134	932	167	0.543	145	0.526	149	0.017	−4	13	137	16	147	3
Bangladesh	65.7	126	53.5	165	52	155	1241	156	0.543	146	0.533	146	0.010	0	13	137	15	134	2
Kenya	53.6	158	73.6	136	59	142	1542	150	0.540	147	0.530	147	0.010	0	13	137	16	147	3
Papua New Guinea	60.7	140	57.8	159	40	172	2084	139	0.540	148	0.536	145	0.004	3	15	161	15	134	0
Haiti	61.0	138	62.1	155	52	155	1155	159	0.532	149	0.523	150	0.009	−1	14	151	15	134	1
Sudan	57.9	147	60.9	156	39	173	2086	138	0.530	150	0.526	148	0.004	2	14	151	15	134	1
Tanzania (United	55.0	156	72.3	140	57	146	1208	158	0.529	151	0.518	153	0.011	−2	14	151	16	147	2
Ghana	56.5	152	65.0	151	56	148	1334	154	0.526	152	0.520	151	0.006	1	14	151	15	134	1
Cameroon	50.9	165	67.9	146	52	155	2128	137	0.523	153	0.515	154	0.008	−1	14	151	16	147	2

Table B.1: Ranking results in 2007 (n=182, unbalanced) (continued)

	Life expectancy		Adult literacy rate		Combined gross enrolment ratio		GDP per capita		HDI (old method)		HDI (new method)		Gap between the new and old HDI (old minus new)		MAXOR		MINOR		Difference between (a) and (b) [(b)−(a)]
	raw value (years)	rank	raw value (%)	rank	raw value (%)	rank	raw value (PPP$)	rank	value	rank	value	rank	value	rank	n−th group (a)	rank	n−th group (b)	rank	
Mauritania	56.6	151	55.8	161	50	160	1927	143	0.520	154	0.519	152	0.001	2	15	161	15	134	0
Djibouti	55.1	155	70.3	145	25	182	2061	140	0.520	155	0.502	155	0.018	0	14	151	18	171	4
Uganda	51.9	163	73.6	136	62	130	1059	164	0.513	156	0.497	156	0.016	0	13	137	16	147	3
Lesotho	44.9	180	82.2	124	61	134	1541	151	0.513	157	0.483	160	0.030	−3	13	137	17	160	4
Nigeria	47.7	173	72.0	141	53	153	1969	142	0.511	158	0.496	157	0.015	1	14	151	17	160	3
Togo	62.2	136	53.2	166	53	153	788	171	0.499	159	0.484	158	0.015	1	15	161	16	147	1
Malawi	52.4	162	71.8	142	61	134	761	173	0.492	160	0.472	163	0.020	−3	13	137	17	160	4
Benin	61.0	138	40.5	174	52	155	1312	155	0.491	161	0.484	159	0.007	2	15	161	15	134	0
Timor−Leste	60.7	140	50.1	168	63	128	717	174	0.489	162	0.473	162	0.016	0	13	137	17	160	4
Cote d'Ivoire	56.8	150	48.7	169	37	175	1690	147	0.483	163	0.481	161	0.002	2	16	170	16	147	0
Zambia	44.5	181	70.6	144	63	128	1358	153	0.480	164	0.458	165	0.022	−1	13	137	17	160	4
Eritrea	59.2	146	64.2	154	33	178	626	178	0.471	165	0.448	167	0.023	−2	15	161	18	171	3
Senegal	55.4	154	41.9	173	41	171	1666	148	0.464	166	0.463	164	0.001	2	16	170	16	147	0
Rwanda	49.7	169	64.9	152	52	155	866	169	0.459	167	0.447	168	0.012	−1	15	161	17	160	2
Gambia	55.7	153	42.5	172	46	167	1225	157	0.456	168	0.454	166	0.002	2	16	170	16	147	0
Liberia	57.9	147	55.5	163	57	146	362	180	0.441	169	0.404	171	0.037	−2	14	151	18	171	4
Guinea	57.3	149	29.5	178	49	162	1140	161	0.435	170	0.424	169	0.011	1	16	170	16	147	0
Ethiopia	54.7	157	35.9	176	49	162	779	172	0.413	171	0.407	170	0.006	1	16	170	17	160	1
Mozambique	47.8	172	44.4	171	54	150	802	170	0.401	172	0.397	172	0.004	0	15	161	17	160	2
Guinea−Bissau	47.5	175	64.6	153	36	176	477	179	0.395	173	0.373	175	0.022	−2	16	170	18	171	2
Burundi	50.1	167	59.3	157	49	162	341	181	0.394	174	0.363	178	0.031	−4	15	161	18	171	3
Chad	48.6	170	31.8	177	36	176	1477	152	0.392	175	0.388	173	0.004	2	17	177	18	171	1
Congo	47.6	174	67.2	148	48	166	298	182	0.389	176	0.345	181	0.044	−5	15	161	18	171	3
Burkina Faso	52.7	161	28.7	179	32	179	1124	162	0.388	177	0.381	174	0.007	3	17	177	17	160	0
Mali	48.1	171	26.2	182	46	167	1083	163	0.370	178	0.364	176	0.006	2	17	177	18	171	1
Central African Republic	46.7	177	48.6	170	28	180	713	175	0.369	179	0.363	177	0.006	2	17	177	18	171	1
Sierra Leone	47.3	176	38.1	175	44	170	679	176	0.364	180	0.362	179	0.002	1	17	177	18	171	1
Afghanistan	43.6	182	28.0	181	50	160	1054	165	0.352	181	0.346	180	0.006	1	16	170	18	171	2
Niger	50.8	166	28.7	179	27	181	627	177	0.339	182	0.333	182	0.006	0	18	182	18	171	0

Notes:
1. This table was made by the author based on the data of the Human Development Report 2009.
2. Countries were arranged in accordance to the rank order of the old HDI.
3. The HDI rank is determined using HDI values to the sixth decimal point.
4. 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. (Several developed countries have no data for adult literacy rate and a value of 99.0% was applied to each of these countries.)
5. 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.

Table B.2: Ranking results in 2006 (n=179, unbalanced)

	Life expectancy		Adult literacy rate		Combined gross enrolment ratio		GDP per capita		HDI (old method)		HDI (new method)		Difference between the new and old HDI (old minus new)		MAXOR		Extended MAXOR		MINOR		Extended MINOR		Difference between the MAXOR and MINOR	
	raw value (years)	rank	raw value (%)	rank	raw value (%)	rank	raw value (PPP$)	rank	value	rank	value	rank	value	rank	n-th group (a)	rank	n-th group (b)	rank	n-th group (c)	rank	n-th group (d)	rank	original [(c)-(a)]	extended [(d)-(b)]
Iceland	81.6	3	99.0	1	96	11	35814	14	0.968	1	0.968	1	0.000	0	1	1	2	7	2	2	3	10	0	1
Norway	79.9	13	99.0	1	98	7	40000	1	0.967	2	0.966	2	0.001	0	1	1	1	1	1	1	1	1	0	0
Canada	80.4	9	99.0	1	99	6	36687	12	0.966	3	0.966	3	0.000	0	1	1	1	1	2	2	1	1	1	0
Australia	81.0	5	99.0	1	100	1	33035	20	0.965	4	0.965	4	0.000	0	1	1	2	7	3	5	2	6	2	0
Ireland	78.6	24	99.0	1	97	9	40000	1	0.959	5	0.958	6	0.001	−1	2	9	1	1	2	2	1	1	0	0
Sweden	80.7	6	99.0	1	94	15	34056	18	0.958	6	0.958	5	0.000	1	2	9	2	7	3	5	3	10	1	1
Netherlands	79.4	16	99.0	1	97	9	36099	13	0.958	7	0.957	7	0.001	0	2	9	1	1	3	5	3	10	1	2
Luxembourg	78.6	24	99.0	1	94	15	40000	1	0.956	8	0.954	9	0.002	−1	3	18	1	1	3	5	1	1	0	0
Japan	82.4	1	99.0	1	86	40	31951	24	0.955	9	0.955	8	0.000	1	1	1	6	28	5	17	5	19	4	−1
France	80.4	9	99.0	1	95	13	31980	23	0.954	10	0.954	10	0.000	0	2	9	2	7	4	9	2	6	2	0
Finland	79.1	20	99.0	1	100	1	32903	21	0.954	11	0.953	11	0.001	0	2	9	3	18	4	9	4	15	2	1
Switzerland	81.4	4	99.0	1	82	45	37396	11	0.954	12	0.952	12	0.002	0	1	1	2	7	5	17	2	6	4	0
Denmark	78.1	30	99.0	1	100	1	35125	16	0.952	13	0.951	13	0.001	0	1	1	2	7	4	9	2	6	3	0
Austria	79.6	15	99.0	1	90	25	35523	15	0.950	14	0.949	14	0.001	0	2	9	2	7	4	9	4	15	2	2
United States	78.0	31	99.0	1	92	19	40000	1	0.950	15	0.949	15	0.001	0	4	26	1	1	4	9	1	1	0	0
Spain	80.7	6	97.4	55	96	11	29208	27	0.948	16	0.948	16	0.000	0	2	9	5	27	4	9	4	15	2	−1
Belgium	79.1	20	99.0	1	94	15	33243	19	0.948	17	0.947	17	0.001	0	3	18	2	7	4	9	3	10	1	1
Greece	79.1	20	97.0	58	100	1	31290	26	0.947	18	0.946	18	0.001	0	3	18	3	18	5	17	4	15	2	1
New Zealand	80.0	12	99.0	1	100	1	25260	31	0.944	19	0.944	19	0.000	0	2	9	3	18	4	9	5	19	2	2
Italy	80.4	9	98.8	45	91	22	28828	28	0.944	20	0.943	20	0.001	0	3	18	6	28	5	17	5	19	2	−1
United Kingdom	79.2	18	99.0	1	89	30	32654	22	0.942	21	0.941	21	0.001	0	3	18	4	23	5	17	3	10	2	−1
Hong Kong, China (SAR)	82.1	2	94.6	70	74	81	39146	10	0.942	22	0.938	23	0.004	−1	1	1	2	7	8	39	7	27	7	5
Germany	79.3	17	99.0	1	88	33	31766	25	0.940	23	0.939	22	0.001	1	3	18	4	23	5	17	5	19	2	1
Israel	80.5	8	97.1	57	89	30	24405	33	0.929	24	0.929	24	0.000	0	3	18	6	28	5	17	6	25	2	0
Korea (Republic of)	78.2	29	99.0	1	98	7	22985	34	0.927	25	0.926	25	0.001	0	3	18	6	28	5	17	5	19	2	−1
Slovenia	77.7	34	99.0	1	92	19	25021	32	0.922	26	0.921	26	0.001	0	5	33	6	28	5	17	5	19	0	−1
Brunei Darussalam	76.9	36	94.6	70	78	61	40000	1	0.919	27	0.916	27	0.003	0	5	33	2	7	7	33	7	27	2	5
Singapore	79.7	14	94.2	74	64	124	40000	1	0.918	28	0.911	28	0.007	0	2	9	4	23	11	89	15	60	9	11
Kuwait	77.4	35	93.3	77	72	96	40000	1	0.912	29	0.908	30	0.004	−1	5	33	3	18	8	39	7	27	3	4
Cyprus	79.0	23	97.6	52	77	70	25837	30	0.911	30	0.910	29	0.001	1	4	26	7	33	8	39	8	34	4	1
United Arab Emirates	78.5	27	89.8	95	65	122	40000	1	0.902	31	0.896	33	0.006	−2	4	26	3	18	10	69	15	60	6	12
Bahrain	75.4	44	88.3	101	90	25	34516	17	0.901	32	0.900	31	0.001	1	5	33	4	23	8	39	7	27	3	3
Portugal	77.9	32	94.6	70	88	33	20845	40	0.899	33	0.899	32	0.000	1	5	33	7	33	6	26	8	34	1	1

