Composite Indices for Multidimensional Development and Poverty: An Application to MDG Indicators

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Abstract: The measurement of development or poverty as multidimensional phenomena is very difficult because there are many theoretical, methodological and empirical problems. The literature of composite indicators offers a wide variety of aggregation methods, all having pros and cons. In this paper, we propose a new and alternative composite index denoted as MPI (Mazziotta-Pareto Index) which, starting from a linear aggregation, introduces penalties for the countries or geographical areas with 'unbalanced' values of the indicators. As an example of application of the MPI, we consider a set of indicators in order to measure the MDGs and we present a comparison among HDI (Human Development Index) methodology, HPI (Human Poverty Index) methodology and the MPI.

Keywords: composite indicators, development, poverty, ranking.

JEL Classification: C43 – Index numbers and aggregation; I32 - Measurement and Analysis of Poverty; O10 – Economic development: general.

1. Introduction[1]

Many socioeconomic phenomena are complex and therefore difficult to measure and to evaluate. Complexity implies also multidimensionality. Development and poverty are two socioeconomic important concepts that for a long time have been substantially regarded as unidimensional, especially by economists: the first has been usually measured by personal income or by per capita product, while the second has been measured as lack of income or low expenditure.
Recently, there is a growing international consensus about the multidimensional nature of both development and poverty, and their irreducibility to the income dimension.[2]

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[1] The paper is the result of the common work of the authors: in particular P. De Muro has written Sects 1 and 2; M. Mazziotta has written Sects. 4.1 and 5; A. Pareto has written Sects. 3, 4.2 and 4.3.
[2] This concerns also other related socioeconomic phenomena such as well-being, quality of life, and standard of living.

The Millennium Development Goals, adopted by the United Nations General Assembly in 2000, reflect this advanced vision.[3]
The shift from a single dimension to multiple dimensions, by enlarging and enriching the scope of the analysis, represents an important theoretical progress and has some relevant advantages in terms of policy. However, notwithstanding those benefits, the multidimensionality makes the measurement and evaluation of development and poverty more difficult. In fact, while measuring and assessing a given single dimension can be done with a single indicator, multiple dimensions require a set of various indicators. This multiplicity implies a number of theoretical and statistical problems, especially when we need to make comparisons over time and/or space.
The fundamental question is what is the better approach to (re)present complex phenomena and multidimensional realities. This work try to give some answers. The aim of the work is twofold. Firstly, we briefly discuss the main theoretical and methodological problems related to the multidimensional analysis of development and poverty (Section 2). Secondly, we consider the need to build composite indices of development and poverty that have some desirable properties. To this end, we propose a new composite index, the Mazziotta-Pareto Index (MPI) and compare it with some existing composite indices (Sections 3 and 4). The empirical comparison is made by using a number of national and regional single indicators that are included in the set of indicators chosen by the UN to monitoring the progress toward the MDGs (Section 5). Finally, we briefly discuss the results of the comparison and draw some conclusions (Section 6).

2. Measuring development and poverty

2.1 From one to many dimensions

The modern concept of development has entered the international political and economic discourse soon after the end of World War II. Since then, most of the international development scholars and organizations has evaluated the development level and process mainly by using the per capita product or income. Of course, many other variables have been generally used to analyze the development process, but per capita product or income has been always used as the main –and often only– measure of the ultimate outcome of this process. In other terms, per capita product or income has been the paramount measure of development for decades. In this dominant view, development was essentially unidimensional and largely coincided with economic growth.
From the end of the 1950s (Galbraith, 1958), but especially in the 1960s and 1970s there has been an increasing dissatisfaction with this approach: «...it has become increasingly evident, particularly from the experience of the developing countries, that rapid growth at the national level does not automatically reduce poverty or inequality or provide sufficient productive employment» (World Employment Conference, 1976, p. 15). «Dudley Seers talked about "dethroning the GNP"» (Ranis, 2005) and in the *The Meaning of Development* he defined development as «the reduction and elimination of poverty, inequality and unemployment within a growing economy» (Seers, 1969).

[3] For further information about the MDGs see the web site http://www.un.org/milleniumgoals.

