Efficiency of Pena's P2 Distance in Construction of Human Development Indices

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Abstract

The paper is an attempt to evaluate the efficiency of Pena's DP-2 method over a host of methods used to make composite indices. To undertake this exercise, variables and data used and methodology adopted in Human Development Report 2011 are employed along with nine other methodologies employed by other scholars. Although there is no agreed principle of judging an index to be best among alternative indices, it may be suggested that the composite index which is most informative among all other indices may be considered as the most acceptable one. The present study reveals that Pena-DP2 index and Penmax index have close similarity. Computationally, Pena's method of construction of index is much simpler, but the interpretation of Penmax index is more straightforward. On the other hand, Maxmin index is norm-based and has a justification on Wald's principle of decision-making. The Maxmin index also is the most egalitarian index against the Principal Component based index, which is known to be most elitist. On 'sum of absolute correlation' and 'sum of squared correlation', too, the Maxmin index is superior to other indices. It appears, therefore, that the Maxmin composite index which is obtained by maximization of minimum of correlation between the composite index and the constituent variables is a better than others. Further, if we go by the argument of Neumann and Morgenstern none of the composite indices is a cardinal measure in the strict sense of measurement.

I. Introduction

Many scholars and development agencies have made several attempts in the past to create a broader measure of development and human well-being by combining indicators that shed light on both means and ends of social progress. All these attempts have been made because of the pioneering work of United Nations (1954) in which specific recommendations were made against the use of GNP per capita as a measure of standard of living. Beginning in the mid 1960s through the 1970s a number of studies concentrated on the construction and use of socioeconomic indicators to measure development [Adelman and Morris, 1967; UNRISD, 1966 & 1972 and OECD, 1973 & 1976 as quoted by Stanton (2007:13); United Nations Economic and Social Council, 1975; Hicks and Streeten, 1979; Morris, 1979]. As a result of these attempts basic needs approach became the core of the debate on development policies (Hicks and Streeten, 1979; Streeten et al., 1981). However, no theoretical proposition emerged to define the concept of development or social welfare in spite of all these exercises.

UNDP in 1990 came forward to publish its first Human Development Report (HDR) in which construction of Human Development Index (HDI) was proposed. Since then many criticisms have been raised against its construction and robustness. As a result some improvements have been made in its construction by UNDP in its subsequent reports in 1991, 1994, 1999 and 2010 as well as by others (Cahill and Sanchez 1998; Noorbakhsh, 1998; Prescott-Allen Robert, 2001; Chakravarty, 2003; Cummins et al., 2003; Social Watch, 2005; Economists Intelligence Unit, 2004; Department of Economic Statistics, Sweden, 2004 as quoted by Bandura (2008); Chatterjee, 2005; Herrero et al., 2007; Nathan et al., 2008). If we examine in detail, none of the above mentioned proposed methods are free of criticisms. An alternative method proposed by Pena way back in 1977, which was published in Spanish and could not attract attention of researchers for a long time, is currently gaining a remarkable popularity for determining weights and construction of synthetic indicators of quality of life (QoL). The publication of Somarriba and Pena (2009) made Pena's work accessible to the English-knowing researchers. The Pena's method (so called P2 Distance or DP2 method) is claimed to possess almost all the desirable properties such as non-negativity, commutativity, triangular inequality, existence, determination, monotony, uniqueness, transitivity, invariance to change of origin and/or scale of the units in which the variables are defined, invariance to a change in the general conditions and exhaustiveness and reference base, etc. It is also claimed that this indicator solves a large number of problems such as the aggregation of variables expressed in different measures, arbitrary weights and duplicity of information (Pena, 1977; Zarazosa, 1996; Somarriba and Pena, 2009; Montero et al., 2010; Martína and Fernández, 2011). So claimed, the synthetic indicators constructed by Principal Component Analysis (PCA), Data Envelopment Analysis (DEA) or other alternatives using non-Euclidean norms are deficient in one or the other desirable properties in comparison to the Pena's method (Mishra, 2009). Because of the deficiencies in other available methods the work of Pena created a lot of impacts on other researchers and since then a number of research papers have been published that refer to or use the Pena's method.

Is Pena's method truly a superior one as compared to other methods? The present paper is an attempt in this regard to answer this question. For this purpose, the paper has been organized into seven sections: (I). Introduction; (II). Pena's DP2 Method; (III). Review of Literature; (IV). Data and Methodology; (V). Main Findings, (VI). An Assessment of Pena's Method; and (VII). Conclusion.

II. Pena's DP2 Method

Although Pena's DP2 method was published in 1977 it did not attract attention of researchers since it was not published in a widely read language, namely, English. It came to the notice when Somarriba and Pena (2009) published a paper to measure quality of life of the people of the European Union by using DP2 method. In their paper, before introducing Pena's method, they first criticized both PCA and DEA for not being valid methods for obtaining synthetic indicators. According to them PCA as a method does not allow making cardinal inter-spatial and inter-temporary comparisons but only ordinal comparisons as opposed to the DEA and DP2 methods. The weights of partial indicators lack socio-economic interpretation. The method has a tendency to pick up the subset of highly correlated variables to make the first component and assign marginal weights to relatively poor correlated subsets of variables. Although DEA facilitates spatial and temporary comparisons and guarantee impartiality in the weights but the program could assign a zero or very low weight to a specific factor. It has the disadvantage of yielding multiple virtual solutions and the existence of restrictions causes problems of non-feasibility. It further allows some degree of arbitrariness in the model while identifying output and input variables. Pena's P2 Distance which overcomes all these deficiencies is introduced as follows:

$$DP2_i = \sum_{j=1}^{m} \left[\left(\frac{d_{ij}}{\sigma_j} \right) \left(1 - R^2_{j,j-1,\ldots,1} \right) \right]; \quad i = 1, 2, \ldots, n \qquad \ldots \qquad (1)$$

where: $i = 1, 2, \ldots, n$ are cases (e.g. countries, districts, etc); m is the number of constituent variables, X, such that $x_{ij} \in X; i = 1, 2, \ldots, n; j = 1, 2, \ldots, m;$ $d_{ij} = \left| x_{ij} - x_{\rho j} \right|; i = 1, 2, \ldots, n; j = 1, 2, \ldots, m;$ ρ is the reference case pertaining to $\min_i (x_{ij})$; σ_j is the standard deviation of variable

j; $R^2_{j,j-1,...,1}$; $j>1$; is the coefficient of determination in the regression of x_j over $x_{j-1}, x_{j-2}, ..., x_1$. In equation (1), (d_{ij}/σ_j) is merely a change in the origin and the scale. Also, one may use zero as the reference (ρ) point and [$\max_i(x_{ij})$- $\min_i(x_{ij})$] instead of σ_j as a scaling factor, without any adverse effect on the formula. The real crux, however, lay in the weights $(1-R^2_{j,j-1,...,1})$. It may be noted that the first variable obtains an absolute weight of unity $(1-R^2_1)$. The subsequent variable $j=2$ obtains a weight $(1-R^2_{2,1})$ and in general, the j^{th} variable obtains a weight of $(1-R^2_{j,j-1,...,1})$. Due to this, it is obvious that the weights assigned to a variable will depend on its position in the order (Montero, 2010; Mishra, 2012-a), which makes DP2-based composite (synthetic) indices indeterminate and arbitrary.