Table B.2: Ranking results in 2006

Table B.2: Ranking results in 2006 (n=179, unbalanced) (continued)

	Life expectancy		Adult literacy rate		Combined gross enrolment ratio		GDP per capita		HDI (old method)		HDI (new method)		Difference between the new and old HDI (old minus new)		MAXOR		Extended MAXOR		MINOR		Extended MINOR		Difference between the MAXOR and MINOR	
	raw value (years)	rank	raw value (%)	rank	raw value (%)	rank	raw value (PPP$)	rank	value	rank	value	rank	value	rank	n-th group (a)	rank	n-th group (b)	rank	n-th group (c)	rank	n-th group (d)	rank	original [(c)-(a)]	extended [(d)-(b)]
Qatar	75.3	45	89.8	95	77	70	40000	1	0.898	34	0.894	35	0.004	−1	6	39	2	7	9	53	7	27	3	5
Czech Republic	76.2	39	99.0	1	83	42	22004	36	0.897	35	0.895	34	0.002	1	6	39	8	36	6	26	6	25	0	−2
Malta	79.2	18	91.4	89	81	49	21715	37	0.894	36	0.893	36	0.001	0	4	26	8	36	8	39	10	42	4	2
Barbados	76.9	36	99.0	1	83	42	17497	46	0.888	37	0.886	37	0.002	0	6	39	9	40	6	26	8	34	0	−1
Hungary	73.1	64	98.9	44	90	25	18154	43	0.876	38	0.874	38	0.002	0	6	39	8	36	7	33	7	27	1	−1
Poland	75.3	45	99.0	1	87	38	14675	50	0.874	39	0.872	39	0.002	0	6	39	9	40	6	26	9	38	0	0
Chile	78.4	28	96.4	63	82	45	12997	56	0.873	40	0.871	40	0.002	0	4	26	11	53	6	26	10	42	2	−1
Slovakia	74.4	52	99.0	1	80	51	17837	44	0.872	41	0.869	41	0.003	0	7	48	9	40	7	33	8	34	0	−1
Estonia	71.3	90	99.0	1	91	22	19155	42	0.871	42	0.867	42	0.004	0	6	39	7	33	8	39	7	27	2	0
Lithuania	72.7	69	99.0	1	92	19	15739	47	0.869	43	0.866	43	0.003	0	6	39	9	40	6	26	9	38	0	0
Latvia	72.3	75	99.0	1	90	25	15389	48	0.863	44	0.860	44	0.003	0	7	48	9	40	7	33	9	38	0	0
Croatia	75.5	43	98.6	47	77	70	14309	51	0.861	45	0.859	45	0.002	0	7	48	10	46	8	39	12	48	1	2
Argentina	75.0	49	97.6	52	88	33	11985	60	0.859	46	0.856	46	0.003	0	6	39	11	53	7	33	12	48	1	1
Uruguay	76.1	40	97.8	50	90	25	10203	66	0.859	47	0.855	47	0.004	0	6	39	10	46	6	26	10	42	0	0
Cuba	77.9	32	99.0	1	94	15	6876	88	0.854	48	0.846	49	0.008	−1	4	26	13	61	8	39	15	60	4	2
Bahamas	72.8	68	95.8	67	71	101	20253	41	0.853	49	0.849	48	0.004	1	7	48	9	40	9	53	9	38	2	0
Costa Rica	78.6	24	95.8	67	73	89	9889	69	0.847	50	0.843	50	0.004	0	5	33	15	69	9	53	15	60	4	0
Mexico	75.8	42	91.7	87	80	51	12176	59	0.842	51	0.841	51	0.001	0	7	48	13	61	8	39	13	53	1	0
Libyan Arab Jamahiriya	73.6	61	86.2	111	95	13	13362	54	0.839	52	0.838	52	0.001	0	4	26	10	46	9	53	12	48	5	2
Oman	75.3	45	83.7	118	68	112	20999	39	0.838	53	0.836	53	0.002	0	7	48	10	46	10	69	16	68	3	6
Seychelles	72.0	80	91.8	86	82	45	15105	49	0.835	54	0.834	54	0.001	0	8	62	10	46	9	53	11	46	1	1
Saudi Arabia	72.4	74	84.3	116	76	75	22053	35	0.835	55	0.834	55	0.001	0	7	48	10	46	10	69	10	42	3	0
Bulgaria	72.9	67	98.3	49	82	45	10295	65	0.833	56	0.830	56	0.003	0	7	48	14	65	8	39	14	56	1	0
Trinidad and Tobago	69.4	107	98.6	47	61	131	21669	38	0.833	57	0.823	61	0.010	−4	7	48	10	46	12	103	20	87	5	10
Panama	75.3	45	93.2	79	79	55	10135	67	0.831	58	0.829	58	0.002	0	7	48	14	65	7	33	14	56	0	0
Antigua and Barbuda	72.7	69	85.8	113	78	61	17642	45	0.830	59	0.829	57	0.001	2	8	62	11	53	9	53	12	48	1	1
Saint Kitts and Nevis	71.2	94	97.8	50	73	89	13975	53	0.830	60	0.826	59	0.004	1	8	62	12	57	10	69	12	48	2	0
Romania	72.2	78	97.6	52	79	55	10433	64	0.825	61	0.822	62	0.003	−1	8	62	13	61	8	39	14	56	0	1
Venezuela (Bolivarian Republic of)	73.4	62	93.0	80	79	55	11115	62	0.825	62	0.824	60	0.001	2	8	62	15	69	8	39	14	56	0	−1
Malaysia	73.9	57	91.5	88	71	101	12536	58	0.823	63	0.821	63	0.002	0	8	62	14	65	9	53	17	73	1	3

Table B.2: Ranking results in 2006 (n=179, unbalanced) (continued)

