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Are African Countries Richer Than They Are Developed?
A Multidimensional Analysis of Well-Being

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Abstract

Sen's capability approach inspired a new conception of development and succeeded in the Human Development Index (HDI). On the basis of HDI critics, we propose to enlarge the number of variables and we use 9 indicators of Standard of Living and 9 indicators of Quality of Life that allows measuring two components of well-being and that can be divided into various fields (health, education, environment, etc.) to provide a finest measurement of poverty. The empirical results for 170 countries in 2000 are based on two different multidimensional analysis of poverty, the Totally Fuzzy Analysis and the Factorial Analysis of Correspondences. The conclusions depend on the considered method but are generally similar. The paper focuses on the African continent and shows that some countries are "richer" than "developed" or inversely. The correlation matrix between different indicators reveals that education is a key variable for defining poverty. Comparisons extended with HDI classification and GDP per capita classification prove that monetary poverty is related with all other dimensions of poverty and that the HDI takes into account its essential dimension even if it can't be used to reduce some specific aspects as our original index.

Résumé

L'approche des « capabilités » de Sen a inspiré une nouvelle conception du développement et a abouti à l'Indice du Développement Humain (IDH). Sur la base des critiques de l'IDH, nous proposons d'élargir le nombre de variables et d'utiliser 9 indicateurs de Niveau de Vie et 9 indicateurs de Qualité de Vie permettant de mesurer deux éléments du bien être et pouvant être divisés en divers domaines (santé, éducation, environnement, etc) pour fournir une mesure plus fine de la pauvreté. Les résultats empiriques pour 170 pays en 2000 sont basés sur deux différentes analyses multidimensionnelles de la pauvreté, la « Totally Fuzzy Analysis » issue de la logique floue et l'Analyse Factorielle des Correspondances. Les conclusions dépendent de la méthode considérée mais sont généralement similaires. Le papier se focalise sur le continent africain et montre que certains pays sont plus « riches » qu'ils ne sont « développés » ou inversement. La matrice des corrélations entre les différents indicateurs révèle que l'éducation est une variable clé pour définir la pauvreté. Les comparaisons étendues avec la classification selon l'IDH et la classification selon le PIB par tête prouvent que la pauvreté monétaire est liée à toutes les autres dimensions de la pauvreté et que l'IDH prend en compte sa dimension essentielle même s'il ne peut pas être utilisé pour réduire certains aspects spécifiques comme notre indice original.

Chapter I: Introduction

The eight Millennium Development Goals[1] lie within a very specific scope of poverty reduction and they reflect an awakening of the multiple dimensions of development and well-being. International organizations have recognized that development goes beyond economic growth and that poverty is a multidimensional phenomenon that covers all dimensions of human well-being. Some of this recognition goes back to Sen's work on social justice and inequalities (1985, 1992), which inspired a new conception of development and poverty. His capability approach has contributed to the construction of the Human Development Index (HDI) in 1990, intended as a more comprehensive indicator for comparing the well-being of nations than income per capita. However, the HDI has received two essential critics. First, it has been argued that the number of indicators remains insufficient and that their selection is arbitrary. Second, the definition of the HDI is still inadequate to make the capability approach operational.[2] The originality of this article is to define two new composite indices across 170 countries, supporting Sen's capability approach. The first one we call "Standard of Living", the second one we call "Quality of Life". Focusing on 52 African countries, we adopt and compare two recent methodologies, the Totally Fuzzy Analysis (TFA) and the Factorial Analysis of Correspondences (FAC), to analyse the usefulness of these two new composite indices. The results are confronted with the HDI and income per capita (measured by per capita gross domestic product (GDP)), which also allows us to examine the cogency of the HDI and the closeness of the GDP per capita indicator with broader quality of life indicators.

This article is organized in the following way. Section 2 proposes the two new indices (Standard of Living and Quality of Life); section 3 is devoted to the justification and the presentation of the two methodologies for the analysis of the two new indices while the obtained results are presented and discussed in section 4. Lastly, section 5 provides our conclusions.

Chapter II: Concepts for Standard of Living and Quality of Life

Traditionally, GDP per capita is the most commonly used indicator to compare wealth among nations.[3] It refers to a concept of well-being and level of development exclusively based on material wealth. An insufficient income is merely one dimension of poverty and consequently, development cannot be apprehended by taking into account only economic performances. The neglect of qualitative aspects has been criticized and gave way to the emergence of new approaches of development and poverty reduction that were accompanied by new indicators taking into account other than economic aspects in the definition of well-being. Thus, the HDI was precisely created in 1990 by the United

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[1] The Millennium Development Goals are: (1) eradicate extreme poverty and hunger, (2) achieve universal primary education, (3) promote gender equality and empower women, (4) reduce child mortality, (5) improve maternal health, (6) combat HIV/AIDS, malaria and other diseases, (7) ensure environmental sustainability and (8) develop a global partnership for development.
[2] The literature on HDI critics is important. We will quote for example work of Ivanova et al. (1999), Kelley (1991), McGillivray (1991) and Srinivasan (1994).
[3] Even though GDP per capita is a flow concept, it is generally used as a measure of a stock concept.

Nations Development Programme (UNDP) to measure broader aspects of development as well as to reflect a new concept of how to achieve development.[4]

II.1.   Sen's Capability Approach and the Need for Going Beyond the HDI

The HDI is based on the theoretical Sen's capability approach (1985) which proposes a normative framework to evaluate individual well-being, social relationships and changes in societies.[5] The three main components of this approach are the "commodities" or resources, the "functionings" and the "capabilities". First of all, the "commodities" are the whole of goods and services, not necessarily merchants. They can also include transfers in kind and they have the characteristic to make possible the "functionings". The latter takes into account the achievements of individuals, i.e., what they "are" and what they "make" with their resources. They reflect the style of life an individual carries out. Lastly, the concept of "capabilities" is related to the concept of "functionings" but it also incorporates notions of opportunity and freedom; it is the whole of opportunities a person has and among which he/she can choose. Then, "capabilities" correspond to various combinations of functionings (beings and doings) that the person can achieve. "Capability is, thus, a set of vectors of functionings, reflecting the person's freedom to lead one type of life or another (...) to choose from possible livings" (Sen, 1992, p 40). A functioning is an achievement, while capability is about the aptitude to realize. Functionings are thus more directly related to living conditions. On the contrary, capability is a concept of freedom, in a positive term.