The critique about the meaning of development gave birth in the Sixties and Seventies to new lines of research on unconventional measures of development. If the main goal of development was meeting (basic) human needs (World Employment Conference 1976; 1977), than the appropriate measure of development should not be based on (per capita) income, but rather on the quality of life of people and its progress.
The scientific research on alternative measures of development was carried out firstly at the United Nations Research Institute for Social Development (UNRISD), where composite indices of development were elaborated using a bundle of physical, social and cultural indicators (UNRISD, 1970). Another important contribution was given by two researchers (Morris and Liser, 1977) at the Overseas Development Council that created the Physical Quality of Life Index (PQLI).
By the end of the Seventies there was a large consensus among social scientists about the fact that «the phenomenon of "development" or the existence of a chronic state of "underdevelopment" is not only a question of economics or the simple quantitative measurement of incomes, employment and Gini coefficient», but «is now viewed as a multidimensional process» (Todaro, 1979, p. 224).
A further fundamental contribution in this direction has been given in the following decades by Amartya Sen (1985, 1992, 1999) and other scholars, that elaborated the "capability approach", and by the *Human Development Reports* (HDRs)[4], prepared by the United Nations Development Programme (UNDP), that put into practice some of Sen's ideas together with the research experience of the previous decades. The HDRs propose a comprehensive multidimensional approach to development – the human development paradigm – that has a sound theoretical reference (the capability approach) and includes a battery of composite indices of development and poverty. Two of those indices, the Human Development Index (HDI) and the Human Poverty Index (HPI), will be discussed and used in the following sections of this work.
The UNDP indices are not the only composite indices that have been produced in the last thirty years. In fact, along with a mounting attention toward multidimensional development,[5] there is a growing number of composite indices that have been proposed worldwide by scholars and institutions. Here we can not present a review of those indices. The OECD Global Project "Measuring Progress of Societies"[6] is working on indicators that go beyond GDP and undertakes methodological research on accounting frameworks and composite indices.
Regarding poverty, the persistence of the unidimensional income-based approach has been longer and stronger than in the case of development. As a matter of fact, most of the official measurements of poverty at national or international level are made even now with reference to monetary income or consumption. In the scientific literature there are still a few examples of multidimensional poverty indices. The HPI (Anand and Sen, 1997), introduced by UNDP in the 1997 HDR, has been one the first examples of non-monetary composite index of poverty.

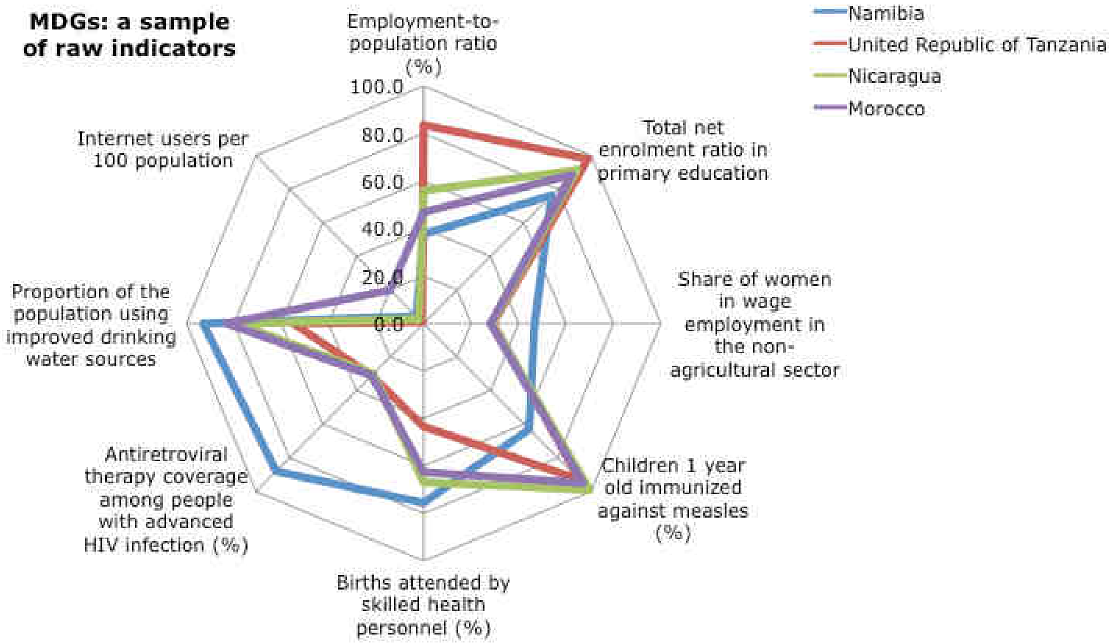
[4] See the web site http://hdr.undp.org.
[5] See the notable International Conference "Beyond GDP" organised jointly by the European Commission, the European Parliament, the Club of Rome, the WWF and the OECD in 2007.
[6] See the web site http://www.oecd.org/progress.