	Life expectancy		Adult literacy rate		Combined gross enrolment ratio		GDP per capita		HDI (old method)		HDI (new method)		Difference between the new and old HDI (old minus new)		MAXOR		Extended MAXOR		MINOR		Extended MINOR		Difference between the MAXOR and MINOR	
	raw value (years)	rank	raw value (%)	rank	raw value (%)	rank	raw value (PPP$)	rank	value	rank	value	rank	value	rank	n–th group (a)	rank	n–th group (b)	rank	n–th group (c)	rank	n–th group (d)	rank	original [(c)–(a)]	extended [(d)–(b)]
Montenegro	74.2	53	96.4	63	74	81	9250	75	0.822	64	0.818	65	0.004	−1	8	62	16	77	9	53	15	60	1	−1
Saint Lucia	73.4	62	94.8	69	79	55	9549	73	0.821	65	0.818	64	0.003	1	8	62	15	69	8	39	15	60	0	0
Serbia	73.8	59	96.4	63	74	81	9468	74	0.821	66	0.817	66	0.004	0	8	62	15	69	9	53	15	60	1	0
Belarus	68.8	108	99.0	1	89	30	9737	72	0.817	67	0.811	67	0.006	0	8	62	11	53	9	53	13	53	1	2
Macedonia (the Former Yugoslav Rep.	74.0	55	96.8	61	70	107	7921	78	0.808	68	0.803	69	0.005	−1	8	62	17	83	9	53	18	81	1	1
Brazil	72.0	80	89.6	98	87	38	8949	77	0.807	69	0.805	68	0.002	1	8	62	12	57	9	53	13	53	1	1
Kazakhstan	66.4	117	99.0	1	91	22	9832	70	0.806	70	0.798	72	0.008	−2	7	48	12	57	10	69	15	60	3	3
Ecuador	74.8	50	92.4	83	78	61	7145	84	0.806	71	0.802	70	0.004	1	8	62	19	93	8	39	21	91	0	2
Albania	76.3	38	99.0	1	67	117	5884	96	0.806	72	0.797	74	0.009	−2	7	48	16	77	10	69	17	73	3	1
Russian Federation	65.2	121	99.0	1	81	49	13205	55	0.805	73	0.797	73	0.008	0	8	62	12	57	12	103	11	46	4	−1
Bosnia and Herzegovina	74.6	51	96.7	62	69	111	6801	89	0.802	74	0.795	76	0.007	−2	8	62	16	77	9	53	16	68	1	0
Mauritius	72.6	72	87.0	109	76	75	10571	63	0.802	75	0.801	71	0.001	4	9	84	18	89	10	69	19	84	1	1
Turkey	71.6	87	88.1	103	71	101	11535	61	0.798	76	0.796	75	0.002	1	9	84	14	65	10	69	17	73	1	3
Dominica	74.1	54	88.0	105	78	61	7715	79	0.797	77	0.795	77	0.002	0	8	62	16	77	9	53	17	73	1	1
Lebanon	71.7	86	88.3	101	76	75	9757	71	0.795	78	0.794	78	0.001	0	9	84	15	69	10	69	16	68	1	1
Peru	71.0	96	88.7	100	88	33	7088	85	0.788	79	0.784	79	0.004	0	8	62	15	69	10	69	16	68	2	1
Thailand	70.0	102	93.9	75	78	61	7613	80	0.786	80	0.782	80	0.004	0	9	84	17	83	9	53	18	81	0	1
Colombia	72.5	73	92.3	85	77	70	6381	92	0.786	81	0.781	81	0.005	0	9	84	16	77	9	53	17	73	0	1
Ukraine	67.7	112	99.0	1	88	33	6224	93	0.785	82	0.776	83	0.009	−1	9	84	15	69	10	69	17	73	1	2
Iran (Islamic Republic of)	70.5	100	84.0	117	73	89	10031	68	0.777	83	0.776	82	0.001	1	10	102	21	100	11	89	20	87	1	−1
Armenia	71.8	84	99.0	1	72	96	4879	100	0.776	84	0.767	88	0.009	−4	8	62	16	77	10	69	16	68	2	0
Tonga	73.0	66	99.0	1	78	61	3677	117	0.774	85	0.761	93	0.013	−8	8	62	17	83	10	69	17	73	2	0
Grenada	68.4	111	96.1	66	73	89	7217	83	0.774	86	0.768	86	0.006	0	9	84	19	93	12	103	21	91	3	2
Jamaica	72.3	75	85.5	114	78	61	6409	91	0.771	87	0.769	84	0.002	3	9	84	17	83	10	69	18	81	1	1
Belize	76.0	41	75.1	131	78	61	6679	90	0.771	88	0.768	85	0.003	3	7	48	18	89	11	89	22	97	4	4
Suriname	69.8	104	90.1	93	74	81	7268	82	0.770	89	0.767	87	0.003	2	10	102	17	83	10	69	17	73	0	0
Jordan	72.2	78	92.7	82	78	61	4654	105	0.769	90	0.761	91	0.008	−1	9	84	18	89	10	69	20	87	1	2
Dominican Republic	71.8	84	88.8	99	73	89	6093	95	0.767	91	0.763	89	0.004	2	10	102	21	100	10	69	19	84	0	−2
Saint Vincent and the Grenadines	71.3	90	88.1	103	68	112	7057	86	0.765	92	0.762	90	0.003	2	10	102	18	89	11	89	20	87	1	2

Table B.2: Ranking results in 2006 (n=179, unbalanced) (continued)

	Life expectancy		Adult literacy rate		Combined gross enrolment ratio		GDP per capita		HDI (old method)		HDI (new method)		Difference between the new and old HDI (old minus new)		MAXOR		Extended MAXOR		MINOR		Extended MINOR		Difference between the MAXOR and MINOR	
	raw value (years)	rank	raw value (%)	rank	raw value (%)	rank	raw value (PPP$)	rank	value	rank	value	rank	value	rank	n-th group (a)	rank	n-th group (b)	rank	n-th group (c)	rank	n-th group (d)	rank	original [(c)-(a)]	extended [(d)-(b)]
Georgia	70.8	98	99.0	1	74	81	4009	112	0.762	93	0.750	95	0.012	−2	8	62	22	108	10	69	21	91	2	−1
Tunisia	73.7	60	76.9	128	76	75	6958	87	0.762	94	0.761	92	0.001	2	9	84	19	93	11	89	22	97	2	3
China	72.7	69	93.0	80	68	112	4682	104	0.761	95	0.753	94	0.008	1	9	84	21	100	10	69	21	91	1	0
Samoa	71.1	95	98.7	46	74	81	3828	116	0.760	96	0.748	97	0.012	−1	8	62	22	108	10	69	21	91	2	−1
Azerbaijan	67.3	114	99.0	1	66	120	6172	94	0.758	97	0.749	96	0.009	1	10	102	20	97	12	103	22	97	2	2
Paraguay	71.5	88	93.6	76	72	96	4034	110	0.752	98	0.743	100	0.009	−2	9	84	22	108	11	89	21	91	2	−1
Maldives	67.6	113	97.0	58	71	101	5008	98	0.749	99	0.740	101	0.009	−2	10	102	21	100	12	103	22	97	2	1
Algeria	72.0	80	74.6	132	73	89	7426	81	0.748	100	0.747	98	0.001	2	10	102	19	93	11	89	22	97	1	3
El Salvador	71.5	88	83.6	119	72	96	5477	97	0.747	101	0.744	99	0.003	2	11	121	21	100	11	89	19	84	0	−2
Philippines	71.3	90	93.3	77	79	55	3153	122	0.744	102	0.732	104	0.012	−2	9	84	21	100	11	89	22	97	2	1
Fiji	68.5	110	94.4	73	71	101	4548	106	0.743	103	0.735	102	0.008	1	9	84	21	100	12	103	22	97	3	1
Sri Lanka	71.9	83	90.8	91	68	112	3896	115	0.742	104	0.733	103	0.009	1	10	102	22	108	11	89	22	97	1	0
Syrian Arab Republic	73.9	57	82.5	122	65	122	4225	109	0.735	105	0.729	105	0.006	0	9	84	23	114	11	89	23	107	2	0
Occupied Palestinian Territories	73.1	64	92.4	83	80	51	2073	133	0.730	106	0.710	111	0.020	−5	8	62	23	114	12	103	24	112	4	1
Gabon	56.3	147	85.4	115	80	51	14208	52	0.728	107	0.712	110	0.016	−3	9	84	13	61	13	120	26	122	4	13
Turkmenistan	62.8	133	99.0	1	74	81	4826	101	0.728	108	0.715	107	0.013	1	10	102	22	108	13	120	22	97	3	0
Indonesia	70.1	101	91.0	90	68	112	3455	121	0.725	109	0.716	106	0.009	3	10	102	23	114	12	103	23	107	2	0
Guyana	65.8	119	99.0	1	83	42	2782	125	0.724	110	0.706	113	0.018	−3	10	102	22	108	11	89	23	107	1	1
Bolivia	65.1	124	89.8	95	86	40	3989	113	0.723	111	0.714	109	0.009	2	10	102	20	97	12	103	22	97	2	2
Mongolia	66.3	118	97.4	55	79	55	2887	123	0.721	112	0.705	114	0.016	−2	10	102	21	100	12	103	23	107	2	2
Moldova	68.6	109	99.0	1	71	101	2396	128	0.718	113	0.699	116	0.019	−3	9	84	24	120	11	89	24	112	2	0
Viet Nam	74.0	55	90.3	92	62	127	2363	129	0.718	114	0.700	115	0.018	−1	9	84	25	123	13	120	25	118	4	0
Equatorial Guinea	50.8	159	87.0	109	62	127	27161	29	0.717	115	0.679	122	0.038	−7	7	48	8	36	14	126	30	134	7	22
Egypt	71.0	96	71.4	139	76	75	4953	99	0.716	116	0.714	108	0.002	8	10	102	20	97	12	103	23	107	2	3
Honduras	69.7	105	82.6	121	74	81	3553	118	0.713	117	0.707	112	0.006	5	11	121	23	114	11	89	24	112	0	1
Cape Verde	71.3	90	83.0	120	70	107	2833	124	0.705	118	0.696	117	0.009	1	12	126	24	120	12	103	24	112	0	0
Uzbekistan	66.9	115	96.9	60	73	89	2189	132	0.701	119	0.682	120	0.019	−1	10	102	23	114	12	103	24	112	2	1
Nicaragua	72.3	75	80.1	125	72	96	2441	127	0.699	120	0.688	119	0.011	1	10	102	25	123	13	120	25	118	3	0
Guatemala	70.0	102	72.5	136	67	117	4311	108	0.695	121	0.693	118	0.002	3	12	126	24	120	12	103	24	112	0	0
Kyrgyzstan	65.7	120	99.0	1	77	70	1813	141	0.693	122	0.668	123	0.025	−1	11	121	25	123	12	103	25	118	1	0
Vanuatu	69.6	106	77.3	127	62	127	3481	120	0.686	123	0.681	121	0.005	2	12	126	25	123	12	103	25	118	0	0
Tajikistan	66.5	116	99.0	1	70	107	1609	144	0.683	124	0.656	124	0.027	0	10	102	25	123	12	103	26	122	2	1
South Africa	50.1	162	87.6	106	76	75	9087	76	0.669	125	0.641	125	0.028	0	10	102	17	83	14	126	30	134	4	13