To resolve the said indeterminacy, the following iterative procedure has been suggested (Montero, 2010):

Step-1: Initialize the weight vector, $w_j = 1 \ \forall \ j = 1,2,...,m.$ Define $\varepsilon = 0.00001$, say for accuracy.

Step-2: Define $\partial_{ij} = (d_{ij}/\sigma_j) \ \forall \ j=1,2,...,m; \ i=1,2,...,n$

Step-3: Obtain $DF_i = \sum_{j=1}^{m}\left[\left(\frac{d_{ij}}{\sigma_j}\right)w_j\right]; \quad i=1,2,...,n$

Step-4: Compute the Karl Pearson's coefficient of correlation $r(DF,\partial_j)$ between DF and ∂_j, $\forall \ j=1,2,...m$

Step-4: Arrange $|r(DF,\partial_j)|$ in a descending order (and re-index the associated variables, ∂_j, accordingly.

Step-5: Compute $Z_i = \sum_{j=1}^{m}\left[\left(\frac{d_{ij}}{\sigma_j}\right)w_j\right]; \quad i=1,2,...,n; \quad w_j = (1-R^2_{j,j-1,j-2,...,1})$ for $j=2,3,...,m$ and $w_1 = 1$.

Step-6: If $\sum_{i=1}^{n}(DF_i - Z_i)^2 \geq \varepsilon$ then: replace DF by Z (that is, $DF \Leftarrow Z$); go to step-4. Else: stop. Alternatively, to resolve the said indeterminacy, Mishra (2012-b) used combinatorial optimization to obtain maxmin index such that $\min_j(\,|r(Z,\partial_j)|\,)$ is maximized.

III. Review of Literature

To the best of our knowledge about 30 papers have been published so far citing the work of Pena (1977) published in Spanish or the work of Somarriba and Pena (2009) published in English or both. Using three methods of composite synthetic indicators (PCA, DEA and P2 Distance), Somarriba and Pena (2009) constructed and compared quality of life indices using European Union data. Their findings corroborated their criticisms leveled against other methods. Of the three methods analyzed, the authors claimed that Pena's method was found to be the optimal one in obtaining synthetic indicators of well-being. However, they did not clearly define the criteria of optimality. Based on Pena's indicator, Europe was found to display a strong polarization between on the one hand, Nordic countries and Austria, and Eastern European and the new accession countries, on the other. The distance between the averages of both groups was 9.71 units in relation to the reference base. The rest of the countries were between those extremes.

Of those 30 publications, Pena's method was applied directly for measurement of quality of life (QoL) or social welfare in eleven publications and in other papers it was simply referred. Probably the first work to cite Pena is Zarzosa (1996) whose paper was published in Spanish and was not accessible to a larger number of researchers. In 2003 another paper authored by Royuela, Suriñach and Reyes dealt with measurement of QoL following the idea of multidimensionality. The authors applied an option based on the distance indicator approach and devised a methodology that allowed explicitly temporal comparisons and did not depend on the attributes' ranking (as the Ivanovic-Pena distance does) and built a scale for measuring QoL. They also included the possibility of choosing both - the structure of the composite final measure and the weights of each component in the structure. Juana and Jose (2007) proposed a new procedure of obtaining a synthetic indicator (PCA-based Synthetic Poverty Index) to measure intensity of poverty for all the countries of the European Union using data of households and individuals from a longitudinal survey carried out by EUROSTAT for the period from 1994 to 2000. While making a review of synthetic indicators they simply made a reference to the work of Pena without making any use of DP2 method in their analysis.

Hashimoto, Sugita and Haneda (2009), using panel data from Japan's 47 prefectures for the period from 1975 to 2002, measured QoL by applying Data Envelopment Analysis/Malmquist Index (DEA/MI) and identified significant movement in the country's overall QoL using a 'cumulative' frontier shift index. They found that Japan's QoL rose during the so-called 'bubble economy years' (second half of the 1980s), and then dropped in the succeeding 'lost-decade' (1990s). Besides, they identified those prefectures considered most responsible for the shift(s) in QoL. However, they did not use DP2 method for their analysis but only a reference was made to the same.

Although Velázquez (2009) did not use DP2 method for any analysis in his paper but made a reference to the work of Pena while writing a descriptive paper on the current status and new approaches to the measurement of poverty. He simply reviewed the evolution and future perspectives of poverty analysis including concepts and measurements while paying special attention to the studies carried out in Spain.

Using a larger number of variables and applying DP2 method García and Rodriguez (2010) measured social welfare for the least developed countries and ranked them. The details regarding the result could not be presented in this section because English translation of the paper (written in Spanish) was not available.

Montero, Larraz and Chasco (2010) while proposing an alternative approach to build an Environmental Quality Index (EQI) introduced some methodological and practical novelties. From the point of view of the selection of variables, first they considered noise as a relevant environmental variable and added 'subjective' data available at the census tracts level to the group of 'objective' environmental variables for which data were only available at environmental monitoring stations. Combination of data led to a Mixed Environmental Quality Index (MEQI) which is more complete and adequate in a socioeconomic context. In order to build the final synthetic index, instead of using more commonly used method of PCA, they used DP2 method because of its so-called superiority over other methods. According to them DP2 is an iterative procedure that weights partial indicators depending on their correlation with a global index. Its most attractive feature is that it uses all the relevant information contained in the partial indicators eliminating all the redundant variance present in these variables (i.e. avoiding multicollinearity). Since this method has been used to compute QoL and other social indicators in the past by Zarzosa (1996) and Royuela et al. (2003) they proposed its use in the construction of environmental index for its good statistical properties; i.e. multidimensionality, comparability and comprehensibility.

Cuenca, Rodríguez and Navarro (2010 measured social welfare of fifteen countries of Central America and the Caribbean using DP2 method on the basis of sixteen social indicators. In their paper they vouched in favor of the synthetic indicator like DP2 having multidimensional characteristics with a series of mathematical properties to be able to provide a good measurement. Using DP2 method the authors concluded that despite the advances made in most countries, there still remained notable differences in the region in the value of certain social indicators, with very unequal progress in some areas basic to social welfare, such as illiteracy, access to potable water, or infant malnutrition.

The State of the Art of Research on Families and Family Policies in Europe is the report of the first Work package of the FAMILYPLATFORM funded by the European Commission 7th Framework Programme. The work of the FAMILYPLATFORM is to chart and review the major trends of comparative family research within the EU. The research review provides an overview of studies on changing family structures, developmental processes, current social and economic conditions of European families, gender and generational relations within families, and on family policies in the EU member states from a comparative perspective. Kuronen (2010) in this regard mentioned the work of Pena while summarizing results of eight Existential Field Reports and two additional Expert Reports which dealt with an extensive systematic literature review on European comparative research published since the mid-1990s using scientific and statistical databases, reports from previous and ongoing EC funded research projects, and other relevant publications.