2.2 Working with many dimensions

Once the multidimensionality is recognized, measuring development has a number of theoretical and methodological problems that are not present in the conventional unidimensional approach.
The first problem concerns the choice of the development dimensions: which and how many dimensions are relevant and should be considered or privileged. This is also called by Sen the problem of the appropriate "informational basis" (Sen, 1999), that is which information is included or excluded in the evaluation exercise. This selection is often driven by the availability of statistics, but it has actually deep theoretical implications and strongly affects the results of the evaluation. In fact, each informational basis correspond to a particular concept of justice or ethics (Sen, 1999). Therefore, the choice of the informational basis should not avoid an explicit discussion and value judgement. A related technical problem concern the choice of the indicators that adequately represent each of the selected dimensions. In this work we will not discuss the problem of the informational basis, because it is outside the scope of the work. In the following sections, as informational basis we will use the eight MDGs and their related indicators.
The second problem concerns the use of the included information. The following sections will focus on this problem. Once the relevant dimensions and indicators have been selected and normalized, we often need to compare them in time and/or space in order to make evaluations. There are at least two alternative ways to make comparisons with multiple indicators: the first is to use "development profiles"; the second is to combine the various indicators into a composite index.
A development profile shows how the various indicators of development varies across dimensions. This approach has some advantages: there is no lost of information and the performance in each single dimension is transparent, allowing for an detailed check-up. However, there is also an important drawback: unless all the values of the indicators are lower or higher for one country (or in one period) compared to the others, we cannot rank the countries (or the periods). In order to illustrate this problem, we present in Figure 1 a comparison between development profiles of four countries.
The eight indicators that have been used are a sample taken from the official list of 60 MDGs indicators. Each indicator refers to a different development goal (or dimension). Looking at the figure it is clear that by simply comparing the four profiles, while is possible to say which country is doing better in each single dimension, it is not possible to say which country is globally doing better. In other words, it is not possible to rank the countries if we do not aggregate the indicators.
The second way to make comparison in time and/or space is to combine the various indicators in a composite index. Composite indices have the advantage of allowing the ranking of countries (or periods), because they represent the overall development level in one number. Notwithstanding, building composite indices implies loosing a certain amount of information and produce results that are less transparent. Furthermore, composite indices have been criticized because, in a way, they re-introduce unidimensionality.
However, as monitoring progress toward development goals often requires overall comparison over space or time, composite indices are very useful for specific purposes.

For instance, if we want to know which countries are doing more progress toward the overall eight MDGs and which countries are doing less progress, we need to build a composite index.

Figure 1: *Comparing development profiles*



The main problem in the construction of composite indices of development is how to aggregate the information. The aggregation problem concerns two interrelated aspects: the assignment of weights to the components when combining them (Scott, 2004) and the choice of the synthetic function. After having normalized (or also standardized) the indicators,[7] there are a number of possible aggregation strategies:

1. Using the arithmetic mean. This approach is often used, because is very simple and easy to apply and to interpret. An implication of the arithmetic mean is that the weights of the components are completely arbitrary. The approach has two versions:
   a. Simple (non weighted) mean. This implies that all the weights are equal and that all the components (dimensions) are perfectly substitutable. Although the equal weights give the impression that this is a "neutral" approach in which there is no hierarchy between dimensions, indeed this approach makes an implicit very strong assumption about the perfect substitutability between dimensions. This assumption has a weak theoretical justification, especially when the components are fundamental dimensions like health and knowledge. This approach has been used to build the HDI by the UNDP;
   b. Weighted mean. In this case, if the weights are not equal, that implies that the substitutability between components is not perfect. This approach is more theoretically consistent, but the weights remains arbitrary;

[7] This part of the methodology will be discussed in the following sections.

2. Using factorial analysis (e.g. principal components, correspondence analysis). Apparently, this approach seems more "objective" because the weights are not assigned by the researcher but rather by a statistical technique. In this way, weights seems not arbitrary and more "scientific", because they are extracted from the data. However, this approach has a couple of serious shortcomings. First, given that the weights are obtained from the data, they are not constant over both time and space and this make very difficult the comparisons. Second, the factorial analysis assigns weights to the original variables on the basis of their variance and covariance. This criteria not necessarily reflects the relative socioeconomic importance of the various dimensions. Therefore, even if with this statistical approach the weights are apparently objective, yet they have not a sound theoretical foundation;

3. Using a power mean or an adjusted mean. With this approach we can have both imperfect substitutability and implicit non arbitrary weights.
   a. A power (or generalized) mean of order greater than one is very useful when we wish to build composite indices of poverty. This mean «places greater weight on those dimensions in which deprivation is larger» (Anand and Sen, 1997, p. 16). This approach has been used to build the HPI by UNDP. Similarly, a power mean of order smaller than one (but grater than zero) can be used to build composite indices of development when we wish to place greater weight on those dimensions in which development is lower. In this case, the power mean penalizes countries (or periods) that have a more "unbalanced" development across dimensions.
   b. An adjusted mean. Another way to penalize unbalanced performances is to adjust the arithmetic mean by using a penalty coefficient or function. This can be done in different ways. In section 4, we will present a methodology for building a class of composite indices of development or poverty (MPI) which includes a penalty coefficient that is function of the variability across dimensions ("horizontal variability").

According to Sen (1999, p. 81): «there is … a strong methodological case for emphasizing the need to assign explicitly evaluative weights to different components of quality of life (or of well-being) and then to place the chosen weights for open public discussion and critical scrutiny». In principle, this would require to use the approach "1b", rather than «some wonderful formula that would simply give us ready-made weights that are "just right"» (Sen 1999, p. 79). However, in some cases to assign evaluative weights and then submit them to open public discussion is not possible. In the latter cases, the approach "3" is the best one.

In the following sections, we will present and compare three composite indices of development and poverty and their properties – the HDI, the HPI and the MPI. The indices uses different aggregation criteria: we will apply those aggregation criteria to a set of MDGs indicators in order to discuss how the different approaches affect the results.