Table B.2: Ranking results in 2006 (n=179, unbalanced) (continued)

	Life expectancy		Adult literacy rate		Combined gross enrolment ratio		GDP per capita		HDI (old method)		HDI (new method)		Difference between the new and old HDI (old minus new)		MAXOR		Extended MAXOR		MINOR		Extended MINOR		Difference between the MAXOR and MINOR	
	raw value (years)	rank	raw value (%)	rank	raw value (%)	rank	raw value (PPP$)	rank	value	rank	value	rank	value	rank	n-th group (a)	rank	n-th group (b)	rank	n-th group (c)	rank	n-th group (d)	rank	original [(c)-(a)]	extended [(d)-(b)]
Botswana	48.9	164	82.1	124	70	107	12744	57	0.663	126	0.631	127	0.032	-1	10	102	15	69	14	126	29	131	4	14
Morocco	70.7	99	54.7	160	59	138	3915	114	0.645	127	0.640	126	0.005	1	12	126	25	123	14	126	28	128	2	3
Sao Tome and Principe	65.2	121	87.5	108	66	120	1534	147	0.643	128	0.624	128	0.019	0	12	126	26	131	13	120	27	125	1	1
Namibia	51.9	156	87.6	106	67	117	4819	102	0.634	129	0.615	129	0.019	0	11	121	23	114	14	126	31	140	3	8
Congo	54.5	151	86.0	112	58	141	3550	119	0.618	130	0.605	132	0.013	-2	11	121	26	131	14	126	27	125	3	1
Bhutan	65.2	121	54.3	162	57	143	4010	111	0.613	131	0.611	130	0.002	1	13	134	25	123	14	126	28	128	1	3
India	64.1	127	65.2	148	61	131	2489	126	0.609	132	0.606	131	0.003	1	13	134	26	131	13	120	26	122	0	0
Lao People's Democratic Republic	63.7	128	72.5	136	59	138	1980	135	0.608	133	0.601	133	0.007	0	13	134	27	135	14	126	27	125	1	0
Solomon	63.2	131	76.6	129	49	158	1586	146	0.591	134	0.579	134	0.012	0	13	134	29	145	15	140	29	131	2	0
Myanmar	61.2	136	89.9	94	56	145	881	164	0.584	135	0.552	140	0.032	-5	12	126	27	135	14	126	31	140	2	4
Cambodia	58.6	142	75.6	130	58	141	1619	143	0.574	136	0.565	136	0.009	0	13	134	28	139	14	126	28	128	1	0
Comoros	64.5	126	74.2	133	46	160	1152	155	0.571	137	0.554	138	0.017	-1	13	134	30	151	15	140	30	134	2	0
Yemen	62.0	135	57.3	156	54	147	2262	131	0.566	138	0.565	135	0.001	3	14	147	27	135	14	126	29	131	0	2
Pakistan	64.9	125	54.2	163	39	168	2361	130	0.561	139	0.554	137	0.007	2	14	147	28	139	15	140	32	143	1	4
Mauritania	63.6	129	55.2	158	50	156	1890	138	0.556	140	0.552	139	0.004	1	14	147	28	139	15	140	30	134	1	2
Swaziland	40.2	179	79.6	126	60	135	4705	103	0.542	141	0.490	152	0.052	-11	12	126	25	123	17	164	32	143	5	7
Madagascar	58.8	141	70.7	142	60	135	878	165	0.532	142	0.515	146	0.017	-4	13	134	30	151	14	126	30	134	1	0
Ghana	59.4	139	64.2	150	52	150	1247	153	0.532	143	0.525	141	0.007	2	14	147	29	145	15	140	32	143	1	3
Kenya	52.7	154	73.6	134	59	138	1436	150	0.531	144	0.520	143	0.011	1	13	134	29	145	14	126	32	143	1	3
Nepal	63.0	132	55.2	158	60	135	999	162	0.528	145	0.517	144	0.011	1	14	147	29	145	14	126	30	134	0	1
Bangladesh	63.5	130	52.5	165	52	150	1155	154	0.524	146	0.516	145	0.008	1	14	147	29	145	15	140	33	150	1	4
Sudan	57.8	144	60.9	153	39	168	1887	139	0.524	147	0.520	142	0.004	5	14	147	32	164	15	140	32	143	1	0
Haiti	60.0	138	61.0	152	51	155	1109	159	0.521	148	0.513	147	0.008	1	14	147	31	159	16	154	31	140	2	0
Papua New Guinea	57.0	146	57.3	156	40	167	1950	137	0.515	149	0.512	148	0.003	1	15	159	29	145	15	140	33	150	0	4
Cameroon	50.0	163	67.9	145	50	156	2043	134	0.513	150	0.505	149	0.008	1	13	134	28	139	15	140	32	143	2	4
Djibouti	54.2	152	70.3	143	25	178	1965	136	0.512	151	0.494	151	0.018	0	14	147	28	139	17	164	35	165	3	7
Tanzania	51.6	158	72.0	138	54	147	1126	157	0.502	152	0.489	153	0.013	-1	14	147	30	151	15	140	33	150	1	3
Senegal	62.6	134	42.0	171	41	166	1592	145	0.502	153	0.494	150	0.008	3	15	159	30	151	16	154	34	156	1	4
Nigeria	46.6	168	71.0	140	52	150	1852	140	0.498	154	0.482	154	0.016	0	14	147	28	139	15	140	32	143	1	4
Lesotho	42.3	175	82.2	123	61	131	1440	149	0.495	155	0.457	159	0.038	-4	13	134	27	135	16	154	33	150	3	6
Uganda	50.5	160	72.6	135	62	127	888	163	0.493	156	0.474	155	0.019	1	13	134	30	151	15	140	33	150	2	3
Angola	42.1	176	67.4	146	25	178	4434	107	0.484	157	0.444	161	0.040	-4	12	126	26	131	17	164	36	172	5	10
Timor-Leste	60.2	137	50.1	166	63	125	668	172	0.483	158	0.465	158	0.018	0	13	134	30	151	16	154	34	156	3	4

Table B.2: Ranking results in 2006 (n=179, unbalanced) (continued)