González, Cárcaba and Ventura (2011a) made an attempt to quantify the relative importance of three different geographic levels of analysis in assessing QoL of Spanish population. They evaluated the extent to which the QoL of an average person living in a given municipality is explained by the province and region in which the municipality is located. To do so, they constructed a composite indicator of QoL for 643 largest municipalities of Spain using

19 variables which were weighted using Value Efficiency Analysis (VEA). Then they made a variance decomposition of the VEA scores to assess the importance of three levels of geopolitical administration. However they did not use DP2 method for their analysis but only a reference to Pena's work was made while mentioning different methods available for measurement of QoL. Their results showed that the municipal level is the most important of these, accounting for 52 per cent of the variance in QoL. Regions explained 38 per cent while provinces only accounted for a moderate 10 per cent. Therefore, they concluded that political action at the regional and municipal level had a larger impact on QoL indicators. A similar type of study was again conducted by González, Cárcaba and Ventura (2011b) where both DEA and VEA methods were applied to measure QoL for Spanish Municipalities but did not use DP2 method.

González, Carcaba, Ventura and Garcia (2011a) undertook a study to measure quality of life for 235 largest Municipalities in Spain using both DEA and VEA techniques. They observed that population ageing and economic status were closely related. They also hypothesized that as people grow older and reach a high economic status, they buy better living conditions migrating to municipalities near the VEA frontier. Another repetitive study was undertaken by them (2011b) in which they measured QoL for the largest 643 Spanish municipalities using VEA with 19 indicators without any use of DP2 method.

Dominguez, Blancas, Gerrero and Gonzalez (2011; in Spanish) made a critical review of various methods of measurement of composite indicators including that of Pena. While doing so they identified the advantages and disadvantages associated with each of these indicators. They also paid particular attention to the issues of reducing the subjectivity associated with synthetic indicator, the ease of interpretation of results, operational complexity, etc. Finally they offered a document that could be used by researchers to choose a particular indicator that best suited their studies out of many available indicators.

Dong and Jensen (2011) using data from 2009 Phase III Agricultural Resource Management Survey (ARMS), Hogs Production Practices and Costs and Returns Report and applying DEA technique developed a composite food safety control indicator by aggregating data from a set of individual indicators of food safety control and investigated variation in food safety practices across 1198 farms from 19 States. They showed how some relevant variables might influence farm food safety control, thus providing empirical evidence for the design of food safety-enhancing agricultural policy measures. However, they did not adopt DP2 method for their analysis.

Rodríguez and Salinas (2011) using DP2 method constructed an index to measure maternal and child health in ten least developed countries of Asia which are beset by profound social and economic inequalities and poverty. Through this index they could integrate variables of maternal and child health that allowed territorial ordering of the LDCs in terms of these partial indicators. They concluded the presence of strongly polarized territorial disparities in maternal and child health care in those countries.

Tenorio and Ramos (2011) in a research paper (in Spanish) advocated construction of a multidimensional index of QoL with seven deemed essential dimensions such as health, equality, education, labor market conditions, economic conditions, environmental conditions, security and transportation. Considering these dimensions, they constructed indices using PCA and DEA techniques to show how income inequality among the major regions of Brazil was translated effectively into disparities in the QoL.

Wolbring (2011) just referred Pena's method while reviewing measurement of QoL, be it for the hearing impaired or not. He presented the views of members of the World Federation of the Deaf on potential beyond species typical abilities enabling therapeutic assistive devices (i.e. related to hearing). Survey respondents showed support for the development and uptake of the beyond normal hearing enabling devices. He also analyzed what guidance code of ethics of hearing enabling professions give in regards to the beyond normal hearing enabling devices.

Mishra (2012-a) using data from human development report of UNDP (2004) demonstrated that DP2 method of construction of a synthetic indicator is very sensitive to the order in which the constituent variables (whose linear aggregation yields the synthetic indicator) are arranged. Since 'm' number of constituent variables may be arranged in m-factorial ways, even a moderately large 'm' can give rise to a very large number of synthetic indicators from which one cannot choose the one which best represents the constituent variables. Given that an analyst has too little information as to the order in which a sizeable number of constituent variables must be arranged so as to obtain the best representative synthetic indicator, DP2 method can give only an arbitrary synthetic indicator whose representativeness is indeterminate and uncertain. In another paper Mishra (2012-b) drew the same conclusion but while making analysis he used discrete global optimization method based on Particle Swarms to obtain a heuristically optimal order in which the constituent variables could be arranged so as to yield DP2 synthetic indicator that maximizes the minimal absolute (or squared) correlation with its constituent variables. Similarly in another paper Mishra (2012-c) used mixed combinatorial-cum-real particle swarm (MCCRPS) method to obtain a heuristically optimal order in which the constituent variables could be arranged so as to yield some generalized maximum entropy synthetic indicators that represent the constituent variables in the best information-theoretic sense. Mishra claimed that it might help resolve the arbitrariness and indeterminacy of the DP2 method. In yet another paper, Mishra (2012-d) used MCCRPS method to obtain entropy-maximizing DP2-based composite indices of globalization of different countries.

Assi, Lucchini and Spagnolo (2012) applied a powerful clustering procedure (the Two-Step Cluster Analysis or BIRCH algorithm) to a set of non-monetary indicators of well-being and QoL taken from the first four waves of the European Social Survey. By employing this technique, they identified nine clusters of people characterized by different forms of well-being and QoL, while preserving as much as possible the multidimensional information contained in the preselected indicators. They also analyzed the distribution of the clusters among European countries, finding significant differences among the groups of Nordic countries, Continental European countries, Mediterranean European countries and Eastern European countries in the chances of belonging to the nine forms of wellbeing and QoL previously identified. However, they did not use Pena's method for their analysis.

In order to determine provincial disparities in social welfare levels in Spain, Espina and Somarriba (2012) used DP2 method to estimate provincial synthetic welfare indicator. Their findings revealed that degree of disparity in welfare levels amongst Spanish provinces was extremely moderate. In terms of geographical distribution, they found how provinces located in the North and North-East of the peninsula enjoyed the highest levels of welfare. Further the study revealed that increased GDP undoubtedly enhanced provincial welfare in Spain but its explanatory power regarding provincial disparities was extremely low.

Although Henning and Zarnekow (2012) did not use DP2 method for their analysis, however, they mentioned Pena's work as a method for construction of a synthetic indicator. Their work presented empirical evidence from cross-sectional and panel data models that social capital is a determinant of local government performance. To make such analysis they applied DEA to estimate local government performance in rural communities in Poland for the years 2002-2005. Further, they calculated the Malmquist index to measure the temporal change in government performance.

Rodríguez, Salinas and Ubiña (2012) presented a new proposal for measuring progress towards Millennium Development Goal-6 to combat HIV, AIDS and malaria in the context of sub-Saharan Africa. To construct the index, they used a large number of variables and adopted DP2 method. Their index incorporated variables that permitted the countries of sub-Saharan Africa to be ordered at territorial scale in terms of the value of the partial indicators. Results revealed notable differences across countries of sub-Saharan Africa concerning fulfillment of the MDG 6.

Rodríguez (2012) constructed a new composite index of child health by DP2 method using variables defined in the Goals of the Millennium Declaration for thirty-one LDCs of Africa grouped into 5 geographical divisions of the continent, namely, Central Africa, East Africa, West Africa, Horn of Africa and Southern Africa. The results exhibited the existence of territorial disparities with regard to child health in 2008.

Okulicz-Kozaryn (2012) investigated the effect of income on life satisfaction (livability theory) in a regression framework using variables such as unemployment, marital status, age, education and community size at the sub-national level across West European countries. Living conditions measured by regional income was observed to increase life satisfaction beyond personal income and national income. There existed larger life satisfaction inequality between the rich and the poor in the poor provinces than that in the rich provinces. Personal income mattered more for life satisfaction in the poor provinces than in the rich provinces. However, he did not use DP2 method for his analysis.

