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Measuring and Monitoring Poverty and Well-Being: A New Approach for the Synthesis of Multidimensionality

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Abstract The aim of this paper is to introduce a new approach for the synthesis and analysis of multidimensional poverty and well-being indicators. Our general perspective is inspired by the theoretical foundations of the capability approach and sustainable human development paradigm. The new synthesis of indicators aims at monitoring outcomes of units of interest. Its defining features include: full sensitiveness, continuity, flexibility in substitution between dimensions, and the straightforward interpretation of the results. All these properties are obtained through a transparent and accountable process that is fully open to public scrutiny and reason (as suggested by Amartya Sen). The main contribution of this approach is that the degree of substitutability between dimensions can be directly linked to the general level of well-being of a person, which addresses the so-called "inescapable arbitrariness" issue discussed by Anand and Sen (Concepts of human development and poverty: a multidimensional perspective. Human Development Papers. UNDP, New York, 1997). The new synthesis proposed opens up new possibilities for different types of applications, including monitoring and evaluating development programmes.

Keywords Measurement · Multidimensional well-being · Multidimensional poverty · Composite Multidimensional Index · Sustainable human development · Capability approach

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1 Introduction

Measuring and monitoring poverty, well-being, and the quality of life is a key topic in social science research and is of crucial importance for local and national governments and international organisations who need to measure and gauge performance beyond a narrow range of economic indicators. The momentous consensus reached by the international community that culminated in the United Nations 2030 Agenda and the formation of 17 Sustainable Development Goals (SDGs) with a large number of corresponding targets and indicators has resulted in an increasing need for a consistent monitoring system for all countries. The complexity of the targets to be measured requires the identification of many indicators, which will be a difficult exercise to manage especially in the case of comparisons across territories or over time.

In the last decades a large part of the literature on social indicators has focused on developing functions that reduce multidimensional achievements to unidimensional values.

The aim of this paper is to introduce a new approach to synthesise multidimensional poverty and well-being indicators. The "unit" mentioned in the paper can be an individual, as well as a country or a geographical area. The word "dimension" or "domain" are used interchangeably to indicate an area of the quality of life, "indicator" is a proxy variable for that area, while an "achievement" is the value[1] observed for a specific unit. Data are supposed to be organised in a real-valued matrix X with generic entry x_{ij} $(i = 1, \ldots, n, j = 1, \ldots, k)$ representing the j-th achievement for unit i. A "synthesis" (or "index", or "function") is a real-valued function defined on data matrices $I{:}R^{nxk} \rightarrow R$.

The properties of the functions and their implications for monitoring outcomes are presented in a transparent way. The main contribution of this approach is that the degree of substitutability between dimensions can be directly linked to the general level of well-being of a person (Anand and Sen 1997; Gaertner and Xu 2008), which addresses the so-called "inescapable arbitrariness" issue discussed by Anand and Sen (1997: 16).

From a philosophical perspective, the method of synthesis proposed in this paper is inspired by the capability approach and its understanding of the sustainable human development process in terms of opportunities (Sen 1985b, 1999; UNDP 1990; Comim et al. 2008; Biggeri and Mauro 2010). "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). In this respect, 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.

Indexes that are used as a summary should clearly take into account the nature of the relationship between the selected indicators. This relationship can be reflective or formative (Maggino 2017a, b). Reflective indicators are seen as functions of the conceptual latent variable (e.g. poverty or well-being), so that indicators are assumed to be highly correlated and interchangeable. Any uncorrelated indicator cannot measure the defined conceptual construct and should be excluded. At the same time, the high correlation between the indicators allows a reduction of the dimensions and therefore a simpler synthesis. In contrast, formative indicators are assumed as causes of the latent variable, and the selected indicators are not necessarily correlated with each other. Two uncorrelated indicators can both contribute to the measurement of the same conceptual variable, while two correlated indicators may turn out to be redundant in measuring the concept. The

[1] For simplicity, and without loss of generality, achievements are assumed to be bounded between 0 (worst possible achievement in a dimension) and 1 (best possible achievement in a dimension).

synthesis of poverty and well-being indicators introduced in this paper is developed assuming a formative framework.