In accordance with Sen's proposed definition, the UNDP (1997) defines human development as the process of increasing people's choices by expanding their human capabilities and opportunities. According to this approach, poverty is not identified as a deprivation of basic needs but as a deprivation of basic capabilities or freedoms that would allow an individual to have the kind of life he/she wants. Sen's (1999) approach is both qualitative and multidimensional. Hence, it also calls into question the validity of an income-determined poverty line concept.

The HDI, supposed to make Sen's approach for international comparisons operational, has been improved, in particular for the GDP calculation and the extremes fixing (Jahan, 2002).[6] It has also permitted the development of other indices such as the Human Poverty Index (HPI). In 2001, the World Bank has reintroduced the term of "basic needs",[7] providing an intermediate approach between monetary poverty and the HDI. These basic needs that can change within time and according to the considered society, allow the calculation of a "poverty line" for each individual economy. In addition, several heterodox works of the World Bank consider indicators of inequality for the analysis of a right development. Nevertheless, Easterly (2002) and Pritchett, Suryahadi and Sumarto

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[4] The HDI is the arithmetic mean of three elements: health/longevity (life expectancy at birth), education measured by a combination of the literacy rate (2/3) and the school enrolment (1/3) and standard of living (GDP per capita expressed in real terms and purchasing power parity).

[5] His approach has not been only used in development economics but also in other analysis as political philosophy, social policy or welfare economics.

[6] Jahan (2002) presents the refinements in the methodology of the HDI over time and mentions the treatment of income as well as the fixing of minima and maxima for variables in 1994. Before, extremes changed from year to year and made impossible to carry out trend analysis of the HDI.

[7] The concept of "basic needs" was proposed by the *International Labour Organisation* in the 1970s and refers to Hicks and Streeten (1979). The concept was then reintroduced by the World Bank (2001).

(2000) use household data and do not consider problems related to the measurement of poverty but rather to the measurement of inequality.

After GDP per capita, the HDI is actually the most discussed measure of well-being. From this point of view, the literature seems to take two trajectories, which are not inevitably exclusive to each other. On the first trajectory, the main critics of the HDI are related to the index' very narrow definition of human well-being. New indices, sometimes excluding the income component, have been proposed without having its content necessarily justified or based on an explicit theoretical approach of well-being. For example, the Physical Quality of Life Index (PQLI) developed by Morris (1979) takes into account life expectancy, infant mortality and literacy. The Quality of Life Index of Dasgupta and Weale (1992) adds civil liberties and political rights to the HDI. The Index of Economic Well-Being proposed by Osberg and Sharpe (1998) falls under the same line, though it also takes into account all economic aspects of well-being neglected by the GDP per capita (like production stocks, inequality in income distribution and insecurity related to future income expectations). Besides, Rahman, Mittelhammer and Wandschneider (2003) propose a composite index of well-being taking in consideration eight social dimensions; each of which includes several indicators for social relationships, emotions, health, work, material well-being, civil and political liberties, personal security and quality of environment. Their index is assessed for 43 countries using the Borda rule[8] and the principal components analysis method. Simultaneously, several other work [see Qizilbash (2004), Ogwang and Abdou (2002), and Ivanova et al. (1999)] underline the difficulties and the risks to create indices, taking into account multidimensional aspects of poverty as well as the redundancy of variables and the measurement sensitivity to any weighing system.

On the second trajectory, the reductionistic character of the HDI is also denounced but critics imply either larger interrogations, like adequacy between the capability approach and the concept of human development (Gasper, 2002), or broader interrogations, concerning the contents and the empirical measurement of the concept of "capabilities". The majority of the work trying to make operational the capability approach use disaggregated data resulting from households surveys,[9] only some rare applications use aggregated data to allow international comparisons. Slottje (1991) uses 20 indicators to build a composite index of well-being for 126 countries. Similarly, Baliamoune (2003) takes explicitly Sen's capability approach and proposes to carry out a classification of countries according to new indicators supposed to be closed to the concept of freedom conveyed by the concept of "capability".

II.2. Alternative Applications of the Capability Approach

The work that tries to make Sen's approach operational has two weaknesses. First, they do not give a measurement of the concept of "capability". Taking into account the constrained availability of data, only "functionings" accomplished or carried out are in general used as a proxy of "capabilities". Second, these attempts are sometimes far away from the conceptual framework they are supposed to be linked to because the composite indices rely on a combination of indicators which are different by nature, some correspond

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[8] The Borda rule was first applied for a single-winner election in a voting system in which each voter rank-orders the candidates.
[9] For example, we can name the work of Schokkaert and van Ootegem (1990), Brandolini and d'Alessio (1998), Chiappero-Martinetti (2000), Lelli (2001) and Qizilbash (2002).

to "capabilities" (civil liberties and political rights), others to "functionings" (literacy rate) and some others to resources or assets (number of telephones per capita or income per capita). It is precisely the GDP per capita component of the HDI that can be called in question, in particular, if the HDI is conceived as a pure indicator of "capabilities". In the same vein, the concepts of well-being, standard of living and quality of life are generally not differentiated in these studies, while at the same time, they apply different concepts and realities. Finally, this work raises two highly correlated questions. The first one is the selection and the number of indicators to integrate in order to take the concept of human development into account. The second relates to new and more complete indices that aim at making the distinction between the various concepts of Sen's approach operational.

Sen does not give any explicit list of "capabilities" to take into account for the development of well-being indices and allows multiple proposals (Alkire, 2002). Consequently, nothing justifies theoretically and empirically the three selected indicators for the construction of the HDI compared to other indicators like the respect of political rights and civil liberties. Obviously, this selection suggests that if "capabilities" were carried out in these three basic dimensions, it would then be the case in the other dimensions of human development. The selection of indicators can clearly be called into question by taking again the three fundamental concepts of the capability approach into account. Indeed, while the indicators of education and life expectancy referred to "functionings", the income per capita component corresponds a priori to a "commodity". Of course, one can present income per capita as an approximation of "functionings" that the two other indicators do not seize. However, as Sen suggests, well-being is not determined by the possession of resources but by the transformation of these resources into "functionings" which depends on personal but also social and environmental factors. Precisely, the distinction between the "commodities", "functionings" and "capabilities" lets open the possibility of designing several composite indicators.