	Life expectancy		Adult literacy rate		Combined gross enrolment ratio		GDP per capita		HDI (old method)		HDI (new method)		Difference between the new and old HDI (old minus new)		MAXOR		Extended MAXOR		MINOR		Extended MINOR		Difference between the MAXOR and MINOR	
	raw value (years)	rank	raw value (%)	rank	raw value (%)	rank	raw value (PPP$)	rank	value	rank	value	rank	value	rank	n-th group (a)	rank	n-th group (b)	rank	n-th group (c)	rank	n-th group (d)	rank	original [(c)-(a)]	extended [(d)-(b)]
Togo	58.0	143	53.2	164	56	145	792	167	0.479	159	0.468	156	0.011	3	15	159	31	159	15	140	34	156	0	3
Gambia	59.0	140	42.5	170	46	160	1152	155	0.470	160	0.465	157	0.005	3	15	159	34	169	16	154	34	156	1	0
Benin	55.8	149	39.7	172	52	150	1259	152	0.458	161	0.455	160	0.003	1	15	159	33	166	15	140	33	150	0	0
Malawi	47.0	167	70.9	141	61	131	703	169	0.456	162	0.432	162	0.024	0	14	147	31	159	16	154	34	156	2	3
Zambia	41.2	178	68.0	144	63	125	1273	151	0.453	163	0.424	164	0.029	−1	13	134	30	151	17	164	34	156	4	4
Eritrea	57.2	145	60.5	154	33	173	519	175	0.442	164	0.418	166	0.024	−2	15	159	32	164	17	164	34	156	2	2
Rwanda	45.8	171	64.9	149	52	150	819	166	0.435	165	0.419	165	0.016	0	15	159	31	159	16	154	34	156	1	3
Cote d'Ivoire	47.7	166	48.7	167	37	170	1632	142	0.431	166	0.428	163	0.003	3	16	170	30	151	16	154	34	156	0	4
Guinea	55.3	150	29.5	176	49	158	1118	158	0.423	167	0.414	167	0.009	0	16	170	34	169	16	154	35	165	0	1
Mali	53.7	153	22.9	179	44	164	1058	161	0.390	168	0.377	170	0.013	−2	17	176	35	174	17	164	36	172	0	1
Ethiopia	52.2	155	35.9	174	45	162	700	170	0.389	169	0.385	168	0.004	1	16	170	35	174	17	164	35	165	1	0
Chad	50.4	161	25.7	178	36	171	1470	148	0.388	170	0.379	169	0.009	1	16	170	31	159	17	164	35	165	1	4
Guinea-Bissau	46.0	170	62.8	151	36	171	467	176	0.382	171	0.361	172	0.021	−1	15	159	33	166	17	164	35	165	2	2
Burundi	48.9	164	59.3	155	45	162	333	178	0.381	172	0.351	175	0.030	−3	15	159	34	169	17	164	36	172	2	2
Burkina Faso	51.7	157	26.0	177	30	175	1084	160	0.372	173	0.364	171	0.008	2	17	176	35	174	17	164	36	172	0	1
Niger	56.2	148	29.8	175	26	177	612	174	0.369	174	0.355	174	0.014	0	16	170	36	178	17	164	36	172	1	0
Mozambique	42.4	174	43.8	169	54	147	739	168	0.365	175	0.357	173	0.008	2	16	170	34	169	16	154	35	165	0	1
Liberia	45.1	172	54.4	161	57	143	335	177	0.363	176	0.334	177	0.029	−1	15	159	33	166	17	164	35	165	2	2
Congo (Democratic Republic of	46.1	169	67.2	147	33	173	281	179	0.361	177	0.318	179	0.043	−2	15	159	34	169	17	164	36	172	2	2
Central African Republic	44.0	173	48.6	168	28	176	679	171	0.351	178	0.345	176	0.006	2	17	176	35	174	17	164	36	172	0	1
Sierra Leone	42.1	176	37.1	173	44	164	630	173	0.329	179	0.325	178	0.004	1	17	176	36	178	17	164	36	172	0	0

Notes:
1. This table was made by the author based on the data of the Human Development Report 2008.
2. Countries were arranged in accordance to the rank order of the old HDI.
3. The HDI rank is determined using HDI values to the sixth decimal point.
4. 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. (Several developed countries have no data for adult literacy rate and a value of 99.0% was applied to each of these countries.)
5. 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.

6. Extended MAXOR and MINOR employed the bandwidth of 0.174.

Table B.3: The MAXOR and MINOR from 1994 to 2006

(balanced panel dataset (n=166), number of rank groups=16)

	MAXOR						MINOR					
	1994	1998	2000	2004	2006	S.D.	1994	1998	2000	2004	2006	S.D.
Albania	9	9	8	8	6	1.22	9	9	9	10	9	0.45
Algeria	9	9	8	10	9	0.71	10	10	9	10	10	0.45
Angola	8	12	12	14	11	2.19	14	15	15	16	16	0.84
Antigua and Barbuda	6	6	6	8	7	0.89	6	6	7	9	8	1.30
Argentina	5	6	6	7	5	0.89	5	6	6	7	6	0.71
Armenia	6	7	6	8	7	0.84	10	9	9	10	9	0.55
Australia	3	2	1	1	1	0.89	4	2	1	1	2	1.22
Austria	3	3	2	2	2	0.55	3	4	4	3	3	0.55
Azerbaijan	7	7	7	9	9	1.10	10	8	8	11	11	1.52
Bahamas	5	6	6	7	6	0.71	5	6	8	10	8	1.95
Bahrain	5	6	6	6	5	0.55	7	6	7	7	7	0.45
Bangladesh	13	13	13	13	13	0.00	13	13	13	14	14	0.55
Barbados	5	5	5	6	5	0.45	5	5	6	6	5	0.55
Belarus	6	6	6	7	7	0.55	7	7	7	9	8	0.89
Belgium	3	2	1	2	3	0.84	3	2	1	2	4	1.14
Belize	7	8	7	9	6	1.14	8	8	7	9	10	1.14
Benin	13	13	12	15	14	1.14	14	13	14	15	14	0.71
Bhutan	14	12	12	13	12	0.89	14	13	13	14	13	0.55
Bolivia	9	9	9	8	9	0.45	10	10	11	12	11	0.84
Botswana	8	8	8	10	9	0.89	10	13	15	15	14	2.07
Brazil	7	6	7	8	7	0.71	9	9	8	8	8	0.55
Brunei Darussalam	1	6	5	6	5	2.07	7	7	6	7	6	0.55
Bulgaria	7	6	7	8	6	0.84	7	7	8	8	7	0.55
Burkina Faso	15	15	15	15	16	0.45	16	16	15	16	16	0.45
Burundi	15	15	13	15	14	0.89	15	16	16	16	16	0.45
Cambodia	11	11	10	13	12	1.14	14	12	12	13	13	0.84
Cameroon	12	12	11	13	12	0.71	12	12	12	14	14	1.10
Canada	1	1	1	2	1	0.45	1	1	2	2	2	0.55
Cape Verde	9	8	7	10	11	1.58	11	9	9	10	11	1.00
Central African	13	14	13	16	16	1.52	13	14	15	16	16	1.30
Chad	14	14	13	15	15	0.84	15	14	14	16	16	1.00
Chile	6	6	5	5	4	0.84	6	6	6	7	5	0.71
China	10	9	8	9	8	0.84	10	9	9	9	9	0.45
Colombia	7	7	7	8	8	0.55	7	7	8	8	8	0.55
Comoros	13	12	12	13	12	0.55	13	12	13	13	14	0.71
Congo	11	12	10	12	10	1.00	11	13	14	15	13	1.48
Costa Rica	5	6	6	6	5	0.55	6	7	7	8	8	0.84
Cote d'ivoire	13	12	12	15	15	1.52	13	13	13	15	15	1.10
Cuba	6	6	6	5	4	0.89	8	8	7	8	7	0.55
Cyprus	5	4	4	5	4	0.55	6	4	6	6	7	1.10
Czech Republic	5	5	5	6	5	0.45	6	6	6	6	5	0.45
Denmark	3	2	2	2	1	0.71	4	4	4	4	4	0.00
Djibouti	14	13	11	14	13	1.22	15	15	15	15	16	0.45
Dominica	6	7	7	7	7	0.45	6	7	7	9	8	1.14
Dominican Republic	8	8	8	10	9	0.89	9	8	9	11	9	1.10
Ecuador	7	7	8	8	7	0.55	7	9	8	10	7	1.30
Egypt	8	9	8	10	9	0.84	12	11	11	11	11	0.45
El Salvador	10	9	9	10	10	0.55	10	9	9	10	10	0.55
Equatorial Guinea	10	11	7	6	7	2.17	12	12	11	15	13	1.52
Estonia	6	5	5	5	5	0.45	7	6	6	7	7	0.55

Table B.3: Ranking results from 1994 to 2004

Table B.3: The MAXOR and MINOR from 1994 to 2006 (continued)

(balanced panel dataset (n=166), number of rank groups=16)