3. HDI and HPI methodologies

In this section, we consider the methodological aspects related to the Human Development Index (HDI) and Human Poverty Index (HPI) construction (UNDP, 2007).

3.1 The Human Development Index

The HDI is a composite indicator of human development based on the arithmetic mean. It is measures the average achievements in a country or geographical area in three basic dimensions: (i) wellbeing, (ii) knowledge, (iii) standard of living. The list of used indicators is showed in table 1.

Table 1: *List of individual indicators of the HDI*

N.	Description	Minimum value	Maximum value
	WELLBEING		
1	Life expectancy at birth (years)	25	85
	KNOWLEDGE		
2	Adult literacy rate (%)	0	100
3	Combined gross enrolment ratio (%)	0	100
	STANDARD OF LIVING		
4	Gross Domestic Product per capita (PPP US$)	100	40,000

The steps in the construction of the HDI are the following.

i) Normalization
Let **X**={x_{ij}} be the matrix with n rows (countries or geographical areas) and 4 columns (indicators in table 1). The normalized matrix **Y**={y_{ij}} is computed as follows:

$$y_{ij} = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)}$$

where $\min(x_j)$ and $\max(x_j)$ are the minimum and maximum values (*goalposts*) for the j-th indicator reported in table 1[8].

ii) Aggregation
The HDI is given by:

[8] Let us note that the logarithm of income is used for the GDP per capita normalization.

$$\mathrm{HDI}_i = \frac{y_{i1} + y_{i5} + y_{i4}}{3}$$

where

$$\mathrm{y}_{\mathrm{i5}} = \frac{2y_{i2} + y_{i3}}{3}.$$

The HDI is then computed as a simple arithmetic mean of the three dimension indices. The main characteristic of this methodology is that it assumes a complete substitutability among the dimensions of human development: a deficit in one dimension can be compensated by a surplus in another (e.g. a good standard of living can always substitute any knowledge deficit).

3.2 The Human Poverty Index

While the HDI measures average achievement, the HPI measures deprivations.
There are two type of HPI: the HPI-1 for developing countries and the HPI-2 for selected OECD countries. Both the indices are based on the mean of order three.
The HPI-1 measures deprivations in the three basic dimensions of human development captured in the HDI while the HPI-2 captures social exclusion too. Calculating HPI-1 and HPI-2 is more straightforward than calculating HDI since the indicators used to measure the deprivations are already normalized between 0 and 100.
In this context, we will refer to HPI-1. The indicators used are listed in table 2.

Table 2: *List of individual indicators of the HPI-1*

N.	Description	Minimum value	Maximum value
	WELLBEING		
1	Probability at birth of not surviving to age 40 (times 100)	0	100
	KNOWLEDGE		
2	Adult illiteracy rate (%)	0	100
	STANDARD OF LIVING		
3	Percentage of population not using an improved water source	0	100
4	Percentage of children under weight-for-age	0	100

Being $\mathbf{X}=\{x_{ij}\}$ the matrix with n rows (countries or geographical areas) and 4 columns (indicators in table 2), the formula used to compute the HPI-1 is:

$$\mathrm{HPI\text{-}1}_i = \left(\frac{x_{i1}{}^3 + x_{i2}{}^3 + x_{i5}{}^3}{3} \right)^{1/3}$$

where

$$x_{i5} = \frac{x_{i3} + x_{i4}}{2}.$$

In this case, the use of the mean of order three for calculating the composite indicator allow to give greater weight to the dimension in which there is the most deprivation.

4. An alternative methodology: the MPI

4.1 General aspects

The MPI (Mazziotta and Pareto, 2007) wants to supply a composite measure of a set indicators that are considered “non-substitutable” (all components must be “balanced”).
It is designed in order to satisfy the following properties:

i) normalization of the indicators by a specific criterion that delete the unit of measure and the variability effect (Delvecchio, 1995);
ii) synthesis independent from an “ideal unit”, since a set of “optimal values” is arbitrary, non-univocal and it can vary during the time;
iii) simplicity of computation.

These properties can be satisfied by the following approach. It is known, the distributions of different indicators, measured in different way, can be compared by the transformation in standardized deviations (Aureli Cutillo, 1996). Therefore, it is possible to convert the individual indicators to a common scale with a mean M=100 and standard deviation S=10: the obtained values will range approximately in the interval (70; 130)[9].
In this type of normalization the “ideal vector” is the set of the mean values and it is easy individuate both the units that are over the mean (values greater than 100) and the units that are under the mean (values less than 100).
In this context, it is possible to introduce a penalty coefficient that is function, for each territorial units, of the indicators variability in relation to the mean value (“horizontal variability”): this variability can be measured by the *coefficient of variation*. The proposed approach penalizes the score of each units (the mean of the standardized values) with a quantity directly proportional to the “horizontal variability”. The purpose is to favourite the units that, mean being equal, have a greater balance among the indicators values.
Finally the use of standardized deviations allows to obtain a “robust” measure and less influenced by *outliers* (Mazziotta C. *et al.*, 2008).