II.3. Justification of Standard of Living and Quality of Life indices

In order to take other dimensions of development into account, while respecting the distinction between the concepts, we define the composite indices of Standard of Living (SL) and of Quality of Life (QL). The distinction is justified on the basis of differentiation established between the "commodities" on the one hand, and the "functionings" and "capabilities" on the other hand. Thus, in our approach, SL corresponds not only to the quantity of various goods and services but also to the services the GDP allows to obtain. In other words, SL includes several indicators of means which correspond to "commodities" that could be identified as inputs. In the same manner, we define an index QL which includes, contrary to SL, more intangible or qualitative aspects such as the quality of education, the degree of child labor, the quality of the environment, etc. It corresponds to a combination of "functionings" and/or "capabilities" indicators within the meaning of freedoms. They can be identified as result indicators which would refer to output within a transformation logic of "commodities" as Sen suggests.

The selection of indicators in table 1 is justified with preceding arguments but it is also limited by the availability of data in order to get SL and QL indices for at least as many countries as there is data on the HDI and GDP per capita (we obtain 170 countries). In addition, the division of indicators between Standard of Living and Quality of Life is not always easy to establish for two reasons. First, the concept of "capability" is difficult to apprehend from country data because this concept is initially defined in reference to individuals and his/her relationships with other members in the society. Several lists of

"basic capabilities" were proposed in the literature (Alkire, 2002) to approach the concept of human development but their utility to identify indicators is limited in general to the disaggregated data resulting from households investigations. Second, several indicators can be interpreted at the same time as a "commodity", a "functioning" or a "capability". For example, the percentage of population having access to safe water, as an indicator of access, is related to the concept of "capability". In the same way, the percentage of working children, aged from 10 to 14, could be interpreted as a negative indicator of the level of education. It is consequently difficult to lead to a division of indicators which is not contestable.

Table 1: List of Selected Indicators

STANDARD OF LIVING	**STANDARD OF HEALTH** Public Health expenditure (% of GDP) Improved water source (% of population with access) Physicians (per 1000 people) **STANDARD OF EDUCATION** Age dependency ratio (dependents to working-age population) Public spending on education, total (% of GDP) Net primary enrolment ratio (%) **MATERIAL WELL-BEING** Vehicles (per 1,000 people) Roads paved (% of total roads) Televisions sets (per 1,000 people)
QUALITY OF LIFE	**QUALITY OF HEALTH** Under-weight or Under-height children under age five (%) Life expectancy at birth (years) Maternal mortality ratio reported (per 100,000 live births) **QUALITY OF EDUCATION** Literacy rate, adult total (% of people ages 15 and above) Labor force, children 10-14 (% of age group) Labor force, female (% of total labor force) **QUALITY OF ENVIRONMENT** Openness degree (trade, % of GDP) CO_2 emissions (metric tons per capita) Political Rights and Civil Liberties (index)[10]

Source: UNDP (2002) and World Bank (2002)

The SL composite index includes nine indicators that can be classified in three areas: standard of education, standard of health and standard of material well-being. Each area includes several other indicators which reflect different aspects. For example, for the standard of health, we select the public health expenditure as percentage of GDP to take into account the amount of produced resources devoted to the health sector, the number of physicians for 1,000 people which translates the decisions as regards prevention but also treatment and finally, the percentage of the population having access to safe water or sanitation as an indicator of public services development and their distributive aspect.

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[10] Indicators of political rights and civil liberties are available on *House of Freedom* web site: http://www.freedomhouse.org/ratings/index.htm

Similarly, QL composite index is a combination of nine indicators divided into three areas: quality of health, quality of education and quality of environment in a broad sense. For example, the quality of health includes three indicators corresponding to "functionings" that we could put in connection with the standard of health since this last gathers the indicators of means. Thus, the life expectancy is an indicator of capacity to carry out a long life, maternal mortality ratio accounts for the capacity to be able to give birth under salubrious conditions and the percentage of underweight or stunted children under age five accounts for the potentiality to be malnourished. Poverty in terms of these two indices is defined as a plurality of deficiencies in the considered areas.

Chapter III: Retained Methodologies for the Analysis of Standard of Living and Quality of Life

The development of indices SL and QL and more precisely the measurement of the deficiency or "deprivation" degree for each country in these two fields, require the choice of a suitable methodology for measurement. Taking the multidimensional aspect of poverty into account, we propose to use and compare the methodology from the fuzzy sets approach (the Totally Fuzzy Analysis) and the one from the simple Factorial Analysis of Correspondences.[11]

III.1. Measure of Standard of Living and Quality of Life Indices Using the *Fuzzy Sets Approach*

As components of human well-being, Standard of Living and Quality of Life are multidimensional and vague concepts. The fuzzy sets theory, which originated with Zadeh (1965) and was further developed by Dubois and Prade (1980), provides an adequate mathematical tool to analyse phenomena for which no clearly identifiable criteria exists to define the membership to a given set. The application of this methodology in economics is relatively new. The most famous studies based on fuzzy sets approach concern multidimensional analysis of poverty.[12] However, these different applications are usually based on micro-level data from census and household surveys but rarely on macro-level data. At our knowledge, Baliamoune (2003) made the first attempt in this area, deriving several indices of human well-being based on fuzzy sets. The fuzzy sets approach used in her paper yields the rankings for 48 countries and provides a measurement of their achievements or advantages in areas like education, life expectancy, political and civil rights, etc.

The construction of our composite indices for SL and QL via using the fuzzy theory follows two main steps. The first one concerns the definition of the membership function to a given set associated to each considered country and indicator. While the membership function can take several formulations [Lelli (2001) and Baliamoune (2003)], we consider the "Totally Fuzzy Analysis (TFA)" as defined originally by Cerioli and Zani (1990) in contrast to the "Totally Fuzzy and Relative" (TFR) defined by Cheli and Lemmi (1995).

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[11] Besides, these two methods were used in the context of individual data by Lelli (2001).

[12] Cerioli and Zani (1990) are the first to have applied it in this field. Other work followed such as those of Cheli and Lemmi (1995) who develop a slightly different version of the method, those of Chiappero-Martinetti (1996 and 2000), of Lelli (2001) who uses it to make operational Sen's capability approach and finally the one of Qizilbash (2002) who measures the vulnerability to poverty in South Africa.