	MAXOR						MINOR					
	1994	1998	2000	2004	2006	S.D.	1994	1998	2000	2004	2006	S.D.
Ethiopia	15	15	14	15	15	0.45	16	15	15	16	16	0.55
Fiji	5	6	7	9	8	1.58	6	8	8	10	11	1.95
Finland	2	3	3	2	2	0.55	3	4	3	3	3	0.45
France	2	3	2	3	2	0.55	2	3	3	3	3	0.45
Gabon	10	8	7	11	8	1.64	10	12	12	13	12	1.10
Gambia	14	13	12	14	14	0.89	14	15	15	14	15	0.55
Georgia	7	6	6	8	7	0.84	10	7	9	12	9	1.82
Germany	4	4	3	4	3	0.55	4	4	4	4	4	0.00
Ghana	12	11	11	13	13	1.00	12	11	12	13	14	1.14
Greece	4	4	4	4	3	0.45	4	5	5	4	4	0.55
Grenada	5	6	7	9	8	1.58	6	7	10	11	11	2.35
Guatemala	10	10	10	11	11	0.55	12	11	11	11	11	0.45
Guinea	15	12	12	14	15	1.52	16	15	14	15	15	0.71
Guinea-Bissau	14	14	14	16	14	0.89	15	14	15	16	16	0.84
Guyana	8	8	7	9	9	0.84	9	10	11	11	10	0.84
Haiti	14	14	12	14	13	0.89	15	15	13	14	15	0.89
Honduras	9	10	10	11	10	0.71	10	10	10	12	10	0.89
Hong Kong, China (SAR)	1	2	2	1	1	0.55	5	8	7	6	7	1.14
Hungary	6	5	5	6	5	0.55	7	6	6	6	6	0.45
Iceland	1	1	1	1	1	0.00	2	2	2	1	2	0.45
India	12	11	11	12	12	0.55	12	12	11	12	12	0.45
Indonesia	9	10	9	10	9	0.55	9	10	9	11	11	1.00
Iran (Islamic Republic	8	8	8	9	9	0.55	9	9	9	9	10	0.45
Ireland	4	4	2	1	2	1.34	4	4	4	4	2	0.89
Israel	4	5	3	3	3	0.89	5	5	4	5	4	0.55
Italy	3	3	3	3	3	0.00	5	3	4	4	4	0.71
Jamaica	7	8	7	10	8	1.22	8	9	9	10	9	0.71
Japan	1	1	1	1	1	0.00	4	2	4	5	4	1.10
Jordan	8	9	9	9	8	0.55	8	9	10	9	9	0.71
Kazakhstan	7	7	7	6	6	0.55	8	8	10	11	9	1.30
Kenya	11	12	11	14	12	1.22	11	12	13	15	13	1.48
Korea (Republic of)	5	5	5	4	3	0.89	6	6	5	5	4	0.84
Kuwait	2	2	5	6	5	1.87	9	9	9	7	7	1.10
Kyrgyzstan	7	8	8	8	10	1.10	10	9	9	13	11	1.67
Lao People's Democratic Republic	11	11	11	13	12	0.89	11	12	13	13	13	0.89
Latvia	7	7	6	6	6	0.55	8	8	7	7	6	0.84
Lebanon	7	7	7	8	8	0.55	7	8	8	9	9	0.84
Lesotho	11	11	10	12	12	0.84	12	11	13	16	15	2.07
Libyan Arab Jamahiriya	4	6	6	5	4	1.00	9	8	7	8	8	0.71
Lithuania	6	6	6	5	5	0.55	8	6	7	6	5	1.14
Luxembourg	1	1	1	1	3	0.89	8	6	5	5	3	1.82
Madagascar	13	12	11	14	12	1.14	15	13	13	15	13	1.10
Malawi	10	10	9	13	13	1.87	15	15	15	16	15	0.45
Malaysia	7	7	7	8	7	0.45	9	8	8	8	8	0.45
Maldives	9	8	7	9	9	0.89	10	9	8	11	11	1.30
Mali	15	14	13	16	16	1.30	16	14	14	16	16	1.10
Malta	5	6	4	6	4	1.00	7	6	5	7	7	0.89
Mauritania	14	12	13	14	13	0.84	14	13	14	14	14	0.45
Mauritius	6	7	7	8	8	0.84	9	9	8	8	9	0.55
Mexico	7	7	7	7	6	0.45	7	7	8	8	7	0.55

Table B.3: The MAXOR and MINOR from 1994 to 2006 (continued)

(balanced panel dataset (n=166), number of rank groups=16)

	MAXOR						MINOR					
	1994	1998	2000	2004	2006	S.D.	1994	1998	2000	2004	2006	S.D.
Moldova (Republic of)	8	8	8	9	8	0.45	10	9	10	13	10	1.52
Mongolia	9	10	9	9	9	0.45	10	11	11	12	11	0.71
Morocco	10	10	10	11	11	0.55	12	11	11	13	13	1.00
Mozambique	15	15	14	15	15	0.45	16	15	16	16	15	0.55
Myanmar	10	11	10	11	11	0.55	13	11	12	15	13	1.48
Namibia	6	7	8	11	10	2.07	12	12	12	13	13	0.55
Nepal	13	11	11	13	13	1.10	15	12	13	14	13	1.14
Netherlands	3	3	2	2	2	0.55	3	3	2	2	3	0.55
New Zealand	2	4	4	2	2	1.10	3	4	4	3	3	0.55
Nicaragua	9	10	10	11	9	0.84	11	11	10	11	12	0.71
Niger	15	15	16	16	15	0.55	16	16	16	16	16	0.00
Nigeria	12	13	11	14	13	1.14	12	13	13	15	15	1.34
Norway	2	1	1	1	1	0.45	2	2	3	1	1	0.84
Oman	7	7	7	7	7	0.00	13	10	10	9	9	1.64
Pakistan	12	11	12	13	13	0.84	13	12	12	14	14	1.00
Panama	7	7	7	7	6	0.45	7	7	7	8	6	0.71
Papua New Guinea	10	11	11	13	14	1.64	12	12	12	14	14	1.10
Paraguay	8	8	8	9	8	0.45	9	8	9	10	10	0.84
Peru	6	8	7	9	7	1.14	9	9	8	10	9	0.71
Philippines	7	6	7	8	8	0.84	9	9	8	9	10	0.71
Poland	5	5	5	7	5	0.89	6	5	6	7	5	0.84
Portugal	5	5	5	5	5	0.00	6	5	6	5	5	0.55
Qatar	5	5	5	6	6	0.55	8	8	8	7	8	0.45
Romania	7	7	7	8	7	0.45	8	7	8	8	7	0.55
Russian Federation	6	6	6	7	7	0.55	8	8	9	10	11	1.30
Saint Kitts and Nevis	6	7	6	8	7	0.84	7	7	8	9	9	1.00
Saint Lucia	7	8	8	8	7	0.55	8	8	8	8	7	0.45
Saint Vincent and the Grenadines	6	8	9	9	9	1.30	8	8	10	9	10	1.00
Samoa	6	9	9	8	7	1.30	8	9	9	10	9	0.71
Sao Tome and Principe	11	11	10	11	11	0.45	11	12	11	14	12	1.22
Saudi Arabia	7	7	7	8	7	0.45	10	10	9	12	9	1.22
Senegal	14	14	14	14	14	0.00	15	15	14	15	15	0.45
Seychelles	7	7	6	7	7	0.45	8	7	7	7	8	0.55
Sierra Leone	16	16	15	13	16	1.30	16	16	16	16	16	0.00
Singapore	3	2	4	5	2	1.30	6	6	6	6	10	1.79
Slovakia	5	5	5	7	6	0.89	6	6	6	7	6	0.45
Solomon Islands	9	10	10	12	12	1.34	12	11	12	14	14	1.34
South Africa	6	5	6	9	9	1.87	9	11	11	13	13	1.67
Spain	2	3	2	3	2	0.55	4	4	4	3	3	0.55
Sri Lanka	8	9	8	8	9	0.55	8	9	8	10	10	1.00
Sudan	14	13	12	14	13	0.84	14	13	13	15	14	0.84
Suriname	7	6	7	10	9	1.64	7	7	7	10	9	1.41
Swaziland	8	9	9	12	11	1.64	10	10	13	16	16	3.00
Sweden	3	2	1	2	2	0.71	3	2	2	2	3	0.55
Switzerland	1	1	2	2	1	0.55	4	4	3	5	4	0.71
Syrian Arab Republic	8	10	9	9	8	0.84	9	10	9	11	10	0.84
Tajikistan	9	8	8	10	9	0.84	11	11	11	14	11	1.34
Tanzania (United Republic of)	12	13	11	15	13	1.48	15	15	15	16	14	0.71
Thailand	7	8	7	9	8	0.84	9	10	9	9	8	0.71
Togo	13	12	11	14	14	1.30	13	13	13	14	14	0.55

Table B.3: The MAXOR and MINOR from 1994 to 2006 (continued)

(balanced panel dataset (n=166), number of rank groups=16)

	MAXOR						MINOR					
	1994	1998	2000	2004	2006	S.D.	1994	1998	2000	2004	2006	S.D.
Trinidad and Tobago	6	7	7	8	6	0.84	6	7	7	10	11	2.17
Tunisia	8	8	7	8	8	0.45	9	9	8	9	10	0.71
Turkey	8	8	8	10	8	0.89	9	9	9	10	9	0.45
Turkmenistan	4	8	7	9	9	2.07	9	9	8	12	12	1.87
Uganda	13	13	11	12	12	0.84	15	15	14	15	14	0.55
Ukraine	6	6	7	8	8	1.00	8	8	8	10	9	0.89
United Arab Emirates	5	5	5	6	4	0.71	7	8	8	12	9	1.92
United Kingdom	4	3	3	3	3	0.45	4	3	3	3	4	0.55
United States	1	1	1	1	4	1.34	3	3	3	4	4	0.55
Uruguay	6	5	6	6	5	0.55	6	6	6	7	5	0.71
Uzbekistan	8	9	7	9	9	0.89	9	10	9	13	11	1.67
Vanuatu	11	10	10	12	11	0.84	11	11	14	12	11	1.30
Venezuela (Bolivarian Republic of)	8	7	8	8	7	0.55	13	8	8	8	7	2.39
Viet Nam	9	9	8	10	8	0.84	12	10	10	12	12	1.10
Yemen	13	12	12	13	13	0.55	14	13	13	15	13	0.89
Zambia	12	13	12	15	12	1.30	15	15	15	16	16	0.55