4.2 Steps for computing the MPI

The MPI building proceeds in the following stages.

i) Normalization

[9] On the basis of Bienaymé-Cebycev theorem, the terms of the distribution within the range (70; 130) are at least 89% of the total of terms.

Let $\mathbf{X}=\{x_{ij}\}$ be the matrix with n rows (countries or geographical areas) and m columns (development or poverty indicators) and let M_{x_j} and S_{x_j} denote the mean and the standard deviation of the j-th indicator:

$$\mathrm{M}_{x_j}=\frac{\sum_{i=1}^{n}x_{ij}}{n}; \qquad \mathrm{S}_{x_j}=\sqrt{\frac{\sum_{i=1}^{n}(x_{ij}-\mathrm{M}_{x_j})^2}{n}}.$$

The standardized matrix $\mathbf{Z}=\{z_{ij}\}$ is defined as follows:

$$z_{ij}=100\pm\frac{(x_{ij}-\mathrm{M}_{x_j})}{\mathrm{S}_{x_j}}10$$

where the sign ± depends on the relation of the j-th indicators with the phenomenon to be measured (+ if the individual indicator represents a dimension considered positive and – if it represents a dimension considered negative).

ii) Aggregation
Let cv_i be the coefficient of variation for the i-th units:

$$\mathrm{cv}_i=\frac{\mathrm{S}_{z_i}}{\mathrm{M}_{z_i}}$$

where:

$$\mathrm{M}_{z_i}=\frac{\sum_{j=1}^{m}z_{ij}}{m}; \qquad \mathrm{S}_{z_i}=\sqrt{\frac{\sum_{j=1}^{m}(z_{ij}-\mathrm{M}_{z_i})^2}{m}}.$$

Then, the generalized form[10] of MPI is given by:

$$\mathrm{MPI}_i^{+/-}=\mathrm{M}_{z_i}(1\pm\mathrm{cv}_i^2)=\mathrm{M}_{z_i}\pm\mathrm{S}_{z_i}\mathrm{cv}_i$$

where the sign of the penalty (the product $\mathrm{S}_{z_i}\mathrm{cv}_i$) depends on the kind of phenomenon to be measured and then on the direction of the individual indicators (De Muro, Mazziotta and Pareto, 2008).

If the indicator is "increasing" or "positive", i.e. increasing values of the indicator correspond to positive variations of the phenomenon (e.g. the development of the country or geographical area), then MPI^- is used. Vice versa, if the indicator is "decreasing" or "negative", i.e. increasing values of the indicator correspond to negative

[10] It is a generalized form since it includes "two indices in one".

variations of the phenomenon (e.g. the poverty of the country or geographical area), then MPI^+ is used.

4.3 MPI as development and poverty measure

The possibility to add or subtract the penalty depending on the phenomenon nature allow to construct appropriate measures of development and poverty.

1) Development Index
   The MPI of development is given by:

$$MPI_i^- = M_{z_i} - S_{z_i} cv_i$$

   where the mean of the standardized values is adjusted subtracting a quantity proportional to the standard deviation and direct function of the coefficient of variation.
   The higher is the index, the more developed is the country or geographical area. The index assumes high value when the mean is high and the standard deviation is low.
   The MPI^- results are different from HDI methodology because the second one does not penalize in the case of an “unbalanced” set of indicators.

2) Poverty Index
   The MPI of poverty is obtained as:

$$MPI_i^+ = M_{z_i} + S_{z_i} cv_i$$

   where the mean of the standardized values is adjusted adding a quantity proportional to the standard deviation and direct function of the coefficient of variation.
   The higher is the index, the poorer is the country or geographical area. The index assumes high values when the mean is high and the standard deviation too.
   The MPI^+ results are very similar to the HPI methodology because both indices penalize in the same “direction”.

5. An application to MDGs indicators

In order to compare the different methodologies considered, a double application is presented where seven human development indicators (the data are referred to the years 2006-2008) and seven poverty indicators (years 2003-2006) from MDGs are selected. The list of indicators is reported in table 3.
The indicators are intentionally chosen so that they have the property of non-substitutability: it is very important that there are not compensative effects among indicators so relevant for the description of the regions development and poverty. In fact, the indicators have been selected so that they treat different subjects about development and poverty. The geographical domains are the 10 world macro-areas (tables 4 and 5) but it is also presented a focus on singles countries (figures 2 and 3).