The value of the membership function will provide a country-specific deprivation degree relative to a given indicator.

Assume $i \in [1, N]$ countries, $j \in [1, M]$ indicators of Standard of Living (SL) and $j' \in [1, M']$ indicators of Quality of Life (QL). Consider $X_j = \{ x_j / j = 1...M \}$ and $X_{j'} = \{ x_{j'} / j = 1...M' \}$ vectors of components respectively of Standard of Living and Quality of Life. Variables x_j^i and $x_{j'}^i$ are the values taken by indicators j and j' for the ith country. When ranking values of j and j' by increasing order (i.e., the lower the value of a given indicator, the higher is the deprivation), functions $\mu_j(i)$ and $\mu_{j'}(i)$ are defined as follows:

$$\mu_j(i) = \begin{cases} 1 & si \quad x_j^i \leq x_j^{min} \\ \dfrac{x_j^{max} - x_j^i}{x_j^{max} - x_j^{min}} & if \quad x_j^{min} < x_j^i < x_j^{max} \\ 0 & si \quad x_j^i \geq x_j^{max} \end{cases}$$

with $x_j^{min} = Min_i (x_j^i)$ and $x_j^{max} = Max_i (x_j^i)$

Functions $\mu_j(i)$ and $\mu_{j'}(i)$ provide the deprivation degrees of the ith country relative to indicators j and j'.

Inversely, if values of indicators are reordered by decreasing values (which is the case for CO_2 emission), functions $\mu_j(i)$ and $\mu_{j'}(i)$ are then defined in the following manner:

$$\mu_j(i) = \begin{cases} 1 & if \quad x_j^i \geq x_j^{max} \\ \dfrac{x_j^i - x_j^{min}}{x_j^{max} - x_j^{min}} & if \quad x_j^{min} < x_j^i < x_j^{max} \\ 0 & if \quad x_j^i \leq x_j^{min} \end{cases}$$

These functions are increasing linearly between zero and one according to the degree of deprivation.

In a second step, the different degrees of deprivation obtained for each country and each indicator need to be summarized in order to obtain the composite indices of SL and QL for each country. In this perspective, poverty can be defined as an accumulation of "deprivations" or "shortfalls" according to the different considered dimensions. Inversely, the index value can be interpreted as an accumulation of "effective achievements". Following Cerioli and Zani (1990), composite indices are defined by taking the weighted arithmetic mean of the membership functions according respectively to the component M and M' indicators:[13]

$$\mu_{SL}(i) = \sum_{j=1}^{M} \omega_j \mu_j(i)$$

$$\mu_{QL}(i) = \sum_{j'=1}^{M'} \omega_j' \mu_j'(i)$$

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[13] As Chiappero-Martinetti (1996) underlines it, the function must have a value ranging between the maximum and the minimum and must allow interaction between the various indicators.

With $\omega_j \geq 0 \quad and \quad \sum_{j=1}^{M}\omega_j = 1$

Where ω_j and $\omega_{j'}$ are the weights attributed respectively to indicators j and j'.

The weights are defined as follows:[14]

$$\omega_j = \frac{\ln\left(\dfrac{1}{\overline{\mu}_j}\right)}{\sum_{j=1}^{M}\ln\left(\dfrac{1}{\overline{\mu}_j}\right)} \quad with \quad \overline{\mu}_j = \frac{1}{N}\sum_{i=1}^{N}\mu_j(i)$$

The weight ω_j is an inverse function of the mean deprivation level relative to the indicator j. In this manner, a more important weight is given to the indicators that are more widespread between the considered countries. As an illustration, if access to improved water represents a fundamental basic need at an international level, it follows that a lack of access to this service must to be considered as a symptom of poverty or under-development.

According to the given formulations above, the higher the SL (respectively the QL) for a given country i, the closer to zero is the value index. Inversely, the closer the value of the composite index is to one, the higher is the degree of deprivation relative to the SL (respectively the QL).

The application of the fuzzy sets methodology to several socio-economic indicators yields country rankings according to indices SL and QL. Due to the additively decomposable property of fuzzy indices, SL and QL can be broken down in order to obtain several sub-indices by area (education, health, environment, etc.). The decomposition permits to provide important basic information about the level and the structure of poverty and particularly about domains that contribute the most to the state of deprivation and under-development. It also offers information to policy makers for the design of structural socio-economic policies aimed at eradicating the main causes of poverty and under-development. The identification of areas where structural intervention is necessary could lead to the building of structures in order to improve accessibility to education, health services, etc.

Due to its definition, the TFA measurement of poverty overpasses the common limitations addressed to the traditional one-dimensional poverty measure based on income. It does not make use of a poverty line, which serves of partitioning the considered sample between "poor" and "non-poor". As it is well known, beyond country rankings, building international indexes of well-being can be used by international organisations to justify the allocation of development assistance. At first glance, the TFA method cannot theoretically define the number of countries that could receive aid to help building socio-economic structures in a given area, except if arbitrarily defining a poverty line. However, it is possible to adopt a dichotomous approach to derive a critical value from the cumulative

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[14] The logarithmic curve function introduced into the weighting system translates the idea that poverty does not vary in a linear way.

distribution of the deprivation index in terms of SL, QL and their components. This critical value which can be defined for each index and their components serves as a threshold to estimate the number of countries experiencing a genuine deprivation in a particular dimension. It follows that the critical value (or breaking value) $\mu_j crit$ associated to indicator j can be defined as:

$$F\left(\mu_j crit\right) = 1 - \overline{\mu}_j$$

With F the cumulative distribution function and $\overline{\mu}_j$ the average value of indicator j which indicates, in a dichotomous perspective, the proportion of poor countries according to j.

The TFA method offers various possibilities in order to capture the information provided by well-being socio-economic indicators among nations. The most frequent critics addressed to this kind of method relates to the choice of a weighting system. Precisely, one way to test the robustness of rankings is to confront results obtained with the TFA to those issued from Factorial Analysis of Correspondences (FAC).