Table B.4: The New and Old HDI in 2010 (n=169)

Country	Life expectancy at birth (years)	Mean years of schooling (years)	Expected years of schooling (years)	Gross national income (GNI) per capita (PPP$)	HDI (new method)		HDI (old method)		Gap between the new and old HDI (old minus new)	
					value	rank	value	rank	value	rank
Norway	81.0	12.6	17.3	58810	0.923	1	0.923	2	0.000	1
Australia	81.9	12.0	20.5	38692	0.922	2	0.924	1	0.002	−1
New Zealand	80.6	12.5	19.7	25438	0.892	3	0.896	3	0.004	0
United States	79.6	12.4	15.7	47094	0.889	4	0.889	4	0.001	0
Ireland	80.3	11.6	17.9	33078	0.880	5	0.882	6	0.002	1
Liechtenstein	79.6	10.3	14.8	81011	0.877	6	0.882	5	0.005	−1
Netherlands	80.3	11.2	16.7	40658	0.876	7	0.877	7	0.002	0
Canada	81.0	11.5	16.0	38668	0.874	8	0.877	8	0.002	0
Germany	80.2	12.2	15.6	35308	0.872	9	0.874	11	0.002	2
Sweden	81.3	11.6	15.6	36936	0.871	10	0.874	10	0.003	0
Japan	83.2	11.5	15.1	34692	0.871	11	0.875	9	0.004	−2
Korea (Republic of)	79.8	11.6	16.8	29518	0.863	12	0.865	12	0.002	0
Switzerland	82.2	10.3	15.5	39849	0.860	13	0.865	13	0.005	0
Israel	81.2	11.9	15.6	27831	0.859	14	0.863	14	0.003	0
France	81.6	10.4	16.1	34341	0.858	15	0.862	15	0.004	0
Finland	80.1	10.3	17.1	33872	0.857	16	0.859	17	0.002	1
Iceland	82.1	10.4	18.2	22917	0.855	17	0.860	16	0.005	−1
Belgium	80.3	10.6	15.9	34873	0.853	18	0.856	19	0.003	1
Denmark	78.7	10.3	16.9	36404	0.852	19	0.854	20	0.002	1
Spain	81.3	10.4	16.4	29661	0.849	20	0.853	21	0.004	1
Hong Kong, China (SAR)	82.5	10.0	13.8	45090	0.849	21	0.856	18	0.008	−3
Greece	79.7	10.5	16.5	27580	0.841	22	0.844	24	0.003	2
Italy	81.4	9.7	16.3	29619	0.841	23	0.845	23	0.005	0
Luxembourg	79.9	10.1	13.3	51109	0.839	24	0.846	22	0.007	−2
Austria	80.4	9.8	15.0	37056	0.837	25	0.842	25	0.005	0
United Kingdom	79.8	9.5	15.9	35087	0.835	26	0.839	27	0.004	1
Singapore	80.7	8.8	14.4	48893	0.832	27	0.841	26	0.008	−1
Czech Republic	76.9	12.3	15.2	22678	0.830	28	0.832	28	0.002	0
Slovenia	78.8	9.0	16.7	25857	0.816	29	0.819	30	0.004	1
Andorra	80.8	10.4	11.5	38056	0.815	30	0.824	29	0.009	−1
Slovakia	75.1	11.6	14.9	21658	0.806	31	0.808	32	0.001	1
United Arab Emirates	77.7	9.2	11.5	58006	0.804	32	0.815	31	0.012	−1
Malta	80.0	9.9	14.4	21004	0.801	33	0.808	34	0.006	1
Estonia	73.7	12.0	15.8	17168	0.800	34	0.802	37	0.002	3
Cyprus	80.0	9.9	13.8	21962	0.798	35	0.804	35	0.006	0
Hungary	73.9	11.7	15.3	17472	0.793	36	0.795	38	0.002	2
Brunei Darussalam	77.4	7.5	14.0	49915	0.793	37	0.804	36	0.011	−1
Qatar	76.0	7.3	12.7	79426	0.790	38	0.808	33	0.017	−5
Bahrain	76.0	9.4	14.3	26664	0.788	39	0.791	39	0.004	0
Portugal	79.1	8.0	15.5	22105	0.783	40	0.790	40	0.007	0
Poland	76.0	10.0	15.2	17803	0.782	41	0.785	41	0.003	0
Bahamas	74.4	11.1	11.6	25201	0.776	42	0.779	44	0.003	2
Barbados	77.7	9.3	13.4	21673	0.776	43	0.781	43	0.006	0
Lithuania	72.1	10.9	16.0	14824	0.771	44	0.773	46	0.002	2
Chile	78.8	9.7	14.5	13561	0.770	45	0.777	45	0.007	0
Argentina	75.7	9.3	15.5	14603	0.763	46	0.767	47	0.004	1
Kuwait	77.9	6.1	12.5	55719	0.761	47	0.783	42	0.022	−5
Montenegro	74.6	10.6	14.4	12491	0.757	48	0.761	48	0.004	0
Latvia	73.0	10.4	15.4	12944	0.757	49	0.760	51	0.003	2
Romania	73.2	10.6	14.8	12844	0.755	50	0.758	52	0.003	2
Croatia	76.7	9.0	13.8	16389	0.755	51	0.761	49	0.006	−2
Uruguay	76.7	8.4	15.7	13808	0.754	52	0.760	50	0.006	−2

Table B.4: The New and Old HDI in 2010

Table B.4: The New and Old HDI in 2010 (n=169) (continued)

Country	Life expectancy at birth (years)	Mean years of schooling (years)	Expected years of schooling (years)	Gross national income (GNI) per capita (PPP$)	HDI (new method)		HDI (old method)		Gap between the new and old HDI (old minus new)	
					value	rank	value	rank	value	rank
Libyan Arab Jamahiriya	74.5	7.3	16.5	17068	0.747	53	0.751	53	0.004	0
Panama	76.0	9.4	13.5	13347	0.743	54	0.749	54	0.006	0
Saudi Arabia	73.3	7.8	13.5	24726	0.740	55	0.746	55	0.006	0
Mexico	76.7	8.7	13.4	13971	0.738	56	0.746	56	0.007	0
Malaysia	74.7	9.5	12.5	13927	0.733	57	0.738	57	0.005	0
Bulgaria	73.7	9.9	13.7	11139	0.732	58	0.736	58	0.005	0
Trinidad and Tobago	69.9	9.2	11.4	24233	0.725	59	0.729	60	0.004	1
Serbia	74.4	9.5	13.5	10449	0.724	60	0.729	59	0.006	−1
Belarus	69.6	9.3	14.6	12926	0.720	61	0.722	63	0.002	2
Costa Rica	79.1	8.3	11.7	10870	0.713	62	0.727	61	0.014	−1
Peru	73.7	9.6	13.8	8424	0.711	63	0.718	64	0.007	1
Albania	76.9	10.4	11.3	7976	0.711	64	0.722	62	0.011	−2
Russian Federation	67.2	8.8	14.1	15258	0.707	65	0.708	66	0.001	1
Azerbaijan	70.8	10.2	13.0	8747	0.702	66	0.707	67	0.004	1
Kazakhstan	65.4	10.3	15.1	10234	0.702	67	0.704	69	0.002	2
Ukraine	68.6	11.3	14.6	6535	0.699	68	0.707	68	0.007	0
Bosnia and Herzegovina	75.5	8.7	13.0	8222	0.699	69	0.709	65	0.010	−4
Iran (Islamic Republic of)	71.9	7.2	14.0	11764	0.692	70	0.698	75	0.005	5
Georgia	72.0	12.1	12.6	4902	0.691	71	0.704	70	0.013	−1
Mauritius	72.1	7.2	13.0	13344	0.690	72	0.697	76	0.007	4
The former Yugoslav Republic of Macedonia	74.5	8.2	12.3	9487	0.690	73	0.699	72	0.009	−1
Venezuela (Bolivarian Republic	74.2	6.2	14.2	11846	0.689	74	0.699	73	0.009	−1
Brazil	72.9	7.2	13.8	10607	0.688	75	0.695	77	0.007	2
Armenia	74.2	10.8	11.9	5495	0.687	76	0.699	71	0.012	−5
Ecuador	75.4	7.6	13.3	7931	0.684	77	0.695	78	0.011	1
Belize	76.9	9.2	12.4	5693	0.684	78	0.699	74	0.015	−4
Jamaica	72.3	9.6	11.7	7207	0.679	79	0.686	80	0.008	1
Colombia	73.4	7.4	13.3	8589	0.678	80	0.687	79	0.009	−1
Tunisia	74.3	6.5	14.5	7979	0.675	81	0.685	81	0.010	0
Jordan	73.1	8.6	13.1	5956	0.670	82	0.680	83	0.010	1
Turkey	72.2	6.5	11.8	13359	0.668	83	0.679	84	0.011	1
Algeria	72.9	7.2	12.8	8320	0.666	84	0.676	85	0.009	1
Tonga	72.1	10.4	13.7	4038	0.666	85	0.682	82	0.015	−3
Fiji	69.2	11.0	13.0	4315	0.661	86	0.672	86	0.012	0
Turkmenistan	65.3	9.9	13.0	7052	0.659	87	0.662	90	0.003	3
Dominican Republic	72.8	6.9	11.9	8273	0.653	88	0.664	88	0.011	0
China	73.5	7.5	11.4	7258	0.653	89	0.664	87	0.012	−2
El Salvador	72.0	7.7	12.1	6498	0.649	90	0.658	91	0.010	1
Sri Lanka	74.4	8.2	12.0	4886	0.648	91	0.662	89	0.015	−2
Thailand	69.3	6.6	13.5	8001	0.645	92	0.652	92	0.006	0
Gabon	61.3	7.5	12.7	12747	0.638	93	0.639	97	0.001	4
Suriname	69.4	7.2	12.0	7093	0.636	94	0.643	94	0.007	0
Bolivia	66.3	9.2	13.7	4357	0.632	95	0.640	96	0.008	1
Paraguay	72.3	7.8	12.0	4585	0.629	96	0.643	95	0.013	−1
Philippines	72.3	8.7	11.5	4002	0.628	97	0.643	93	0.015	−4
Botswana	55.5	8.9	12.4	13204	0.623	98	0.625	99	0.002	1
Moldova (Republic of)	68.9	9.7	12.0	3149	0.614	99	0.629	98	0.015	−1

