Paper Proposal

Measuring and Monitoring Poverty and Wellbeing: Introducing a new class of indexes for the synthesis of multidimensionality

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Abstract
The aim of this paper is to introduce a new class of indexes for the synthesis of multidimensional poverty and wellbeing.
The class of indexes introduced is anchored theoretically on the capability approach and its philosophical understanding of development processes. "The capability approach proposes a change – a serious departure – from concentrating on the means of living to the actual opportunities of living in itself" (Sen, 2009: 17). The essential idea of the capability approach is that social arrangements should aim to expand people's capabilities – their freedom to promote or achieve valuable beings and doings.
This new class of indexes is thought to monitoring and therefore presents relevant desirable properties advancing the current debate. Among the properties we require, the most important are: full sensitiveness, flexible rate of substitution between achievements, and straightforward interpretation of the results. All these properties are obtained through a transparent and accountable process that overcome the so called "inescapable arbitrariness " (Anand and Sen, 1997: 16)", that can therefore be open to public scrutiny as suggested by Amartya Sen.

Keywords: Measurement, Multidimensional Wellbeing, Multidimensional Poverty, Composite Multidimensional Index, Sustainable Human Development, Capability Approach.

1. Introduction

Measuring and monitoring poverty and wellbeing is a key topic in the agenda 2030 debate. The international community reached a large consensus on the 17 Sustainable Development Goals (SDGs) that resulted in an increasing need for a consistent monitoring system in all countries. The complexity of the concepts to measure requires the identification of many indicators, which however turn out to manage especially when comparisons across territories and/or over time are required. The synthesis of indicators has been deeply studied and in the last decades a part of the literature on social indicators has been focused on summarising multidimensional achievements into unidimensional measures.[1]

In this paper, we introduce a new approach to synthesis of multidimensional indicators of poverty and wellbeing. It is important to point out that although the synthesis of indicators involves several phases, here we focus merely on the central phase related to aggregation, taking into account both theoretical and empirical aspects.

From a theoretical perspective, the approach introduced in this paper conceptually refers to the capability approach and its philosophical understanding of development processes, focusing not merely on means of living but on the actual opportunities of living in itself (Sen, 2009: 17). In particular, the essential idea of the capability approach is that social arrangements should aim to expand people's capabilities – their freedom to promote or achieve valuable beings and doings. Moreover, following Aristotle, the capabilities of a person have been associated with human flourishing, suggesting that they can be realized in many different ways (Nussbaum, 2000).[2] Therefore, "the focus of the CA is not just on what a person actually ends up of doing, but also on what she is capable of doing, whether or not she chooses to make use of that opportunity" (Sen, 2009: 17). Indeed, "Since any choice of weights should be open to questioning and debating in public discussions, it is crucial that the judgments that are implicit in such weighting be made as

[1] It is not clear if this proxy aims to measure an unidimensional latent variable or it is just a summary of the k dimensions, but this does not influence the development of a proper function.

[2] "To define what well-being means, a multidimensional definition has to be used. Based on academic research and a number of concrete initiatives developed around the world, the Commission has identified the following key dimensions that should be taken into account. At least in principle, these dimensions should be considered simultaneously: (i) Material living standards (income, consumption and wealth); (ii) Health;(iii) Education; (iv) Personal activities including work (v) Political voice and governance; (vi) Social connections and relationships; (vii) Environment (present and future conditions); (viii) Insecurity, of an economic as well as a physical nature. All these dimensions shape people's well-being, and yet many of them are missed by conventional income measures." (Stiglitz, Sen and Fitoussi 2009: 14).

clear and comprehensible as possible, and thus be open to public scrutiny" (Anand and Sen, 1997: 6).

Any procedure aiming to provide a reduction in the dimension of the data leads to a loss of information. Thus, the function summarizing the data is generally chosen in order to obtain the larger reduction associated to a reasonable loss. Nonetheless, it must be noted that the function chosen to synthesize the original data often entails some hypotheses implicitly induced by its mathematical structure. These hypotheses, that should ideally reflect the aims of the index, are not always easy to justify and sometimes appear more as inevitable consequences of the methodology chosen than the result of theoretically sound considerations.
Following these basic considerations, we decided to first focus on the characteristics that the synthetic indicator should guarantee and then tried to derive a consistent mathematical structure.