The synthesis of indicators involves several distinct phases (see Maggino 2009; Nardo et al. 2005). The two most debated phases are the selection of the indicators and the method for compressing them into a unidimensional value. The former phase (Nussbaum 2003; Alkire 2008; Alkire and Santos 2013; Biggeri and Mehrotra 2011) involves the selection and the measurement of the dimensions defining the latent variable, while the latter refers to the methodology chosen to synthesise the dimensions. Although we are aware of the fact that these two phases are highly interconnected, in this paper we focus on the process of aggregation, assuming that the selection of relevant dimensions has been accomplished.[2]

From a methodological point of view, there are two approaches to synthesising indicators (Maggino 2009). The first of these approaches focuses on rows in the data matrix. This approach aims to aggregate the value of an indicator across micro level units. This synthesis allows the created macro units (social groups, age groups, geographical divisions, temporal partitions) to be compared with reference to particular indicators. The second approach concentrates on columns in the data matrix and aims at synthesising basic indicators by aggregating the values of indicators. The values refer to each observed at micro level (individuals) or macro level (regional, national and global or for distinct groups).

For both approaches it is usually necessary to transform the available data (generally through standardisation or normalisation) in order to ensure the original values expressed by the indicators are comparable to each other. The selection of the appropriate transformation should consider several key characteristics of indicators including data properties, the original meaning of indicator, the values to be emphasized or underplayed, the prevalence of absolute versus relative values, the basis of comparison (i.e., with each other or a standard reference unit), whether or not there is a temporal dimension for the evaluation of units (Nardo et al. 2005).

Reducing the dimensionality of a data matrix usually involves two distinct phases of aggregation. In the first phase (horizontal aggregation) each row of the data matrix is summed up in a one-dimensional value. In the second phase (vertical aggregation) these one-dimensional values are aggregated into a single value that represents the final score of the index. Although the two phases are mathematically similar (as they are both $R^n \rightarrow R$ functions) the theoretical background is different, so they should be kept separate. The heterogeneity of achievements *within* individuals could be the result of personal choice, and can therefore be interpreted both as a constraint or the result of a free choice. The heterogeneity *between* individuals is proportional to the degree of inequality within a population, and is therefore considered as less than ideal. Indexes that take into account both kinds of heterogeneity at the same time can produce mixed up results which cannot easily be interpreted. The class of index introduced here focuses on the horizontal aggregation phase.

The paper is divided into six sections. The second section introduces the background to the debate, and considers the strengths and weaknesses of some common approaches to synthesising indicators. In the third section, the properties of our approach are considered. In the fourth section, the new synthesis of indicators is presented. In the fifth section, the implications for policy and research are considered, and a final section concludes.

[2] This is a long process to be accomplished with a great deal of agreement (Clark and Qizilbash 2002).

2 Background

Any procedure aiming to provide a reduction in the dimensionality of the data leads to the loss of relevant information. Therefore, a function summarising the data is generally chosen in order to obtain the largest reduction of dimensions associated with a reasonable loss of information. The mathematical structure of the function—referred to as "formal considerations" by Sen (1989)—entails hypotheses that can be explicit or implicit. Although these hypotheses should ideally reflect the aims of the synthesis of indicators, they sometimes manifest themselves as inevitable consequences of the selected methodology rather than the result of well thought out or theoretically sound considerations.

The proposed synthesis of indicators is inspired by the capability approach and its philosophical understanding of sustainable human development processes relating to poverty and well-being. However, it may find potential connection with other approaches to quality-of-life measurement. According to Sen (1999: 90), "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". "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).[3] Capabilities are notions of freedom, in the positive sense: the real opportunities the person has regarding his or her life (Sen 1987). Following Aristotle, the capabilities of a person have been associated with human flourishing, which suggests they can be realized in many different ways (Nussbaum 2000). 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). It follows that both actual achievements (outcomes or functionings in the jargon) and opportunities (the capability to function in different ways) across the dimensions people have reason value is important for a full understanding of the quality of life (Sen 1985b, 1992, 1999).[4]

Following on from these considerations, we first focus on the characteristics grounded in this theoretical framework that the synthetic indicator should have, and then try to derive a mathematical structure consistent with these attributes.