Table B.4: The New and Old HDI in 2010 (n=169) (continued)

Country	Life expectancy at birth (years)	Mean years of schooling (years)	Expected years of schooling (years)	Gross national income (GNI) per capita (PPP$)	HDI (new method)		HDI (old method)		Gap between the new and old HDI (old minus new)	
					value	rank	value	rank	value	rank
Mongolia	67.3	8.3	13.5	3619	0.612	100	0.622	101	0.010	1
Egypt	70.5	6.5	11.0	5889	0.610	101	0.622	102	0.012	1
Uzbekistan	68.2	10.0	11.5	3085	0.610	102	0.624	100	0.014	−2
Micronesia (Federated States of)	69.0	8.8	11.7	3266	0.605	103	0.619	103	0.014	0
Guyana	67.9	8.5	12.2	3302	0.601	104	0.613	105	0.012	1
Maldives	72.3	4.7	12.4	5408	0.599	105	0.616	104	0.017	−1
Namibia	62.1	7.4	11.8	6323	0.596	106	0.598	110	0.002	4
Honduras	72.6	6.5	11.4	3750	0.595	107	0.613	106	0.018	−1
Indonesia	71.5	5.7	12.7	3957	0.593	108	0.609	108	0.016	0
Kyrgyzstan	68.4	9.3	12.6	2291	0.589	109	0.610	107	0.021	−2
South Africa	52.0	8.2	13.4	9812	0.588	110	0.591	113	0.003	3
Syrian Arab Republic	74.6	4.9	10.5	4760	0.582	111	0.607	109	0.026	−2
Tajikistan	67.3	9.8	11.4	2020	0.572	112	0.594	111	0.022	−1
Viet Nam	74.9	5.5	10.4	2995	0.563	113	0.592	112	0.029	−1
Morocco	71.8	4.4	10.5	4628	0.562	114	0.585	114	0.023	0
Nicaragua	73.8	5.7	10.8	2567	0.557	115	0.584	115	0.028	0
Guatemala	70.8	4.1	10.6	4694	0.557	116	0.578	116	0.022	0
Cape Verde	71.9	3.5	11.2	3306	0.536	117	0.563	117	0.027	0
Equatorial Guinea	51.0	5.4	8.1	22218	0.529	118	0.549	118	0.020	0
India	64.4	4.4	10.3	3337	0.514	119	0.528	119	0.014	0
Timor-Leste	62.1	2.8	11.2	5303	0.512	120	0.526	120	0.014	0
Lao People's Democratic Republic	65.9	4.6	9.2	2321	0.490	121	0.510	122	0.020	1
Swaziland	47.0	7.1	10.3	5132	0.490	122	0.492	126	0.002	4
Solomon Islands	67.0	4.5	9.1	2172	0.487	123	0.511	121	0.024	−2
Cambodia	62.2	5.8	9.8	1868	0.486	124	0.500	125	0.014	1
Sao Tome and Principe	66.1	4.2	10.2	1918	0.483	125	0.506	124	0.022	−1
Pakistan	67.2	4.9	6.8	2678	0.483	126	0.509	123	0.026	−3
Congo	53.9	5.9	9.3	3258	0.481	127	0.482	128	0.002	1
Kenya	55.6	7.0	9.6	1628	0.463	128	0.471	130	0.009	2
Bangladesh	66.9	4.8	8.1	1587	0.462	129	0.490	127	0.029	−2
Ghana	57.1	7.1	9.7	1385	0.460	130	0.473	129	0.013	−1
Cameroon	51.7	5.9	9.8	2197	0.452	131	0.454	138	0.002	7
Myanmar	62.7	4.0	9.2	1596	0.446	132	0.467	133	0.021	1
Yemen	63.9	2.5	8.6	2387	0.444	133	0.470	131	0.027	−2
Comoros	66.2	2.8	10.7	1176	0.434	134	0.467	132	0.034	−2
Benin	62.3	3.5	9.2	1499	0.433	135	0.455	137	0.022	2
Madagascar	61.2	5.2	10.2	953	0.429	136	0.456	136	0.027	0
Mauritania	57.3	3.7	8.1	2118	0.428	137	0.441	140	0.012	3
Nepal	67.5	3.2	8.8	1201	0.427	138	0.465	134	0.038	−4
Papua New Guinea	61.6	4.3	5.2	2227	0.426	139	0.450	139	0.025	0
Togo	63.3	5.3	9.6	844	0.421	140	0.457	135	0.035	−5
Lesotho	45.9	5.8	10.3	2021	0.420	141	0.422	143	0.001	2
Uganda	54.1	4.7	10.4	1224	0.417	142	0.427	141	0.011	−1
Nigeria	48.4	5.0	8.9	2156	0.416	143	0.417	146	0.001	3
Senegal	56.2	3.5	7.5	1816	0.406	144	0.420	144	0.014	0
Angola	48.1	4.4	4.4	4941	0.400	145	0.414	147	0.015	2
Haiti	61.7	4.9	6.8	949	0.398	146	0.427	142	0.030	−4
Djibouti	56.1	3.8	4.7	2471	0.396	147	0.417	145	0.021	−2
Tanzania (United Republic of)	56.9	5.1	5.3	1344	0.394	148	0.411	149	0.016	1
Cote d'Ivoire	58.4	3.3	6.3	1625	0.391	149	0.413	148	0.022	−1

Table B.4: The New and Old HDI in 2010 (n=169) (continued)

Country	Life expectancy at birth (years)	Mean years of schooling (years)	Expected years of schooling (years)	Gross national income (GNI) per capita (PPP$)	HDI (new method)		HDI (old method)		Gap between the new and old HDI (old minus new)	
					value	rank	value	rank	value	rank
Gambia	56.6	2.8	8.6	1358	0.391	150	0.407	150	0.016	0
Zambia	47.3	6.5	7.2	1359	0.390	151	0.393	154	0.003	3
Rwanda	51.1	3.3	10.6	1190	0.387	152	0.394	153	0.007	1
Malawi	54.6	4.3	8.9	911	0.380	153	0.397	152	0.017	−1
Sudan	58.9	2.9	4.4	2051	0.373	154	0.407	151	0.034	−3
Guinea	58.9	1.6	8.6	953	0.356	155	0.385	155	0.030	0
Afghanistan	44.6	3.3	8.0	1419	0.346	156	0.347	158	0.001	2
Ethiopia	56.1	1.5	8.3	992	0.344	157	0.369	157	0.025	0
Mali	49.2	1.4	8.0	1171	0.325	158	0.337	160	0.012	2
Sierra Leone	48.2	2.9	7.2	809	0.315	159	0.326	161	0.011	2
Burkina Faso	53.7	1.3	5.8	1215	0.315	160	0.344	159	0.029	−1
Central African Republic	47.7	3.5	6.3	758	0.310	161	0.321	163	0.011	2
Mozambique	48.4	1.2	8.2	854	0.304	162	0.316	165	0.012	3
Chad	49.2	1.5	6.0	1067	0.300	163	0.318	164	0.018	1
Liberia	59.1	3.9	11.0	320	0.299	164	0.379	156	0.081	−8
Guinea-Bissau	48.6	2.3	9.1	538	0.294	165	0.314	166	0.020	1
Burundi	51.4	2.7	9.6	402	0.284	166	0.323	162	0.039	−4
Niger	52.5	1.4	4.3	675	0.261	167	0.297	168	0.036	1
Congo (Democratic Republic of the)	48.0	3.8	7.8	291	0.236	168	0.288	169	0.052	1
Zimbabwe	47.0	7.2	9.2	176	0.137	169	0.313	167	0.176	−2

Notes:
1. The new and old HDI value are calculated based on the data of the Human Development Report 2010.
2. The new and old HDI ranks are determined using HDI values to the sixth decimal point.

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