III.2.   Charts of SL and QL Obtained by Factorial Analysis of Correspondences

The Factorial Analysis of Correspondences (FAC) is a descriptive method for qualitative data suggested by Benzécri et al. (1973) in order to study contingency tables. Data are presented in a N_{IJ} table in which the rows (countries) are numbered by $i = 1, ..., p$ and the columns (indicators) by $j = 1, ... , q$. Alternatively, the P_{IJ} table, whose general term is $p_{ij} = n_{ij} / n$, allows to have the two marginal distributions: $p_{i\bullet} = n_{i\bullet} / n$ and $p_{\bullet j} = n_{\bullet j} / n$ as well as the conditional distributions in rows and columns, called "row" profiles and "column" profiles, respectively: $p_j^i = p_{ij} / p_{i\bullet}$ and $p_i^j = p_{ij} / p_{\bullet j.}$

To measure the distance between two profiles, we compare the same rank terms (for example, p_j^1 and p_j^2). The χ^2 distance between the row profiles is $d(i,i')$ whose square is given by $d^2(i,i') = \sum_{j=1}^{q}(p_j^i - p_j^{i'})^2 / p_{\bullet j}$

The χ^2 distance between the column profiles is defined in a similar way: $d^2(j,j') = \sum_{i=1}^{p}(p_i^j - p_i^{j'})^2 / p_{i\bullet}$

FAC provides orthogonal basis vectors – principal axes – preserving the distances and calculated according to the least squared method. The origin of the axes, $(0,0)$ characterizes the marginal distribution, the centre of gravity or the "average country".

The duality principle makes it possible to represent the two "profiles" on the same chart, to interpret the proximity between a row and a column profiles, and thus, to explain the connection between two variables.[15] The clouds of points $N(I)$ and $N(J)$ on the principal axes correspond to projections as close as possible from observations. Two values for interpretations are calculated: the contribution (variance) and the quality of representation (squared cosine). Contributions are used to measure the influence (the weight) of a point (for example of a country i) in the definition of a principal axis. The sum of the contributions for each axis equals one. Then, the proximity between projections

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[15] The FAC duality principle is essential but it is a difficult property whose interpretation is delicate. For more precision, consult Foucart (1997) or Casin (1999).

does not always reflect the proximity between the profiles. Some points can be badly represented or moved away from the profiles they represent. Angle θ measures the proximity between the point in space and its projection on the plan. Thus, a weak angle indicates a good proximity (the square cosine is close to one) whereas an angle close to 90° (the square cosine is close to zero) indicates a bad proximity.

We applied these two methods to 170 countries for the year 2000, using the indicators in table 1. In the following section, we present the general results and focus more particularly on the 52 countries available (out of the total 53 African countries; Sao Tome & Principe is missing due to lack of data).

Chapter IV: Results for African Countries

The two methodologies give us the classification of 170 countries according to SL and QL. For the factorial analysis of the correspondences, the classification results from the coordinates on axis 1, available only for SL and QL. On the other hand, the TFA also presents the classification for the different areas of SL (health, education, and material) and QL (health, education, and environment) with a numerical value allowing other calculations, such as correlations or percentages of deficit countries in a particular area.

IV.1. Indices and Sub-Indices for Standard of Living and Quality of Life
The TFA method enables us to calculate SL and QL as well as the various sub-indices (health, education, material, and environment) for each of the 170 countries. Table 2 recalls the statistical indicators of these indices and sub-indices. The determination of the breaking value in relation to the average scores by geographical region (International and African Countries) allows evaluating the percentage of countries having a deficit in each area (Table 3). From an international point of view, poverty in material terms is the area where the deprivation is the highest.

Table 2: Statistical Indicators for SL and QL Components at an International Level

	AVERAGE	STANDARD DEVIATION	MEDIAN	BREAKING VALUE
STANDARD OF LIVING	**0.421**	**0.186**	**0.397**	**0.431**
HEALTH	0.380	0.208	0.349	0.427
EDUCATION	0.365	0.180	0.307	0.374
MATERIAL	0.622	0.262	0.668	0.527
QUALITY OF LIFE	**0.217**	**0.130**	**0.179**	**0.341**
HEALTH	0.218	0.191	0.136	0.391
EDUCATION	0.249	0.183	0.215	0.398
ENVIRONMENT	0.184	0.099	0.162	0.253

All the African average scores are higher than the international average scores, meaning that Africa is the poorest region in the world. High deprivation levels in terms of SL characterize the African continent as 96.2 per cent of the 52 African countries have an insufficient SL index. From a dichotomic point of view, where countries could be described as "rich" or "poor", African countries would express deficiencies in each area. All the average scores are higher than the breaking values, suggesting that Africa is "poor" and cumulate handicaps in all SL dimensions: health, education and material well-being. As for the one-dimensional approach of poverty based on income, we can define the deficit intensity and dispersion within the countries. For example, at an international level, the standard of education shows the most important inequalities among all the countries

having a deficit. Africa is the continent in which the poverty width is the highest whatever the component of the SL index we consider. Material well-being is the area where poverty is the deepest in Africa, though inequalities in Africa are higher for the standard of education.

Table 3: Average Score and Percentage of Countries Having a Deficit in Various Areas

	INTERNATIONAL		AFRICAN COUNTRIES	
	Average Score	**%**	**Average Score**	**%**
STANDARD OF LIVING	**0.421**	**64.7**	**0.599**	**96.2**
STANDARD OF HEALTH	0.380	38.2	0.549	75.0
STANDARD OF EDUCATION	0.365	36.5	0.540	80.8
MATERIAL WELL-BEING	0.622	61.2	0.826	94.2
QUALITY OF LIFE	**0.217**	**21.2**	**0.335**	**51.9**
QUALITY OF HEALTH	0.218	21.8	0.415	57.7
QUALITY OF EDUCATION	0.249	24.7	0.422	59.6
QUALITY OF ENVIRONMENT	0.184	18.2	0.191	13.5

Concerning the QL index, the analysis of the components reveals that Africa is the only region presenting deficiencies in all considered areas. Nevertheless, in comparison with the results obtained for the SL index, we note that the percentage of countries having a deficit in term of quality of life is much weaker. It also turns out that indicators of depth and dispersion have very low values. With regard to Africa, quality of education is the area with the greatest number of deficit countries. Although recording a lower value, quality of health is characterized by relatively high dispersion values. Thus, 57.7 per cent of deficit African countries are relatively unequal concerning quality of health.[16]

IV.2.   Analysis of Correlations and Rank Changes

The correlations of SL and QL indices with their components (like with GDP per capita and the HDI) were calculated to propose the differences and to see whether our indices reflect the same "poverty". The matrix of correlations (Appendix 1) reveals that quality of environment is the only indicator which is not statistically correlated neither with SL and QL nor with the other indicators. The main reason is the heterogeneity of the quality of environment components (trade openness, CO_2 emissions and liberties and freedoms). From a more general point of view, the various indicators are statistically and significantly correlated the ones with the others. The matrix of correlations (Appendix 2) also shows that GDP per capita is more strongly correlated with the SL index than with the QL index, which can be conceived in a capability approach. Moreover, the coefficients of correlation between our two indices and the HDI are higher than with GDP per capita, which shows that our indices are closer to the HDI than to GDP per capita, hence, reflect better "human poverty". We can also notice that SL is most strongly correlated with standard of education and QL with quality of education, which confirms that "education" plays an important part in the definition of a "poor" or "rich" country.