The literature on how individual-level information is combined to obtain overall synthetic measures of poverty of well-being is growing (Bourguignon and Chakravarty 2003; Brandolini and D'Alessio 2009; Clark and Hulme 2010; Alkire and Foster 2011; Decancq and Schokkaert 2016). Two main strands of literature emerge in terms of the aggregation methods employed: namely count measures; and index measures (Aaberge and Brandolini 2014) with relevant and well-known applications of both methods originating from within the capability approach and human development perspective.

The first approach includes multidimensional indexes such as the Multidimensional Poverty Index (MPI) (Alkire and Foster 2010, 2011) which are based on thresholds (or cut-offs). In this approach, a single cut-off is set for each dimensions to define whether or not

[3] 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 they value and have reason to value (Sen 1980, 1985b, 1992). Notice that assessments from a capability approach perspective takes note of what "a person can do in line with his or her conception of the good" (Sen 1985a: 206) and recognizes people as responsible persons (Sen 1999). If a functioning is an achievement, whereas a capability is the opportunity and the ability to achieve, functionings are, in a sense, more directly related to living conditions, since they reflect different aspects of everyday life.

[4] This is similar to the idea of equality of opportunity (Roemer 1998).

the individual in question is deprived. In its basic formulation, once these thresholds are set, indicators referring to different dimensions (formative approach) are aggregated to obtain a binary definition of poverty determined by another subjective cut-off (Chakravarty and D'Ambrosio 2006). Once each unit is identified as "poor" or "non-poor", it is straightforward to derive an overall measure of poverty defined as a function of the number of poor individuals.

The second approach aggregates indicators using a cardinal perspective. Indicators do not define poverty as a binary variable, but rather as a continuous measure of the well-being of an individual.

Although the difference between the two approaches appears intuitive, is not straightforward to formally differentiate the two approaches, as they both introduce a function $I{:}R^{nxk} \rightarrow R$ that summarise in a real value[5] the information contained in the data matrix, so that it is difficult to formally distinguish them. A natural way to establish a difference is through the properties of function I. For example, the counting measures are severely influenced by the choice of thresholds, so the indicator cannot be continuous or strictly monotonic. On the contrary, the indicator measures, by associating "small" changes in matrix X to "small" changes in the outcome, usually result continuous and strictly monotonic.

These considerations about intrinsic properties are crucial. Although counting measures are widely used in the capability and human development literature[6] (mostly because they can readily take into account both ordinal and cardinal variables), they have distinct drawbacks for monitoring purposes due to mathematical properties caused by cut-offs and the functional form of the synthesis. More specifically, indicators based on a binary definition of poverty (being poor vs. not being poor) may not exhibit change if (1) a poor person experiences a worsening (or an improvement) of their situation[7] not large enough to change their status; or (2) a non-poor person experiences an improvement (or worsening) of their situation not large enough to change their status). Furthermore, cut-off based indicators usually violates the so-called "inequality assumption", as a transfer of wealth from a poor to a less poor may result in a reduction in the overall level of poverty.[8]

Another issue is represented by the discontinuities caused by subjective criteria. Moreover, since the cardinality of such discontinuities is finite (as it cannot exceed the number of cut-offs), the function is almost certainly constant, which leads to other issues, in addition to the lack of sensitivity described above. In particular, relatively minor changes in the performances of an individual might result in significant changes in the indicator if the individual is close to a threshold. In sum, the appealing robustness of the cut-off based aggregation procedure generates a function that might both conceal significant changes or amplify minor changes in personal circumstances, which implies that in many cases this synthetic indicator will not constitute a reliable guide to poverty or well-being monitoring.[9]

[5] For counting indexes the function also formally depends on the choice of cut-offs.

[6] See for example the special issue in Social Indicators Research including Trani et al. (2013) as well as.

[7] A reduction in the income of any person currently below the poverty line will leave the headcount unchanged, *ceteris paribus* (Sen 1981: 11).

[8] Clark and Hulme (2010) underline that headcount measures say nothing about the extent or magnitude of income shortfalls below the poverty line, leaving aside the very real issue of where to draw the poverty line.