Poveda (2012) too did not use DP2 method but made reference to work of Pena while analyzing the effectiveness of the control of violence at the level of Colombian departments between 1993 and 2007. Instead he adopted DEA approach to draw necessary conclusions. Findings of his study revealed that majority of departments showed improvement in their scores of effectiveness. A second stage of the regression model revealed that departments with a higher GDP and higher education and employment were more effective in the control of violence, whereas departments with higher political violence, unemployment rates, unsatisfied basic needs, a displaced population, and hectares cultivated with cocoa showed lower effectiveness in the control of violence.

Applying DEA technique, Tsuneyoshi, Hashimoto and Haneda (2012) measured changes in stability of nation using panel data for 97 countries during 1981–2004. This analysis included a *unified* country (Germany) and *split* countries (former Soviet Union, Czechoslovakia, and Yugoslavia). Results revealed shifts in stability before/after the unification or split. The stability gap between the most stable countries and other countries expanded after the end of the cold war, until 2004. The stability of split countries fell typically by 50 per cent or more.

Zorondo-Rodrıguez, et al. (2012) also did not use DP2 method but conducted an insightful study on QoL after surveying 114 individuals from Kodagu district of Karnataka in India. According to them a method measuring QoL could be a useful one if it made a good balance between indicators guided by theories (top-down approach) and indicators defined by local people (bottom-up approach). Accordingly they analyzed the correspondence between HDI as an indicator adopted by governments to assess QoL and the elements defined by local people as important in their QoL, called by them as local means. The findings revealed that HDR did not capture the means defined by people as indicators of QoL. Their findings suggested an important gap between current indicators of QoL considered by the makers of public policies and the means of QoL defined by people. The study provided insights for a set of plausible local indicators useful to achieve a balance between top-down and bottom-up approaches for the local public policies.

The above review of literature reveals that the works of Pena (1977) and Somarriba & Pena (2009) have gained a remarkable popularity by way of a number of citations and application of their method for constructing composite indices, especially the quality of life indices. Therefore, there is a need for relooking at the method proposed by Pena for its suitability for constructing the synthetic indicators.

IV. Data and Methodology

For the purpose of the study we intend to use data of HDR of UNDP (2011). The variables to be considered for construction of various indicators are life expectancy at birth in years for health dimension (LEX), both mean and expected years of schooling for knowledge dimension (EDN) and finally gross national income per capita at constant prices (2005 PPP US $) for the dimension of standard of living (PCY). The formulae and goal posts for each variable mentioned in the 2011 Report would be used for constructing HDI and other indices of human development. As regards construction of Pena's distance there would be no change in the choice of variables but the formula of Pena as mentioned in Section II would be employed.

As it has been amply elaborated in Mishra (2012-d), composite indices as the weighted linear aggregation of indicator variables can be constructed in a number of ways, but whenever the weights (w) are derived intrinsically (from the data pertaining to the indicators or the constituent variables) a criterion function is used which is optimized. Even the (equal) weights used in the construction of HDI in 2011 report of UNDP may be interpreted as optimizing the Hölder's mean with a zero exponent. It may be noted that all arithmetic, geometric and harmonic means are the Hölder's means with exponents 1, 0 and -1 respectively. When weights are obtained such that Minkowski's L_p norm (p=1, 2 and $-\infty$) is maximized, we obtain absolute (norm-1), Euclidean (norm-2 or principal component) and maxmin composite indices. In general, if $Z = Xw,$ where Z, X and w are the composite index, the matrix of m constituent variables in n cases and weights, the norm-1 based composite indices maximize $\left[\sum_{j=1}^{m} | r(Z, x_j) |\right]$, norm-2 based indices maximize $\left[\sum_{j=1}^{m} | r(Z, x_j) |^2\right]^{1/2}$ and maxmin composite indices maximize

$\left[\sum_{j=1}^{m} | r(Z,x_j) |^{p\to(-\infty)}\right]^{1/p}$. It may be noted that $r(Z,x_j)$ is the Karl Pearson's coefficient of correlation between Z and $x_j \in X$.

Another composite index may be obtained by maximization of (Shannon's) entropy in the weights, $\sum_{j=1}^{m}[b_j \ln(b_j)] + B\ln(B)$, where $B = \sum_{j=1}^{m}\left|r(Z,x_j)\right|;\ b_j = \left|r(Z,x_j)\right| / B,\ \ j = 1,2,...,m,$ is maximized. Oftentimes it has been found that the composite indices so obtained have a very high correlation with the norm-1 based composite indices (Mishra, 2011).

In case the composite indices are based on DP2 criterion, the weights (and, therefore, the resulting indices) depend on the order in which the constituent variables enter into the formula. For determinacy, therefore, one has to impose a criterion. Such a criterion could be the magnitude of correlation coefficient of the composite index with its constituent variables (as used by Montero, 2010) or alternatively the maximization of minimal correlation, $\max[\min(\ | r(Z,x_j) |\ )]$. In this paper we call it Penmax index.

Alternatively, composite indices may be derived such that they maximize $S(Z)$, where $S(.)$ is the relative entropy of $(.)$. Entropy itself may be defined in a plethora of manners (see Esteban and Morales, 1995 that discusses 23 measures of entropy). We have used three popular measures of entropy: Shannon, Tsallis and Sharma-Mittal (Beck, 2008).

Construction of all the composite indices proposed here (except the norm-2 composite indices) need direct optimization. In particular, some DP2-based indices require combinatorial and mixed-real-combinatorial optimization. To accomplish this, we have used the Particle swarm method with suitable modifications and incorporation of the Smallest Position Value (SPV) mapping mechanism for obtaining combinatorial solutions (Tasgetiren et al., 2004; Parsopoulos and Vrahatis, 2006; Mishra 2012-b).

In the present study we obtain 10 different composite indices of Human Development: (1) HDI-11 (UNDP), (2) Norm-1, (3) Norm-2, (4) Entrop, (5) Maxmin, (6) Penmax, (7) Shannon, (8) Tsallis, (9) Sharma-Mittal (Sharmit), and (10) Pena-DP2 (by Montero iteration). These names only identify the methods used for obtaining them. The last five indices use DP2 for obtaining weights and the maximization of the criterion only assists into the choice of order in which the constituent variables enter into the DP2 formula. Norm-1, Norm-2 and Maxmin are based on maximization of a particular norm of the coefficient of correlation between the composite index and the constituent variable. Entrop is based on maximization of entropy of the correlation itself. HDI-11 is from 2011 report of UNDP. All the ten indices are presented in Table A.1 in the Appendix. All indices are normalized by the formula $[z_i - \min(Z)]/[\max(Z) - \min(Z)] \times 100$.

V. Main Findings

In Table-1 we present the correlation coefficients between the alternative indices of human development and their constituent variables. It may be noted that PCY has the largest correlation with Pena-DP2 followed by Penmax and HDI-11. All entropy-maximizing DP2-based indices exhibit lesser correlation with PCY. On the other hand, all entropy-maximizing DP2-based indices (except Shannon) have larger correlation with LEX. Shannon has the largest correlation with EDN. On the criterion of SAR (sum of absolute correlation between the index and the constituent variables) and SSR (sum of squared correlation between the index and the constituent variables) and min(r), all DP2-based indices (except Pena-DP2) score poorly. All entropy-maximizing DP2-based indices (except Shannon) yield almost identical composite indices. It is also pertinent to report that all DP2-based indices have optimal order of entry of variables as LEX, EDN and PCY. In Pena-DP2, however, the order is PCY, EDN and LEX.