Another way of apprehending well-being in Africa is to look at the rank changes in the classification of various countries according to SL and QL indices, GDP per capita and the HDI. Some results are presented in Appendix 3. Thus, the same country can be much

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[16] For other results, especially in European countries, Arabic countries or Mediterranean countries, see Bérenger and Verdier-Chouchane (2004).

better or much worse classified according to the considered index. The very strong rank variations then give an indication on the deficiencies of some indices. For example, it is preferable to privilege the Standard of Living rather than the Quality of Life index to classify North African countries (Egypt, Libya, Algeria, Tunisia). The rank is higher according to GDP per capita for Equatorial Guinea, Gabon, Namibia, Botswana and South Africa, and one could conclude that these countries are richer than they are developed. On the contrary, the Quality of Life is more important than other measures in Ghana, Tanzania and Zambia.

IV.3. Graphical Analysis for Africa

The factorial analysis of correspondences was initially carried out at a world level (for 170 countries), though the charts have been created for the 52 African countries. In other words, coordinates of African countries concerning SL and QL indices are analysed compared to global data for 170 countries.

Figure 1: Standard of Living in African Countries
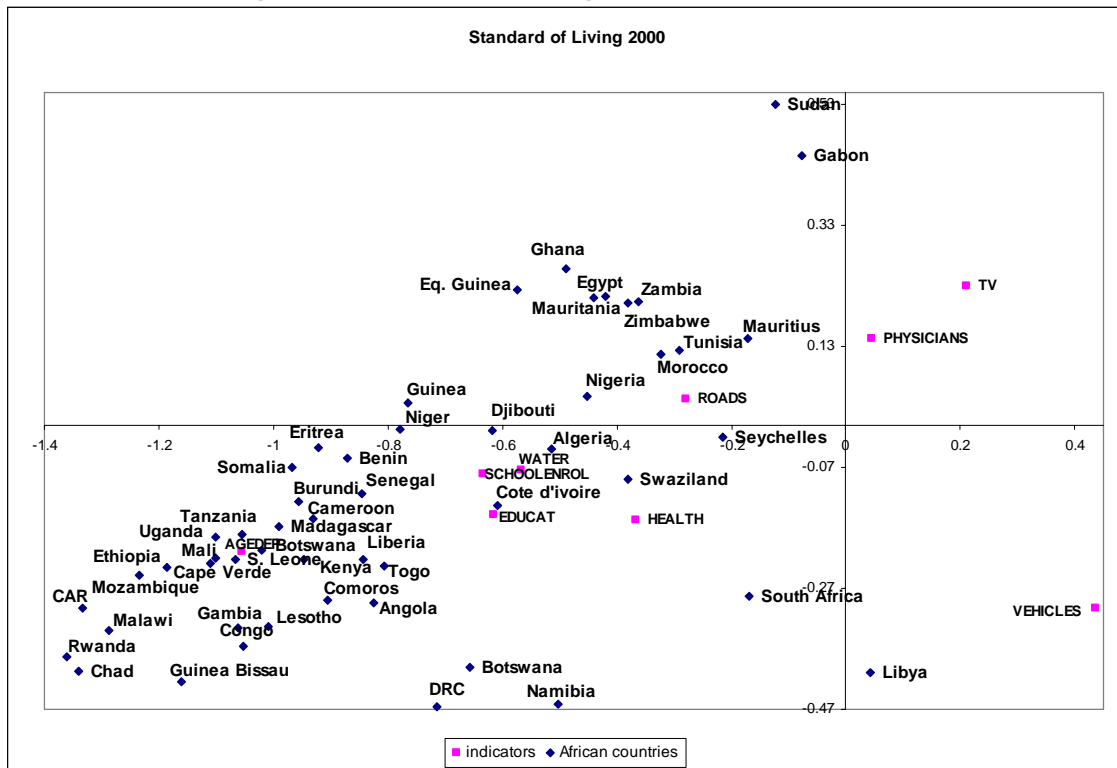
First of all, concerning the Standard of Living (Figure 1), the most representative indicators on axis 1 are for access to safe water, education and transport. These are the indicators whose contributions and square cosines are the highest. Thus, we can consider that on the left side, there are the countries having a low level of public education expenditure and a problem with the populations' access to safe water. We find almost all the African countries on the left side. We notice that all the African countries have negative coordinates and are behind the centre of gravity, which would correspond to the

international "average".[17] On axis 2, material well-being (vehicles and TV) is more important in the top quadrant, i.e., in particular for North-African countries.