Table 3: *List of individual indicators of human development and poverty*

Description	Label
HUMAN DEVELOPMENT	
Total net enrolment ratio in primary education (%)	D1
Literacy rate of 15-24 year-olds (%)	D2
Employees in non-agricultural wage employment who are women (%)	D3
Proportion of seats held by women in national parliament	D4
Proportion of 1 year-old children immunised against measles	D5
Proportion of population using an improved drinking water source	D6
Number of internet users per 100 population	D7
HUMAN POVERTY	
Proportion of population living below $1 (PPP) per day	P1
Prevalence of underweight children under-5 years of age (%)	P2
Proportion of population below minimum level of dietary energy consumption	P3
Infant mortality rate	P4
Under-5 mortality rate per 1,000 live births	P5
Maternal deaths per 100,000 live births	P6
Number of tubercolosis cases per 100,000 population	P7

The individual indicators are normalized by MPI method (section 4.2) and so they have the same mean (M=100) and variability (S=10) (in tables 4 and 5, the indicators values are not standardized). The aim is to compare three different aggregation methods in order to measure the development and the poverty of the ten macro-areas. The functions are the mean (HDI method), the mean of order three (HPI method) and the MPI.
In table 4, the MPI is calculated with the negative sign because we are measuring the development (MPI^-).

Table 4: *Human development indicators - Years 2006-2008*

Regions	D1	D2	D3	D4	D5	D6	D7	Mean (HDI method)	Mean of order 3 (HPI method)	MPI-
CIS Europa	92.8	99.7	52.2	13.9	99.0	97.0	20.2	109.847	110.130	109.561
Latin America	95.5	97.0	42.3	22.2	93.0	92.0	18.7	109.190	109.317	109.065
Eastern Asia	94.3	99.2	41.1	19.8	93.0	88.0	12.5	106.416	106.482	106.351
CIS Asia	93.9	99.6	47.9	13.9	95.0	88.0	6.0	104.227	104.637	103.807
South-Eastern Asia	95.0	95.6	37.8	17.4	82.0	86.0	9.9	102.756	102.893	102.619
Northern Africa	95.0	86.5	21.3	8.3	96.0	92.0	10.4	99.579	100.178	98.974
Western Asia	88.3	92.8	20.3	9.1	88.0	90.0	13.5	98.951	99.367	98.524
Southern Asia	89.9	79.9	18.6	12.9	66.0	87.0	9.7	94.215	94.745	93.676
Sub-Saharan Africa	70.7	72.1	30.8	17.3	72.0	58.0	3.4	88.652	89.598	87.721
Oceania	78.0	70.6	36.4	2.5	70.0	50.0	5.2	86.166	86.775	85.570
Mean	89.3	89.3	34.9	13.7	85.4	82.8	11.0			
Standard Deviation	8.0	10.8	11.2	5.6	11.5	14.8	5.2			

The differences among the methods are very low and it is useless to compute the respective rankings. Nevertheless, it is interesting to note that the MPI^- values are lower than the mean (HDI method) values because there is the penalty effect.
In table 5, the MPI is calculated with the positive sign because we are measuring the poverty (MPI^+). The main aspect seems to be the convergence among the mean of order three and MPI^+ results; in fact, for many areas it is necessary to add more of three decimals in order to find the differences. Therefore, if the aim is to evaluate the poverty of areas the HPI and MPI^+ methods produce the same results.

Table 5: *Human poverty indicators - Years 2003-2006*

Regions	P1	P2	P3	P4	P5	P6	P7	Mean (HDI method)	Mean of order 3 (HPI method)	MPI+
Sub-Saharan Africa	50.3	28.0	31.0	94.0	157.0	900.0	521.0	121.088	121.306	121.312
Southern Asia	38.6	46.0	21.0	61.0	81.0	490.0	287.0	111.089	111.323	111.319
South-Eastern Asia	17.8	25.0	12.0	27.0	35.0	300.0	264.0	100.564	100.728	100.728
CIS Asia	5.4	7.5	20.0	40.0	47.0	51.0	140.0	97.584	97.849	97.846
Eastern Asia	17.8	7.0	12.0	20.0	24.0	50.0	197.0	95.840	95.972	95.972
Western Asia	3.8	13.0	9.0	32.0	40.0	160.0	51.0	95.142	95.218	95.219
Latin America	8.0	8.0	10.0	22.0	27.0	130.0	67.0	94.098	94.115	94.115
Northern Africa	3.8	6.0	4.0	30.0	35.0	160.0	45.0	93.200	93.295	93.296
CIS Europa	5.4	2.4	3.0	15.0	17.0	51.0	118.0	91.394	91.450	91.450
Mean	16.8	15.9	13.6	37.9	51.4	254.7	187.8			
Standard Deviation	15.9	13.5	8.4	23.6	41.2	265.0	144.4			

The results of the three methodologies, both for development and for poverty indicators, are very similar because the normalization method of the elementary data is the same. Besides, it is difficult to find many differences when there are few geographical areas.
This last assumption is not true when there are many territorial units; in figure 2, a specific example is presented in the case of human development measure. There are two countries: the Rwanda has many indicators approximately at the same level and only one with a very high value (high development in the indicator D4); the Ghana has all indicators more or less at the same low level. The mean is calculated and the result is a ranking of the world countries: Rwanda is in position 73 and Ghana in the position 126; subsequently the MPI^- is computed and Rwanda passes in position 95 and Ghana in position 123. Rwanda loses 22 positions because the indicators distribution is not uniform and the "horizontal variability" is the function that penalizes the arithmetic mean. The Ghana ranks (mean vs. MPI^-) are similar because the variability of the indicators distribution is very low.
In figure 3, an example in the case of human poverty measure is presented; so, in this case, the verse of the indicators is opposite and the higher is the indicator the poorer is the country: the penalty function is added to the mean. The mean is calculated: the Tajikistan is in the position 37 and Turkey in the position 111; the MPI^+ is computed and Tajikistan is 30 and Turkey is 111. The Tajikistan is penalized (7 positions) because the indicators distribution is variable and presents two values very different than the others; the Turkey position is constant because the indicators variability is very low.