In our opinion, the main properties are:
i) full sensitivity of the synthesis to any change in the achievements of the observed case; ii) a consistent structure of substitutability between achievements, based on transparent CA theoretical considerations; iii) an easy comparison across territories and groups and over time, and between levels of observation (micro, meso and macro); iv) a focus on between-dimension inequalities due to choices or constraints; v) a straightforward interpretation of the obtained synthetic score (not only through a comparison).
All these properties are obtained through a transparent and accountable process (OECD-JRC, 2007) and therefore open to public debate as indicated by Amartya Sen. Moreover, the flexibility of the function in managing the different substitutability rates can overcome the so-called "inescapable arbitrariness" mentioned by Anand and Sen (1997: 16)."

The academic literature on theoretical aspect and empirical aspects above mentioned is vibrant.

In addition, the practitioners' debate is very vivacious, within National States and especially among the United Nation agencies such as UNDP, UNICEF on the one side and The World Bank or other multilateral organization such as OECD[3].

[3] The European Commission gives an overview of well-being indices used by national and international institutions on http://composite-indicators.jrc.ec.europa.eu/.

Several phases are usually distinguished in the literature, but the two main phases are the selection of the dimensions and the way they are summarised into a unidimensional value.

The former phase takes into account the selection and the measurement of the dimensions through which the poverty status is identified. It is a conceptual phase still not completely consolidated (Nussbaum, 2003; Alkire 2008; Biggeri and Mehrotra 2011; others ???).The latter includes the methodology chosen to synthesise the dimensions chosen in order to build the (usually unidimensional) synthesis.

In this paper we assume that the phase of the selection of dimensions is accomplished, and we only focus on the phase of synthesis, introducing a class of functions that aggregate the *k* variables available.

The paper is structured into six sections. After this introduction, in the second section a background introduces the core elements of counting measures and index measures emphasizing the limits of different type of indices. In the third section, the desirable properties of the new class of indexes are considered and the function properties analysed. In the fourth section, the new class of indexes is proposed. In the fifth section, some research and policy implications are considered, while in the last section the main conclusions given.

2. Background

2.1. Counting measures and index measures

The literature about how individual-level information is combined to obtain an overall poverty synthetic measure is growing (Perali and Menon, 2016). Child poverty, for instance, measurements approaches can roughly be divided in three categories (Roelen and Gassmann, 2008; Decancq and Lugo, 2010) on the basis of the aggregation methods used, namely child poverty count measures, child poverty index measures.(and holistic child poverty approaches?)

The first approach includes indexes like the MPI, MODA that are based on thresholds (or cutoffs). A single cut-off is set to define if the individual is deprived or not in each of the dimensions chosen. In its simple formulation, once these deprivations are set, they are aggregated to obtain a binary definition of poverty, usually according to another subjective cutoff. As all individuals are then labelled as "poor" or "not poor", it is then straightforward to count them and get an overall measure of poverty.

The second class of indexes (HDI, ref) aggregates the variables with a cardinal approach. These indexes do not define poverty as a binary variable, but rather as a continuous measure of the well-being of individual.

Although the difference between the two classes appear intuitive, it is not easy to find a rigorous way to differentiate the two approaches.

Let X be the data matrix with generic entry x_{ij}($i = 1..n, j=1..k$) representing the j-th achievement for individual i. Both the approaches introduced can be seen as a function I: $R^{nxk} \rightarrow R$ where all the information contained in the matrix is conveyed in a real value[4], so that they are mathematically not distinguishable. The only way to set a difference is through the intrinsic properties of the function aggregating the data. The counting measures are in fact influenced by the thresholds chosen, so that the index cannot be continuous nor strictly monotonic, while the index measures associate "small" changes of the matrix X to "small" changes in the outcome, resulting usually continuous and monotonic.

These considerations represent a key factor in the choice of an index. Although the counting measures are widely used, mainly because they can easily take into account both ordinal and

[4] For the counting indexes the function formally depends also on the choice of the cutoffs.

cardinal variables, they present huge problems due to the mathematical properties induced by the cutoffs and the functional form of the index.

More specifically, indexes based on a binary definition of poverty (being poor versus not being poor) may not change if i) a person who is labelled as "poor" experience a worsening of their situation[5](or an improvement not large enough to change their status) or ii) a person who is labelled as "not poor" experiences an improvement of their situation (or a worsening not large enough to change their status). This assumption is hard to justify from a theoretical point of view, especially for people described in the first situation. It might be argued that this a drawback needed in order to rely on the robustness of a strictly binary approach, but, on the other hand, we believe that it presents more disadvantages than advantages, especially in a setting where the thresholds of deprivation are the result of a subjective process.