Figure 2: Quality of Life in African Countries
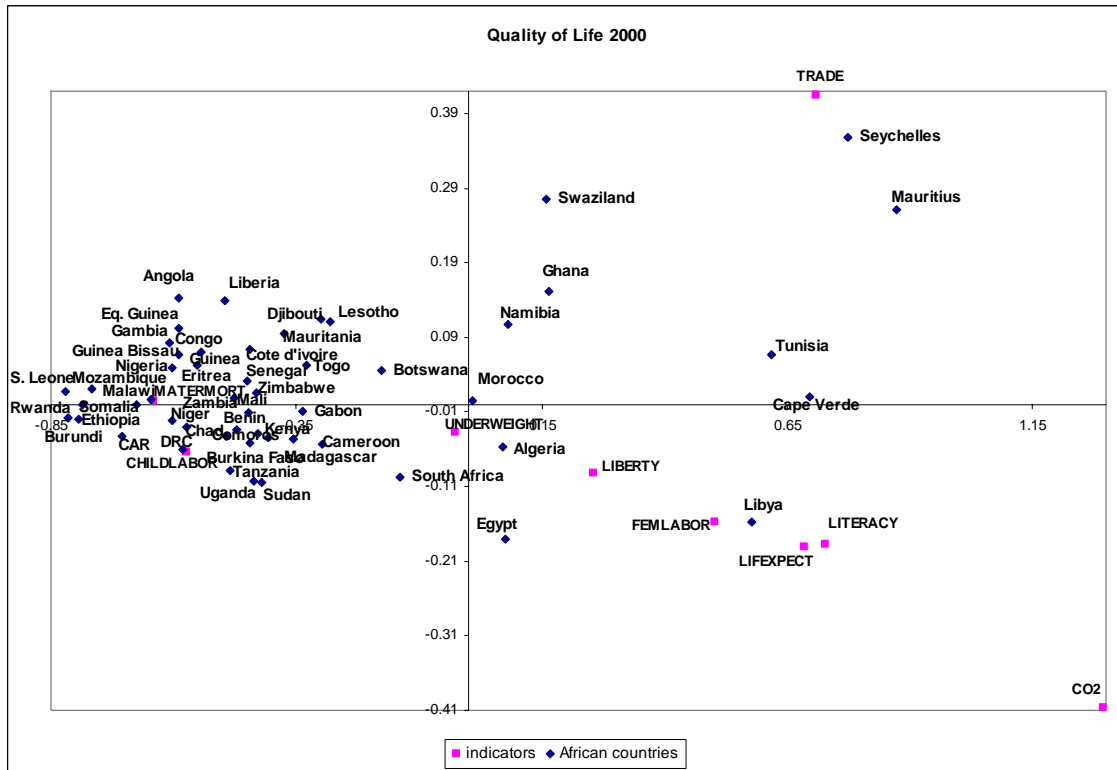
The same analysis for the QL index indicates that African countries are placed primarily according to trade openness, life expectancy and literacy rate. As previously, we find in the right top quadrant the "richest" countries. Contrary to the SL index, several countries have positive coordinates on axis 1, which indicates that their quality of life is higher than the international average. This is the case for the North-African countries but also for some of the islands (Cape Verde, Mauritius, Seychelles). The other countries are rather close to each other and form a relatively homogeneous group where the life expectancy is weak and the literacy rate low.

IV.4. Comparison Between the Two Methods

In order to compare the two methods and to conclude on the results robustness, we classified the various countries by ascending order of poverty and examined first the differences in classification and the weighting systems of the sub-indices and, in a second time, the rank correlations. The two methods of poverty analysis do not indicate exactly the same results, nor do they give the same ranking.[18] These differences come primarily

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[17] In the analysis which will follow, we will evoke only the countries "well represented graphically" i.e. those whose square cosine is higher than 0.50.

[18] For example, out of 52 African countries, TFA and FAC give Morocco the 8th rank concerning the Standard of Living, Cameroon is 32nd with the FAC and 30th with the TAF but the spread can be more important as for Central African Republic (respectively, 50th and 36th). Concerning QL, FAC gives Seychelles the first rank and Mauritius the second, the TFA gives the inverse order. Côte d'Ivoire is respectively 26th and 31st.

from the weights given to the indicators. Indeed, table 4 shows the various weights granted to the sub-indices in 2000. The weights for the FAC are defined by the contributions of the sub-indices (the sum of the area indicators) in the calculation of axis 1. The weights resulting from the TFA method simply correspond to ω_j and $\omega_{j'}$.

Table 4: Weights of Indicators According to the Methods

	STANDARD OF HEALTH	STANDARD OF EDUCATION	MATERIAL WELL-BEING	TOTAL	QUALITY OF HEALTH	QUALITY OF EDUCATION	QUALITY OF ENVIRONMENT	TOTAL
WEIGHTS TFA	0.3526	0.4486	0.1988	**1.0**	0.3540	0.3279	0.3181	**1.0**
WEIGHTS FAC	0.2507	0.2932	0.4561	**1.0**	0.5804	0.2172	0.2024	**1.0**

Thus, the TFA grants the highest weight to standard of education (more than 43 per cent) in the calculation of the SL index and to the quality of health in the QL index (more than 35 per cent). Respectively, the FAC gives the highest weight to material well-being (more than 45 per cent) and to quality of health (more than 58 per cent).

Consequently, the weighting system modifies appreciably the results and explains the differences in the obtained rankings for all African countries. However, from a more comprehensive point of view, the matrix of the rank correlations (Appendix 4) proves that differences in ranking are not significant and on the contrary, the obtained rankings with TFA and FAC methodologies are statistically correlated. We can notice that the coefficients of correlation between the two methods remain appreciably important, giving credit to good classifications and selection methods.

Another set of interesting results relates to the correlation between the SL and QL indices determined by the two methods, GDP per capita, and the HDI. First of all, the coefficients of correlation of the two methods are systematically lower with GDP per capita than with the HDI, but they remain generally high, meaning that "monetary" poverty is strongly related to poverty in all its other dimensions. Second, a high correlation is also found between rankings of countries according to GDP per capita and the HDI ($R^2 = 0.94$), a result we could expect since GDP per capita is one of the three components of the HDI. Third, the strong correlations between SL and QL indices with the HDI indicate that, in spite of the serious critics addressed at the HDI concerning its reductionist character of human well-being, it turns out to perform well in reflecting the essential dimensions of poverty.

Finally, our results are robust and reinforcing each other since the rankings of countries according to TFA, FAC, HDI and GDP per capita are not very different. In other words, monetary poverty (expressed by GDP per capita) conditions the development possibilities of standards of education and health and the acquisitions of material assets but is also related to the quality of environment, health and education in a country. This result is not surprising even if the meticulous study of the rank variations can bring nuances to this simple idea.