Table-1:
Correlations, Norms, Entropy Measures and Composability of Various Indices of Human Development

Index	LEX	EDN	PCY	SAR	SSR	Min(r)	S(Z)	q_1	q_2
HDI-11	0.90151	0.93826	0.94033	2.78010	2.57727	0.90151	-	-	-
Pena-DP2	0.88345	0.89245	0.97769	2.75359	2.53283	0.88345			
Norm-1	0.92510	0.92657	0.93446	**2.78613**	2.58755	0.92510	-	-	-
Norm-2	0.92479	0.92642	0.93491	2.78612	**2.58756**	0.92479	-	-	-
Entrop	0.92505	0.92655	0.93453	2.78613	2.58755	0.92505	-	-	-
Maxmin	0.92859	0.92859	0.92859	2.78576	2.58682	**0.92859**	-	-	-
Penmax	0.89080	0.88533	0.97758	2.75371	2.53300	0.88533	-	-	-
Shannon	0.87597	0.97511	0.89838	2.74946	2.52525	0.87597	0.94299	-	-
Tsallis	0.97347	0.88859	0.88778	2.74984	2.52539	0.88778	0.94046	0.78121	-
Sharma-Mittal	0.97347	0.88859	0.88778	2.74984	2.52539	0.88778	0.93977	0.00004	0.85000

S(Z) is the relative measure of entropy; q_1, and q_2 are the parameters measuring deviance from additivity.

In Table-2 we present correlation among the alternative composite indices of human development. The norm-based indices (Norm-1, Norm-2, Entrop and Maxmin) are perfectly or almost perfectly correlated. On the other hand, all entropy-maximizing DP2-based indices with q_1 different from unity are perfectly correlated. HDI-11 is more correlated with norm-based indices than the DP2-based (except Pena-DP2) indices of human development. It appears, therefore, that the two classes (norm-based and DP2-based) of indices highlight two different aspects of human development. Pena-DP2, Penmax and Shannon strike a balance between the two classes. Pena-DP2 and Penmax indices are very highly correlated.

Table-2:
Correlation Matrix among Different Types of Composite Indices of Human Development

	NORM1	NORM2	ENTROP	MAXMIN	PENMAX	SHANNON	TSALLIS	SHARMIT
NORM1	1.00000	1.00000	1.00000	0.99987	0.98836	0.98684	0.98698	0.98698
NORM2	1.00000	1.00000	1.00000	0.99985	0.98855	0.98678	0.98683	0.98683
ENTROP	1.00000	1.00000	1.00000	0.99986	0.98839	0.98683	0.98695	0.98695
MAXMIN	0.99987	0.99985	0.99986	1.00000	0.98581	0.98749	0.98867	0.98867
PENMAX	0.98836	0.98855	0.98839	0.98581	1.00000	0.96344	0.96236	0.96236
SHANNON	0.98684	0.98678	0.98683	0.98749	0.96344	1.00000	0.96154	0.96154
TSALLIS	0.98698	0.98683	0.98695	0.98867	0.96236	0.96154	1.00000	1.00000
SHARMIT	0.98698	0.98683	0.98695	0.98867	0.96236	0.96154	1.00000	1.00000
HDI-11	0.99784	0.99787	0.99784	0.99724	0.98894	0.99098	0.97593	0.97593
PENA-DP2	0.98832	0.98852	0.98836	0.98572	0.99976	0.96657	0.95949	0.95949

Note: We have r(Pena-DP2, HDI-11)= 0.99006

VI. An Assessment of Pena's Method

There is no generally agreed upon 'ideal' against which one may judge as to which one of the alternative indices is the best. On account of lack of sufficient reason, it may be suggested that the composite index that is most informative among all the alternative indices may be considered the most non-controversial and, therefore, generally acceptable. The Gini Coefficient may be used for this purpose. Larger the Gini coefficient, larger is the information content that a synthetic index could extract from the constituent variables. The Gini coefficient may be obtained by the formula given below:

$$(1/\bar{Z}_\alpha)\left[\left(1/(2n^2)\right)\sum_{i=1}^{n}\sum_{j=1}^{n}|Z_{i\alpha}-Z_{j\alpha}|\right];\text{ where }\bar{Z}_\alpha\text{ is the arithmetic mean of }Z_\alpha.$$

Table-3: Gini Coefficient of the Alternative Indices of Human Development									
Norm-1	Norm-2	Entrop	Maxmin	Penmax	Shannon	Tsallis	Sharmit	HDI-11	Pena-DP2
0.52151	0.52126	0.52147	0.52493	0.48853	0.51500	0.51188	0.51188	0.51777	0.49419

As presented in Table-3, Penmax has the smallest Gini coefficient followed by Pena-DP2. On the other hand, Maxmin has the largest Gini coefficient, followed by Norm-1, Entrop and Norm-2. Z-entropy-based Pena indices (Shannon, Tsallis and Sharmit) are between the norm-based indices and Penmax/Pena-DP2. It appears that entropy maximization tries to extract maximum information from the constituent variables, but the Pena scheme of computing weights pulls it down. It may be noted that Maxmin indices exploit the minimax criteria of Wald and have edge over other criteria in the face of lack of information that may be helpful in decision-making.

VII. Conclusion

From the present study we obtain some hints that Pena-DP2 index and Penmax index have close similarity. Computationally, Pena-DP2 method of construction index is much simpler, but the interpretation of Penmax index is more straightforward. On the other hand, Maxmin index is norm-based and has a justification on Wald's principle of decision-making. The Maxmin index also is the most egalitarian index against the Principal Component based (Norm-2) index, which is known to be most elitist. On SAR and SSR criteria, too, the Maxmin index is superior to other indices. It appears, therefore, that the Maxmin composite index that is obtained by maximization of $[\min(|r(Z, x_j)|)]$ is a better index than others. Among the DP2-based indices, Penmax vies with the Pena-DP2 index. It may be noted, however, that none of the composite indices (including the Montero iteration based Pena-DP2) is a cardinal measure of human development in the strict sense of measurement (Neumann and Morgenstern, 1953: pp. 16-24). They can be used only for ranking the cases (countries, etc).