Moreover, this class of indexes might violate the inequality assumption (ref), as a transfer of wealth from a poor to a less poor may result in a reduction in the overall level of poverty.

From a monitoring perspective, it is difficult to justify that the points in which the function presents discontinuities are chosen with subjective criteria. The cardinality of these (jump) discontinuities is finite (as it cannot exceed the number of cut-offs) so that the function is almost-surely constant, causing at least two important issues. The first is the lack of sensitivity described above, as significant changes in the data may not be captured by the index, the second is that unimportant changes of the data around the thresholds might cause dramatic changes of the index.

In a nutshell, the appealing robustness of the cut-off-based aggregation process induces a hysterical behaviour of the function that could at the same time disregard significant changes while amplifying unimportant changes. In a context like monitoring, where a robust degree of sensitivity is required in order to capture the evolution processes of the wellbeing, this class of indexes appears inadequate and therefore not applicable.

The goal of this work is to develop an index that, on the contrary, is sensitive to any change in any subgroup of the population (including the extremely poor and the non-poor). As a consequence, we restrict our analysis to the index measures class.

[5] The Mo index of the MPI approach (ref) partially take this into consideration

2.2. Issues about index measures (to be completed)

In order to monitor well-being over time/space/levels we need the properties of strict monotonicity (required to fully capture any change in the data) and continuity (required to avoid jump discontinuities that might bias the results).
The class of index measures generally includes these two key properties but is usually associated to some drawbacks in the managements of variables that counting measures do not present, like standardisation, implicit weighting, substitutability rates[6], and difficult interpretation of the results.
In this paragraph, we analyse the main drawbacks of this class of measures, and we propose some methods to take them into account.

"All of the measures discussed so far incorporate the headcount, and therefore depend upon the identification of a poverty line. Selecting an appropriate poverty line raises a range of practical and methodological challenges (see Kanbur and Squire, 1999; Ravallion, 1998). A common approach involves deriving poverty lines from estimates of 'minimal nutritional requirements' or 'consumption norms' in particular societies. This approach, however, takes no account of the fact that nutritional and commodity requirements can vary quite widely both within and between countries. There are also difficulties in terms of defining these requirements, which depend on the choice of commodities and assumptions about the proportion of income spent on food, inter alia (Sen, 1981, pp. 11–14). Another approach involves estimating a subjective poverty line based on qualitative perceptions of 'consumption adequacy' among the poor (e.g. Pradhan and Ravallion, 2000). While this approach has the merit of being bottom up, an allowance inevitably has to be made for 'heterogeneity', as views about what constitutes poverty differ (Pradhan and Ravallion, 2000, p. 462)."

Another key observation is that poverty is a fuzzy or vague concept (Sen, 1981:13). Enrica Chiappero Martinetti (2000), and other researchers, using the fuzzy method and the capability approach recognises that deprivation (and well-being) are vague predicates that manifest themselves in varying degrees in given dimensions. According to Qizilbash's vagueness methodology the solution is to distinguish more categories: i) Lowest admissible critical minimal

[6] Counting measures presents substitutability rates issues, too, but of different nature (see Rippin, 2015)

level (of a dimension of poverty): the level at or below which a person is judged to be definitely poor in a given dimension; ii) Highest admissible critical minimal level (of a dimension of poverty): the level at or above which a person is judged to be definitely non-poor in a given dimension; iii) Core poor: a person who is definitely poor (at or below the lowest admissible critical minimum) in terms of at least one core dimension (Qizilbash, 2003; Clark and Qizilbash, 2008).

2.3 Theoretical considerations

From a theoretical perspective, the new class of indexes proposed in this paper is anchored to the capability approach and its philosophical understanding of development processes.

According to Sen, "What the capability perspective does in poverty analysis is to enhance the understanding of the nature and causes of poverty and deprivation by shifting primary attention away from means to ends that people have reason to pursue, and, correspondingly, to the freedoms to be able to satisfy these ends" (Sen, 1999: 90).

Capability is defined as the various combinations of functionings (beings and doings) that the person can achieve (Sen, 1992). In other words, capabilities are people's real freedom to enjoy being and doing what they value and have reason to value (Sen, 1980, 1985, 1992). Therefore, in assessing from a capability approach perspective, is essential what "a person can do in line with his or her conception of the good" (Sen, 1985: 206) and recognizes people as responsible persons (Sen, 1999).

"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: 40).