Chapter V: Conclusion

The two methods of poverty analysis we proposed, the TFA and the FAC, have the advantage of taking into account several dimensions of poverty, such as liberties, child

labor, number of vehicles for 1,000 inhabitants, etc. The results obtained stress the importance of education as a key variable in the multidimensional development of a country. The results also show that African countries have important deficiencies in the various areas, except perhaps for the quality of environment. Our analysis also compares monetary poverty with the HDI and the SL and QL indices, which we constructed by completely excluding income or any other monetary indicator. The weighting systems of the analysis methods appreciably modify the obtained rankings. However, by considering the rank correlations, the differences between the two methods are not significant. The high coefficients of correlation indicate, in a general point of view, our results are robust and mutually reinforcing. They also permit to reconsider critics addressed to the UNDP for integrating monetary poverty in the calculation of the HDI. Whereas it seems a priori restrictive, the HDI takes finally the essential indicators into account, since it establishes country rankings very close to those of our two indices. However, taking into account their diversity and their originality, the SL and QL indices cover a vaster area of indicators than the HDI. From a conceptual point of view, they are also closer to the definition of Sen's capability and allow assessing two measurements of human well-being, related to the standard of living and to the quality of life. With the TFA method, the two indices can be disaggregated and information can be better exploited to ease the settlement of socio-economic policies in order to fight structural causes of poverty.

In the African context, the MDGs defined during the United Nations Summit in September 2000 are far away to be achieved. Fighting poverty and improving living conditions of people will certainly be the most difficult challenges over the coming years. Our indices confirm that they are priority goals in African countries, particularly in education.

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APPENDIX 1: Matrix of Correlations for Indices and Sub-Indices

	STANDARD OF HEALTH	STANDARD OF EDUCATION	MATERIAL WELL-BEING	QUALITY OF HEALTH	QUALITY OF EDUCATION	QUALITY OF ENVIRON.	STANDARD OF LIVING	QUALITY OF LIFE
STANDARD OF HEALTH	1							
STANDARD OF EDUCATION	0.72889 (<0.0001)	1						
MATERIAL WELL-BEING	0.74575 (<0.0001)	0.66131 (<0.0001)	1					
QUALITY OF HEALTH	0.78611 (<0.0001)	0.80929 (<0.0001)	0.73164 (<0.0001)	1				
QUALITY OF EDUCATION	0.71107 (<0.0001)	0.82384 (<0.0001)	0.68980 (<0.0001)	0.79712 (<0.0001)	1			
QUALITY OF ENVIRON.	0.16860 (0.028)	0.14462 (0.0599)	-0.03223 (0.6765)	0.09053 (0.2403)	0.21796 (0.0043)	1		
STANDARD OF LIVING	0.85466 (<0.0001)	0.89685 (<0.0001)	0.88348 (<0.0001)	0.86252 (<0.0001)	0.86198 (<0.0001)	0.10992 (0.1536)	1	
QUALITY OF LIFE	0.71498 (<0.0001)	0.77968 (<0.0001)	0.61419 (<0.0001)	0.79214 (<0.0001)	0.93196 (<0.0001)	0.50722 (0.0001)	0.81180 (<0.0001)	1

APPENDIX 2: Matrix of Correlations with GDP per capita and HDI

	STANDARD OF LIVING	QUALITY OF LIFE	GDP	HDI
STANDARD OF LIVING	1			
QUALITY OF LIFE	0.8096 (<0.0001)	1		
GDP	-0.71151 (<0.0001)	-0.50248 (<0.0001)	1	
HDI	-0.92149 (<0.0001)	-0.80397 (<0.0001)	0.75804 (<0.0001)	1

Notes:

1/ Calculations carried out on the basis of 166 informed countries.

2/ The GDP per capita we use throughout this article is GDP per capita expressed in current dollars based on purchasing power parity (PPP), identical to the GDP per capita measure UNDP uses for the calculation of the HDI.

3/ The negative correlation coefficients are simply explained by the fact that high levels of SL and QL indices correspond to values close to zero, contrary to GDP per capita and the HDI.

APPENDIX 3: Rank Variations According to Various Indices in Africa

Rank Variations	Spread between SL and QL	Spread between SL and GDP	Spread between QL and GDP
According to:	QL	GDP	GDP
Africa % of displaced countries	**32.7%**	**42.9%**	**32.7%**
Most important deteriorations	Egypt (-56) Libya (-36) Algeria (-31) Tunisia (-23) Comoros (-21) Rwanda (-21)	Egypt (-36) Congo Rep. (-25) Zambia (-22) Comoros (-21) Rwanda (-18)	Zambia (-48) Tanzania (-42) Malawi (-42) Congo Rep (-42) Ghana (-41) Madagascar (-32)
Greatest improvements	Ghana (57) Djibouti (49) Liberia (44) Tanzania (37) Nigeria (29)	Equ. Guinea (107) Gabon (54) Namibia (53) Botswana (46) South Africa (38)	Equ. Guinea (113) South Africa (52) Libya (50) Botswana (46) Gabon (46) Namibia (43)

Rank Variations	Spread between GDP and HDI	Spread between SL and HDI	Spread between QL and HDI
According to:	HDI	HDI	HDI
Africa % of displaced countries	**64.0%**	**57.1%**	**65.3%**
Most important deteriorations	Equ. Guinea (-70) South Africa (-55) Botswana (-55) Namibia (-50) Gabon (-41) Swaziland (-37)	Egypt (-52) Zimbabwe (-43) Algeria (-34) Botswana (-27) Malawi (-25) Congo Rep. (-19)	Zambia (-32) Djibouti (-29) Ghana (-28) Benin.(-27) Cape Verde (-22)
Greatest improvements	Congo Rep. (25) Madagascar (14) Tanzania (14) Malawi (10) Comoros (9)	Equ. Guinea (37) Libya (32) Ghana (15) Gabon (14) Madagascar (14)	Libya (50) Equ. Guinea (43) Seychelles (17) Rwanda (15) Eritrea (14)

APPENDIX 4: Matrix of Rank Correlations

	SL (FUZZY)	QL(FUZZY)	SL (FAC)	QL (FAC)	GDP	HDI
SL (FUZZY)	1					
QL (FUZZY)	0.82894 (<0.0001)	1				
SL(FAC)	0.832065 (<0.0001)	0.71765 (<0.0001)	1			
QL (FAC)	0.8960 (<0.0001)	0.75068 (<0.0001)	0.843957 (<0.0001)	1		
GDP	-0.83276 (<0.0001)	-0.68621 (<0.0001)	0.867768 (<0.0001)	0.864837 (<0.0001)	1	
HDI	-0.91287 (<0.0001)	-0.79406 (<0.0001)	0.887808 (<0.0001)	0.926069 (<0.0001)	0.94121 (<0.0001)	1