Note: *The computer programs used for constructing various indices may be obtained on request to the authors.*

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Appendices

Table. A.1: Composite Indices of Human Development based on Different Optimization Criteria

SN	COUNTRY	NORM1	NORM2	ENTROP	MAXMIN	PENMAX	SHANNON	TSALLIS	SHARMIT	HDI-11	DP2
1	Norway	100.000	100.000	100.000	100.000	97.857	100.000	99.921	99.921	100.000	98.374
2	Australia	98.187	98.169	98.184	98.411	94.236	98.588	100.000	100.000	97.869	94.638
3	Netherlands	95.087	95.084	95.086	95.120	93.033	94.175	96.356	96.356	94.977	93.329
4	United_States	94.542	94.556	94.544	94.371	93.984	94.451	93.288	93.288	94.977	94.509
5	New_Zealand	95.220	95.188	95.214	95.632	89.429	97.937	97.136	97.136	94.673	89.976
6	Canada	94.981	94.975	94.980	95.045	92.714	93.923	96.661	96.661	94.673	92.969
7	Ireland	94.938	94.921	94.934	95.153	91.088	95.825	96.484	96.484	94.673	91.509
8	Liechtenstein	94.914	94.970	94.924	94.196	100.000	88.288	93.698	93.698	94.216	100.000
9	Germany	94.368	94.365	94.367	94.406	92.269	93.641	95.580	95.580	94.216	92.576
10	Sweden	94.380	94.377	94.379	94.412	92.610	92.247	96.639	96.639	94.064	92.733
11	Switzerland	94.622	94.624	94.622	94.583	93.740	90.721	97.620	97.620	93.912	93.674
12	Japan	94.577	94.562	94.574	94.739	92.003	91.087	99.133	99.133	93.607	91.865
13	Hong_Kong	94.167	94.177	94.168	94.017	94.552	88.383	97.653	97.653	93.151	94.296
14	Iceland	93.703	93.689	93.701	93.889	90.588	92.254	96.907	96.907	93.151	90.696
15	Korea_Rep	93.238	93.224	93.235	93.419	89.903	93.194	95.314	95.314	92.998	90.194
16	Denmark	92.524	92.528	92.525	92.475	91.058	92.464	92.514	92.514	92.694	91.479
17	Israel	92.246	92.227	92.243	92.482	88.739	91.020	95.833	95.833	91.629	88.822
18	Belgium	91.496	91.499	91.496	91.452	90.398	89.503	93.134	93.134	91.324	90.541
19	Austria	91.645	91.650	91.646	91.563	91.147	88.132	94.118	94.118	91.172	91.113
20	France	91.723	91.716	91.722	91.793	89.874	88.878	95.081	95.081	91.020	89.836
21	Slovenia	91.031	91.017	91.028	91.212	87.589	91.941	92.495	92.495	91.020	87.972
22	Finland	90.995	90.997	90.995	90.956	89.904	88.866	92.817	92.817	90.715	90.018
23	Spain	90.841	90.827	90.838	90.995	88.224	88.611	94.561	94.561	90.107	88.201
24	Italy	90.349	90.336	90.347	90.494	88.016	87.182	94.747	94.747	89.498	87.866
25	Luxembourg	89.322	89.359	89.329	88.830	92.873	82.300	90.895	90.895	88.432	92.590
26	Singapore	89.639	89.676	89.644	89.144	93.467	81.235	92.263	92.263	88.280	93.005
27	Czech_Republic	87.864	87.851	87.861	88.025	84.532	89.596	88.698	88.698	88.128	84.987
28	UK	88.476	88.487	88.477	88.319	88.869	84.058	91.167	91.167	87.823	88.711
29	Greece	87.814	87.805	87.812	87.921	85.602	86.058	90.904	90.904	87.519	85.624
30	UAE	85.652	85.717	85.662	84.807	92.154	78.665	84.136	84.136	85.236	92.038
31	Cyprus	84.984	84.987	84.985	84.935	84.530	81.135	88.457	88.457	84.323	84.326
32	Andorra	85.653	85.676	85.656	85.326	88.201	77.669	89.764	89.764	84.018	87.627
33	Brunei_Dars	84.776	84.823	84.783	84.158	89.524	77.621	85.574	85.574	84.018	89.229
34	Estonia	82.813	82.804	82.811	82.940	79.619	86.277	82.261	82.261	83.562	80.249
35	Slovakia	82.852	82.852	82.851	82.837	81.188	84.202	82.663	82.663	83.409	81.624
36	Malta	83.702	83.698	83.700	83.731	82.621	80.126	87.764	87.764	83.105	82.384
37	Qatar	86.266	86.366	86.282	84.966	97.671	72.653	85.718	85.718	82.953	96.963
38	Hungary	80.118	80.117	80.118	80.143	78.102	82.201	79.888	79.888	80.670	78.568
39	Poland	80.078	80.077	80.077	80.086	78.680	79.695	81.644	81.644	80.213	78.826
40	Lithuania	78.471	78.476	78.472	78.413	76.880	82.120	76.323	76.323	79.756	77.582
41	Portugal	80.526	80.528	80.526	80.464	80.642	75.092	85.421	85.421	79.604	80.163
42	Bahrain	79.001	79.037	79.006	78.531	82.155	75.054	79.001	79.001	79.148	82.107
43	Latvia	78.255	78.251	78.254	78.318	75.776	81.499	77.578	77.578	78.995	76.345
44	Chile	79.693	79.671	79.690	79.973	76.452	77.714	85.078	85.078	78.995	76.208
45	Argentina	77.742	77.736	77.740	77.815	75.899	77.407	80.025	80.025	77.778	75.974
46	Croatia	77.592	77.590	77.592	77.601	76.573	75.666	80.552	80.552	77.626	76.473
47	Barbados	77.166	77.175	77.168	77.046	77.522	73.587	80.253	80.253	77.169	77.275
48	Uruguay	76.111	76.101	76.109	76.219	74.385	74.042	80.199	80.199	75.647	74.180
49	Palau	74.591	74.574	74.588	74.819	70.491	80.093	73.896	73.896	75.495	71.201
50	Romania	74.873	74.860	74.871	75.040	71.915	76.949	76.306	76.306	75.342	72.209
51	Cuba	76.905	76.828	76.892	77.860	67.299	80.328	84.502	84.502	74.581	67.311
52	Seychelles	73.536	73.555	73.538	73.281	74.770	71.672	74.237	74.237	74.125	74.779
53	Bahamas	74.449	74.484	74.454	73.985	78.163	68.249	76.578	76.578	73.820	77.737
54	Montenegro	73.734	73.718	73.731	73.922	70.843	74.795	76.244	76.244	73.820	70.969
55	Bulgaria	73.267	73.262	73.266	73.332	71.328	74.601	74.440	74.440	73.820	71.560
56	Saudi_Arabia	73.605	73.646	73.611	73.068	77.671	68.702	74.091	74.091	73.668	77.451
57	Mexico	74.186	74.181	74.185	74.218	73.410	70.708	78.806	78.806	73.668	73.034
58	Panama	73.622	73.616	73.620	73.679	72.427	71.383	77.527	77.527	73.364	72.193
59	Serbia	72.819	72.805	72.816	72.980	70.267	73.429	75.489	75.489	73.059	70.336
60	Antigua_Barb	71.939	71.959	71.942	71.670	73.219	70.706	72.113	72.113	72.755	73.296
61	Malaysia	71.884	71.894	71.886	71.750	72.262	69.763	74.022	74.022	72.298	72.135
62	Trinidad_Tob	70.850	70.906	70.859	70.136	75.978	68.370	67.924	67.924	72.146	76.150
63	Kuwait	74.327	74.412	74.340	73.201	84.306	63.162	74.220	74.220	72.146	83.629
64	Libya	72.105	72.107	72.105	72.060	71.747	70.091	74.969	74.969	72.146	71.583
65	Belarus	70.153	70.173	70.156	69.900	70.862	71.522	68.533	68.533	71.537	71.249