Figure 2: *Human development measure: a comparison of countries*

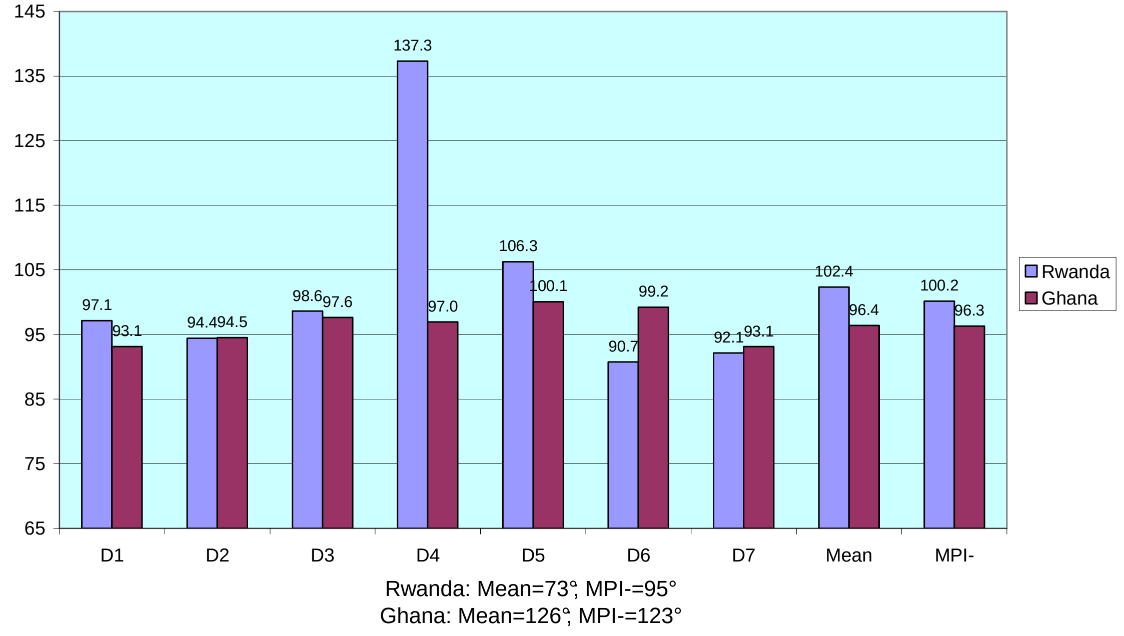
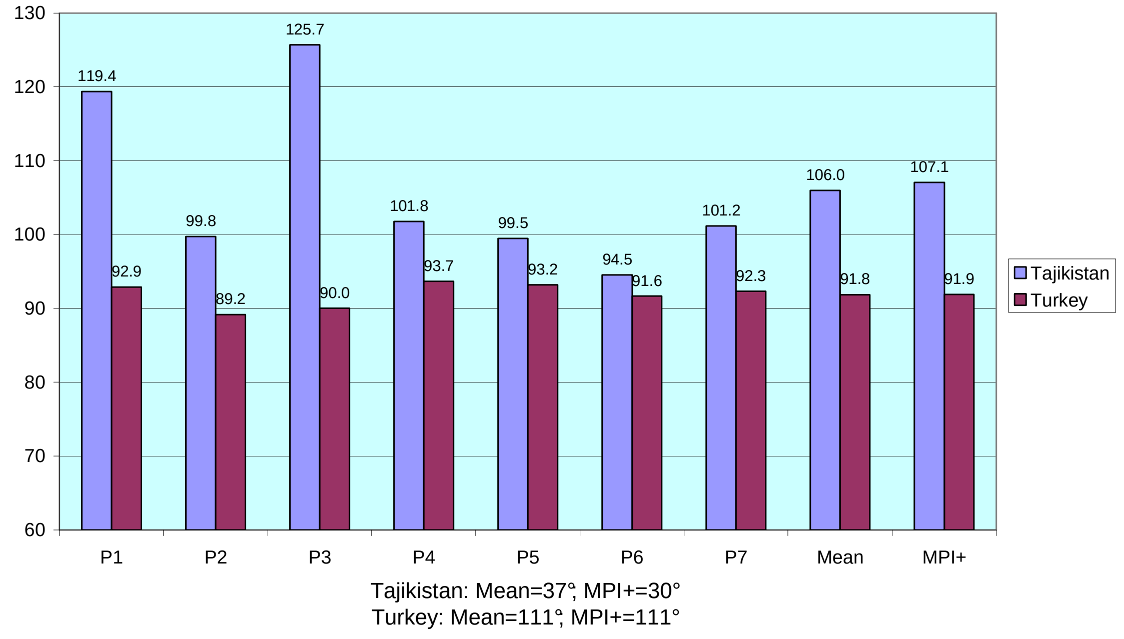