Therefore, the capability approach frames the range of experiences and life situations as "possible functionings". If a functioning is an achievement, whereas a capability is the ability to achieve, functionings are, in a sense, more directly related to living conditions, since they are different aspects of one's everyday life. Capabilities, in contrast, are notions of freedom, in the positive sense: what real opportunities you have regarding the life you may lead (Sen, 1987: 36); in this sense capabilities are both opportunities and capacities of individuals.78 Following, the ancient

[7]This leads to the equal opportunity view (see Roemer, 1998) but from a multidimensional perspective. The freedom to be healthy, educated, well-nourished and integrated is intrinsically valuable regardless of whether the human being uses these capabilities as an instrument for other goals or not.

[8]"There is no difference as far as the space is concerned between focusing on functionings or on capabilities. A functioning combination is a point in such a space, whereas capability is a set of such points" (Sen, 1992: 50).

Greek philosopher Aristotle, the capabilities of a person have been associated with human flourishing, which suggests they can be realized in many different ways (Nussbaum, 2000).

However, it is also important to notice that capabilities and functionings have an intrinsic value as well as an instrumental value (Sen, 1999: 53). This means that a sharp deprivation in a specific dimension not only cause an overall deprivation (intrinsic value) but is going to reflect negatively to other dimensions as well (because of the instrumental value). Moreover, this consideration reflects also to the absence of available choices and mirrors Sen's notion of "development as freedom" (Sen, 1999). According to Sen (1981, 1999) a distinction becomes essential the difference between someone who is starving because of an inability to find sufficient food, and someone who is fasting by their own choice, maybe for political, ideological and/or religious reasons. The first person does not have the capability of feeding himself, while the second does have this capability. More in general this emphasise that in the analysis of wellbeing and the quality of life if a person who is not deprived can chose indifferently.

3. From Desirable Index's Properties to the Function (to be completed)

The index proposed in this paper is developed to monitor wellbeing both over time and for all subgroups of the population of analysis. To fulfil both these goals, we need the aggregating function to be strictly monotonic, so that any change in the situation of any unit considered in the analysismust be captured. More formally, let *X* the data matrix defined above, and let *I* be the function $X \rightarrow R$ that associates the matrix X to a real value bounded between 0 and 1, we require the function *I* to satisfy the following property:

Strict monotonicity: For any X_{nxk} , for any integer *a* in 1…n , and for any integer *b* in 1…k and for any ε>0, I(Xab*)>I(X), where Xab* is defined as the matrix with generic entry defined as follow: x*ij=(xij+ε) if i=a and j=b and x*ij=xij otherwise.
This property guarantees that any improvement (worsening) in any of the dimensions measured for any of the units analysed results in an increase (decrease) of the index. Please note that this condition does not directly imply the continuity of the function I.

The function must be continuous. Of course, if one of more of the dimensions is ordinal, then the results cannot be continuous, but this is due to a "real" jump in the values assumed by the independent variables, and it is not the result of any discontinuity in the function I.
Continuity: For each cell in X, $\lim_{\varepsilon \rightarrow 0} I(X_{ab*}) = I(X)$, where X_{ab*} is the matrix defined above and $\text{limit}_{\varepsilon \rightarrow 0}$ includes both the above and the below limit.

Ideally, an index should take into account the heterogeneity between accomplishments for a single units. Individuals with significant differences between their achievements should be penalised by the index. We therefore require the function to satisfy the following property
Heterogeneity penalisation: let $x_{i1} \geq x_{i2}$ be two generic achievements for individual *i*.For each ε>0, $I(x_{i1},x_{i2})>I(x_{i1}+\varepsilon,x_{i2}-\varepsilon)$, ceteris paribus.

Please note that this property is focused on single individuals, as I is the index calculated for one row only.
The first one is the degree of substitutability between the dimensions that aRk→ R function implies. In a simple example using only two inputs, considering a function R2→ R, the