66	Russian_Fed	69.585	69.615	69.590	69.216	71.123	71.651	66.350	66.350	71.385	71.668
67	Grenada	71.190	71.154	71.185	71.647	66.297	71.997	76.568	76.568	70.320	66.181
68	Kazakhstan	67.908	67.924	67.910	67.720	67.361	73.510	63.677	63.677	69.863	68.239
69	Costa_Rica	71.521	71.505	71.518	71.691	70.279	65.305	79.761	79.761	69.711	69.408
70	Albania	70.081	70.053	70.076	70.412	66.773	68.095	76.572	76.572	68.950	66.345
71	Lebanon	68.393	68.413	68.396	68.134	69.953	65.981	69.821	69.821	68.950	69.811
72	St-Kitts-Nevis	68.075	68.089	68.078	67.895	69.023	65.631	70.284	70.284	68.341	68.822
73	Ven_Boliv_Rep	68.483	68.485	68.483	68.436	68.409	65.707	72.176	72.176	68.341	68.087
74	Bosnia_Herzeg	68.881	68.858	68.878	69.160	65.902	67.585	74.414	74.414	68.037	65.580
75	Georgia	68.836	68.784	68.827	69.493	61.629	73.772	72.953	72.953	68.037	61.904
76	Ukraine	66.541	66.522	66.538	66.795	62.179	73.823	65.194	65.194	67.428	62.983
77	Mauritius	67.359	67.380	67.362	67.084	69.396	63.351	69.967	69.967	67.275	69.034
78	Frm_Yug_Rp_M	67.646	67.637	67.644	67.741	66.380	65.360	72.321	72.321	67.275	66.021
79	Jamaica	67.083	67.057	67.078	67.392	63.312	68.921	70.536	70.536	67.123	63.362
80	Peru	66.971	66.962	66.968	67.067	65.548	65.539	71.028	71.028	66.819	65.292
81	Dominica	68.352	68.328	68.347	68.615	66.049	64.304	75.955	75.955	66.667	65.360
82	Saint_Lucia	66.934	66.924	66.933	67.051	65.466	64.881	71.683	71.683	66.514	65.113
83	Ecuador	66.933	66.915	66.930	67.142	64.822	64.404	72.916	72.916	66.058	64.348
84	Brazil	65.912	65.920	65.913	65.790	66.615	62.712	69.407	69.407	65.753	66.241
85	St_Vincent-G	65.147	65.143	65.146	65.184	64.068	64.770	67.923	67.923	65.601	63.962
86	Armenia	66.123	66.083	66.116	66.609	61.010	67.801	71.405	71.405	65.449	60.912
87	Colombia	64.617	64.615	64.616	64.625	64.250	61.892	69.014	69.014	64.536	63.839
88	Iran-Islamic_Rp	64.349	64.362	64.351	64.159	65.776	60.590	67.735	67.735	64.079	65.347
89	Oman	65.355	65.421	65.367	64.497	73.246	55.640	67.167	67.167	63.775	72.453
90	Tonga	64.224	64.179	64.216	64.791	58.021	68.539	68.295	68.295	63.623	58.196
91	Azerbaijan	62.313	62.325	62.314	62.141	63.160	61.098	63.998	63.998	63.014	63.027
92	Turkey	63.957	63.983	63.961	63.605	67.274	57.195	68.242	68.242	62.861	66.537
93	Belize	64.330	64.300	64.325	64.679	61.253	61.516	72.008	72.008	62.861	60.612
94	Tunisia	63.613	63.604	63.611	63.710	62.677	60.307	69.374	69.374	62.709	62.116
95	Jordan	63.055	63.027	63.049	63.388	59.560	63.260	68.278	68.278	62.709	59.313
96	Algeria	62.758	62.757	62.758	62.754	62.543	60.065	67.141	67.141	62.709	62.115
97	Sri_Lanka	62.719	62.685	62.713	63.125	58.931	61.488	69.784	69.784	61.644	58.440
98	Dominican-Rp	61.883	61.887	61.884	61.801	62.603	57.735	66.753	66.753	61.339	62.014
99	Samoa	61.887	61.845	61.880	62.420	56.307	64.892	66.816	66.816	61.187	56.292
100	Fiji	60.819	60.789	60.814	61.209	55.920	66.387	62.455	62.455	61.187	56.320
101	China	61.618	61.618	61.618	61.596	61.799	57.815	66.791	66.791	61.035	61.215
102	Turkmenistan	58.743	58.764	58.746	58.485	59.345	63.065	55.453	55.453	60.883	59.951
103	Thailand	61.416	61.418	61.416	61.372	62.000	56.518	67.258	67.258	60.274	61.280
104	Suriname	59.441	59.453	59.442	59.277	60.496	57.400	62.033	62.033	59.970	60.202
105	El-Salvador	59.244	59.237	59.243	59.310	58.477	57.162	64.024	64.024	59.056	58.031
106	Gabon	56.451	56.518	56.461	55.613	62.407	57.546	50.450	50.450	59.056	62.908
107	Paraguay	58.273	58.253	58.269	58.503	56.069	56.991	64.016	64.016	57.686	55.612
108	Bolivia	56.300	56.286	56.298	56.487	53.200	61.813	56.376	56.376	57.382	53.649
109	Maldives	59.625	59.601	59.621	59.885	58.107	53.342	69.521	69.521	57.078	56.983
110	Mongolia	55.560	55.534	55.556	55.906	51.469	59.762	58.208	58.208	55.860	51.630
111	Moldova	55.354	55.319	55.347	55.795	50.551	59.313	59.097	59.097	55.251	50.617
112	Philippines	54.277	54.254	54.273	54.554	51.053	57.099	57.453	57.453	54.490	51.053
113	Egypt	55.773	55.767	55.772	55.822	55.805	50.939	62.796	62.796	54.490	54.946
114	Oc_Palest_Terr	55.667	55.614	55.658	56.303	49.827	56.886	63.378	63.378	54.033	49.410
115	Uzbekistan	53.928	53.896	53.922	54.323	49.471	58.283	57.019	57.019	54.033	49.596
116	Micr_Fed_Stat	53.409	53.378	53.404	53.805	49.184	56.640	57.430	57.430	53.272	49.151
117	Guyana	53.139	53.113	53.135	53.467	49.853	54.417	58.086	58.086	52.816	49.596
118	Botswana	49.148	49.257	49.166	47.807	58.359	55.597	34.673	34.673	52.816	59.777
119	Syr_Arab_Rp	55.686	55.661	55.682	55.966	54.155	49.386	66.034	66.034	52.664	52.954
120	Namibia	49.178	49.220	49.185	48.645	52.860	50.813	46.054	46.054	51.598	53.128
121	Honduras	53.221	53.194	53.216	53.539	50.849	50.154	61.519	61.519	51.598	50.018
122	Kiribati	51.109	51.091	51.107	51.341	48.517	53.162	54.673	54.673	51.446	48.392
123	South_Afric	46.804	46.899	46.820	45.644	54.381	54.659	33.053	33.053	50.685	55.836
124	Indonesia	50.580	50.572	50.579	50.666	49.817	49.319	55.442	55.442	50.381	49.332
125	Vanuatu	51.332	51.324	51.331	51.421	50.870	48.232	57.637	57.637	50.381	50.149
126	Kyrgyzstan	50.888	50.841	50.879	51.482	44.641	56.832	54.769	54.769	50.076	44.806
127	Tajikistan	49.650	49.605	49.642	50.236	43.569	55.340	53.731	53.731	48.858	43.686
128	Viet_Nam	50.475	50.438	50.469	50.900	47.892	44.609	62.163	62.163	46.728	46.576
129	Nicaragua	49.335	49.294	49.328	49.821	45.965	45.247	60.251	60.251	46.119	44.832
130	Morocco	47.854	47.858	47.855	47.774	49.743	40.293	56.334	56.334	45.053	48.476
131	Guatemala	46.378	46.386	46.379	46.229	48.842	38.970	54.188	54.188	43.836	47.615
132	Iraq	44.780	44.779	44.780	44.768	45.491	41.047	51.060	51.060	43.683	44.645
133	Cape_Verde	47.140	47.128	47.138	47.248	47.764	38.425	58.345	58.345	42.922	46.212
134	India	39.735	39.760	39.739	39.386	43.352	35.839	43.328	43.328	39.726	42.615