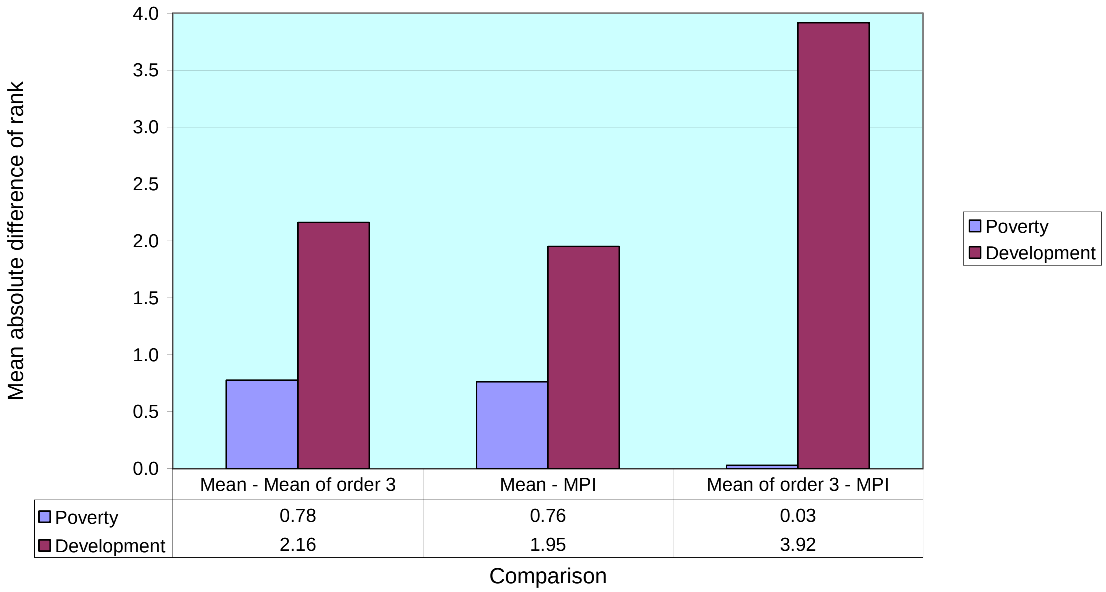
Figure 3: *Human poverty measure: a comparison of countries*



In figure 4, a comparison of countries rankings is shown and the "tool" used is the mean absolute difference of rank. In the case of poverty measure, the differences among the three aggregation methods are very low in fact they are under 1; in particular the mean absolute difference of rank between the Mean of order three and MPI^+ is substantially equal to 0. In the case of development measure, the distances are more relevant

specially for the comparison between Mean of order three and MPI^- in fact, on average, every country changes, more or less, 4 positions.
Finally, these two aggregation methods are coincident when the poverty is measured and they are very different when the development is measured.

Figure 4: *Comparison of final rankings by different aggregation methods*



6. Concluding remarks

The change from unidimensional to multidimensional development and poverty measurement is without any doubt an important theoretical progress and presents many advantages for policy-making. However, there is also a flip side, because multidimensional measurement implies many theoretical, methodological and empirical problems.
The international literature on composite indices of development and poverty offers a wide variety of aggregation methods. We have discussed the pros and cons of some methods. Considering the desirable properties that such composite indices should have, we have proposed a new and alternative composite index denoted as MPI (Mazziotta-Pareto Index) which, starting from a linear aggregation, introduces penalties for the countries or geographical areas with 'unbalanced' values of the indicators. In this way, MPI assumes imperfect substitutability between various dimensions of development or poverty.
We have applied the MPI to a set of MDGs indicators. The MDGs represent a multidimensional approach to development: in fact, they include eight goals that are measured by 60 different indicators. In order to synthesise the information about each country or to monitoring overall progress toward the goals it is useful to aggregate the indicators and to build composite indices. Using MDGs data, we have presented a

comparison among HDI (Human Development Index) methodology, HPI (Human Poverty Index) methodology and the MPI.
HPI metodology and MPI results are similar when the poverty is measured because both indices penalize in the same “direction”. On the contrary, MPI is different from HDI methodology when the development is measured because the second one does not penalize in the case of an “unbalanced” set of indicators.
In summary, the MPI is an alternative composite index based on the property of non substitutability of indicators that wants, in the scientific outline, both to respect the desirable characteristics of a composite index and to be validly applied to different scientific contexts.
In fact, this methodology leaves from the versus and from the range of the elementary indicators. Therefore, the MPI can be a useful “tool” to synthesize multidimensional phenomena, with particular regard to the poverty and development measure.

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