substitutability between the inputs can be explicitly taken into account by choosing a fixed value of the outcome (e.g. 0.5) and then analysing the curve identified by the points in the Cartesian coordinate system that generate that value. As a generic point on the curve represents a couple of inputs, the slope of the curve can be interpreted as the degree of substitutability between dimensions (a slope close to -1 representing a situation of perfect substitutability, and slopes very high or very small representing situations where the marginal rate of substitution reflects lesser level of substitutability). Letting the fixed value of the outcome vary between 0 and 1, one can identify a family of curves, each one associated to different degrees of substitutability. The choice of the functional form of the index implicitly identifies that family, and therefore defines the assumptions about all the marginal rates of substitution for all the possible combinations of all the dimensions. Indexes based on a binary definition of poverty fail to explicitly take the substitutability rates into account. In this class of indexes the marginal rate of substitution is usually a function of the cutoff chosen, so that the researcher has no direct control on the underlying assumptions. For example, in the so-called "intersection approach" of the MPI, where a person is identified as poor only if he is deprived in all the dimensions, there is an (implicit) perfect substitutability rate between all the inputs, while in the "union approach (where a person is labelled as poor as soon as he is deprived in one dimension), the inputs can be considered as perfect complements. As Rippin (2012?) points out, the whole method is based on the indirect assumption that up to the cutoff chosen attributes are perfect substitutes whereas the same attributes are considered perfect complements from the cutoff onwards.

If indexes such as the headcount or the income gap 'is completely insensitive to transfers of income among the poor so long as nobody crosses the poverty line. . .' (Sen, 1981, p. 33), the measure indexes, as the HDI, that aggregate the dimensions into one numerical index involve implicitly or explicitly an exercise in weighting. Considering that,a change of weights determines the aggregate result as admitted by Sen and Anand "there is an inescapable arbitrariness" ((Anand and Sen, 1997: 16).

The arithmetic formula also means that results are sensitive to the choice of normalization. The problem emerges from the fact that the ordering produced by an additive functional form is not invariant to the scale used for measurement of the dimensions. The choice of normalization, which is in principle designed to keep the index on the 0-1 range, can thus have significant implications for the index values, and rankings. Different normalizations will imply different

marginal effects of each variable's improvements on the HDI, with the choice of normalization implying a choice of implicit weights (UNDP, 2011, p. 13)

3.1 Variables harmonisation and the key role of alignment (to be completed)

One of the main drawbacks of the class of indexes chosen is embedded in the standardisation of the variables selected. The variables, in fact, need to be transformed before entering the function I. This represents a crucial process, as the method of used might bias the results (Decancqand Lugo, 2010).

The most common ways to transform the variables are standardisation or normalisation (ref). Both these methods, however, hold an implicit weight on the basis of the degree of dispersion: the smaller the variance of a variable, the higher the implicit weighting that these method assign (Bradshaw et al., 2006). This implicit property is counter-intuitive, as variables very homogeneous in the population (and therefore less important to distinguish poor and non-poor) are overweighed by these common procedures.

(to be completed)

4. A new class of indexes (to be completed)

Reducing the dimensionality of a *nxk* data matrix *X* usually involves two distinct phases of aggregation. In the first, the rows of the matrix are summed up in a one dimensional value (that represents a one-dimensional measure of the *k* achievements of a single unit). In the second phase, the *n* one-dimensional values are summed up in a single value that represents the final score of the index for the whole population studied. Although the two processes are mathematically similar, as they are $R^n \rightarrow R$ functions, the theoretical background is different[9]. The class of index introduced in this paragraph focuses on the first phase. As a result, the generic outcome of the function proposed is a n-dimensional vector containing all the outcomes for the single observations. This vector can then be summarised into a one-dimensional value, or it can be studied as the distribution of well-being among all the population.

Let X be the nxk data matrix with generic entry x_{ij} the *j*-th(aligned) achievement for person *i*. Then

(to be completed)

[9]The heterogeneity of achievements within individuals (horizontal aggregation) analysed in this paper is the reflection of a single person's choices or constraints, and it can be therefore interpreted both as a negative or positive aspect, while the heterogeneity between individuals (vertical aggregation) is the result of the degree of inequality in a society, and it must always be interpreted as a suboptimal situation. Indexes that takes into account the two sources of heterogeneity at the same time might produce mixed up results that cannot be interpreted.

5. Research and Policy implications (to be completed)

6. Conclusions (to be completed)

The view of human beings as the "primary ends" of the process of development calls for emphasis to be placed on what people get from development, not only what they put into it.' (Anand and Sen, 2000, p. 84). Therefore, in the CA what people get from development is linked to the freedoms to live to lead the life that a person has reason to value. This is what this class of indexes try to capture.

This new class of indexes is thought to monitoring and therefore presents relevant desirable properties advancing the current debate. Among the properties we require, the most important are: full sensitiveness, flexible rate of substitution between achievements, and straightforward interpretation of the results. All these properties are obtained through a transparent and accountable process that overcome the so called "inescapable arbitrariness " (Anand and Sen, 1997: 16)", that can therefore be open to public scrutiny as suggested by Amartya Sen.

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