135	Ghana	38.782	38.760	38.778	39.061	36.025	42.079	42.582	42.582	38.813	35.843
136	Equat_Guinea	36.714	36.883	36.742	34.587	54.436	34.080	22.893	22.893	38.204	54.934
137	Congo	34.523	34.570	34.531	33.944	38.897	37.290	31.001	31.001	37.595	39.115
138	Lao_Pe-D_Rep	37.866	37.864	37.865	37.861	38.853	33.730	44.970	44.970	36.225	37.839
139	Cambodia	35.362	35.362	35.362	35.354	35.509	36.192	38.654	38.654	36.073	35.123
140	Swaziland	31.293	31.389	31.308	30.106	39.711	38.828	18.538	18.538	35.921	40.895
141	Bhutan	39.243	39.295	39.252	38.538	46.903	29.369	44.266	44.266	35.921	45.581
142	Solomon_Islan	36.226	36.212	36.224	36.363	36.086	32.317	44.588	44.588	34.094	34.988
143	Kenya	31.773	31.779	31.774	31.708	31.290	38.829	29.838	29.838	33.942	31.715
144	Sao-Tom_Pr¡	34.170	34.168	34.170	34.168	34.791	32.494	39.588	39.588	33.942	34.047
145	Pakistan	34.561	34.581	34.565	34.278	38.092	29.420	40.076	40.076	33.181	37.065
146	Bangladesh	35.567	35.544	35.563	35.830	34.533	31.257	45.452	45.452	32.572	33.292
147	Timor_Leste	32.226	32.269	32.233	31.659	38.045	27.451	34.947	34.947	31.811	37.209
148	Angola	26.839	26.950	26.857	25.446	38.394	27.598	17.803	17.803	30.441	38.731
149	Myanmar	31.405	31.400	31.404	31.437	32.112	28.389	38.382	38.382	29.985	31.123
150	Cameroon	25.519	25.573	25.528	24.847	30.256	31.952	18.797	18.797	29.833	30.880
151	Madagascar	32.704	32.650	32.695	33.356	27.566	34.005	41.963	41.963	29.528	26.787
152	Tanzania	25.782	25.796	25.785	25.603	27.357	28.124	26.889	26.889	27.397	27.129
153	Papua_N_Guin	28.538	28.572	28.544	28.076	33.800	23.020	33.059	33.059	27.397	32.740
154	Yemen	29.887	29.911	29.892	29.546	34.516	22.379	37.032	37.032	26.788	33.135
155	Senegal	25.558	25.588	25.564	25.169	29.513	24.350	27.530	27.530	26.332	28.938
156	Nigeria	22.394	22.458	22.404	21.587	28.857	26.031	16.839	16.839	26.332	29.141
157	Nepal	30.487	30.460	30.482	30.789	29.574	24.866	42.107	42.107	26.180	28.053
158	Haiti	26.146	26.141	26.146	26.193	26.468	25.533	31.686	31.686	25.571	25.709
159	Mauritania	24.427	24.467	24.434	23.907	29.600	22.525	25.807	25.807	25.419	28.996
160	Lesotho	20.203	20.265	20.214	19.438	25.527	28.413	11.552	11.552	24.962	26.363
161	Uganda	21.494	21.516	21.497	21.221	23.365	26.916	19.572	19.572	24.353	23.539
162	Togo	21.957	21.949	21.955	22.052	20.942	27.002	23.735	23.735	22.679	20.843
163	Comoros	22.883	22.886	22.883	22.819	24.379	21.387	28.299	28.299	22.374	23.519
164	Zambia	17.397	17.446	17.405	16.782	21.750	24.946	10.848	10.848	21.918	22.360
165	Djibouti	22.026	22.089	22.037	21.201	30.274	17.311	22.942	22.942	21.918	29.446
166	Rwanda	19.445	19.472	19.450	19.108	22.521	21.765	19.498	19.498	21.766	22.289
167	Benin	19.785	19.821	19.791	19.311	24.349	20.000	20.210	20.210	21.461	23.926
168	Gambia	20.154	20.182	20.158	19.789	24.234	18.308	23.205	23.205	20.396	23.473
169	Sudan	21.797	21.841	21.805	21.205	28.703	14.384	27.050	27.050	18.569	27.364
170	C"te_d_Ivoire	16.211	16.260	16.219	15.569	22.617	14.497	16.834	16.834	17.352	21.984
171	Malawi	15.433	15.446	15.435	15.274	16.866	19.617	15.931	15.931	17.352	16.708
172	Afghanistan	12.662	12.735	12.674	11.750	20.368	16.096	6.901	6.901	17.047	20.538
173	Zimbabwe	14.913	14.884	14.907	15.292	10.369	27.760	13.607	13.607	13.699	11.025
174	Ethiopia	14.303	14.328	14.308	13.964	18.958	9.531	20.290	20.290	11.720	17.696
175	Mali	9.167	9.230	9.178	8.366	16.860	8.771	7.698	7.698	11.111	16.393
176	Guinea_Bissau	6.585	6.653	6.596	5.734	14.191	9.213	2.412	2.412	10.198	14.120
177	Eritrea	13.670	13.651	13.666	13.863	13.748	10.625	23.300	23.300	9.589	12.374
178	Guinea	8.734	8.776	8.742	8.191	14.634	7.006	10.761	10.761	8.828	13.819
179	Centr_Afr_Rp	5.095	5.143	5.103	4.487	10.536	9.095	2.205	2.205	8.676	10.472
180	Sierra_Leone	4.069	4.125	4.079	3.375	10.321	7.678	0.744	0.744	7.610	10.243
181	Burki_Faso	9.400	9.456	9.410	8.662	17.493	4.316	12.218	12.218	6.849	16.363
182	Liberia	11.662	11.611	11.654	12.311	6.225	18.649	17.718	17.718	6.545	5.877
183	Chad	4.775	4.853	4.788	3.784	14.328	3.426	2.576	2.576	6.393	13.782
184	Mozambique	3.946	4.010	3.957	3.114	12.182	3.000	2.960	2.960	5.479	11.578
185	Burundi	3.891	3.894	3.891	3.839	4.505	10.039	4.570	4.570	4.566	4.361
186	Niger	3.675	3.710	3.681	3.203	9.571	0.000	8.228	8.228	1.370	8.372
187	Congo_Dem_Rp	0.000	0.000	0.000	0.000	0.000	7.925	0.000	0.000	0.000	0.000