[9] The theory of fuzzy sets and fuzzy categories is a potential tool for dealing with shortcoming of cutoffs (see e.g. Zimmermann 2001).

The measurement of poverty, well-being and the quality of life in a monitoring framework requires a high degree of sensitivity for individuals in any subgroup of the population (including the extremely poor and the non-poor). The properties of strict monotonicity of an index (required to fully capture any change in the data) and continuity (required to avoid jump discontinuities that might bias results) are therefore necessary. Cardinal measures generally includes these two fundamental properties, but at the expense of having to manage issues that counting measures do not usually include. This in turn means having to deal with potentially difficult and problematic issues such as the standardisation of variables, implicit weighting (linked to the degree of dispersion), the management of substitutability rates, and the interpretation of numerical results (Nardo et al. 2005).

The approach proposed in this paper tries to take all these concerns into account while retaining the full advantages of a cardinal measure.

The main characteristics of this synthesis of indicators are: (1) strict monotonicity (any change in any of the dimensions must be captured by the index); (2) continuity; (3) a theoretically-coherent structure of substitutability between achievements, based on transparent theoretical considerations inspired by the CA; and (4) a straightforward interpretation of the synthetic score (which looks beyond a mere comparisons).

All these properties are achieved through a transparent and accountable process (OECD 2008) and are open to public debate (Anand and Sen 1997).[10]

Before discussing these properties, it must be noted that one of the main caveats in aggregating indicators regards the transformation of the original data (usually normalisation or standardisation). This is a crucial part of the synthesis process, as the method employed might significantly bias the results (Decancq and Lugo 2010; Menon et al. 2016). Therefore, the harmonisation and alignment of the selected indicators is a crucial and unavoidable stage in the synthesis process which requires the setting of appropriate benchmarks and raises a range of practical and methodological challenges. These challenges are not pursued here and have been extensively discussed elsewhere (see Kanbur and Squire 1999; Ravallion 1998; Pradhan and Ravallion 2000; Bradshaw et al. 2007; Clark and Hulme 2010; Decancq and Lugo 2010; Klugman et al. 2011; Menon et al. 2016; Mauro et al. 2017).[11,12]

3 From Desirable Properties of the Synthesis to the Function

The synthesis of indicators proposed in this paper aims to monitor well-being both over time and for all subgroups of the population. To fulfil both these goals, the aggregation function must satisfy certain key properties.

First, any change in the situation of any unit considered in the analysis must be captured. More formally, let X be a data matrix with generic entry $x_{i,j}$ representing the

[10] In this respect Anand and Sen (1997: 6) write: "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 clear and comprehensible as possible, and thus be open to public scrutiny".

[11] According to Qizilbash one solution is to distinguish more categories e.g. from the lowest admissible critical minimal level to the highest admissible critical minimal level (Qizilbash 2003; Clark and Hulme 2010).

[12] In order to avoid these difficulties, Mauro et al. (2017) propose a procedure for harmonisation and alignment of variables based on public scrutiny of specially designed survey questions. This procedure is appropriate for our class of indicators and will help facilitate the interpretation of our results.

achievement in indicator j of individual i; and let I be the function $X \rightarrow R$ that associates matrix X to a real value.

3.1 Strict Monotonicity

For any X_{nxk}, for any integer a In $1\ldots n$, and for any integer b in $1\ldots k$, and for any $\varepsilon > 0, I\left(X_{a,b*}\right) > I(X)$ where $(X_{a,b*})$ is defined as the matrix with generic entry that is: $x^*_{i,j} = \left(x_{ij} + \varepsilon\right)$ if $i = a$ and $j = b$; otherwise $\overset{*}{x}_{i,j} = (x_{ij})$.

This property guarantees that any improvement (worsening) in any indicator observed for any unit results in an increase (decrease) of the synthetic score. This condition does not imply the continuity of function I.

Second, the function must be continuous. Of course, if one or more of indicators is discrete, then the results cannot be continuous. This is due to a "real" jump in the data, and it is not the result of any discontinuity in function I.

3.2 Continuity

For each cell of X, $\lim_{\varepsilon \rightarrow 0} I(X^*_{ab}) = I(X)$ where $\overset{*}{X}_{ab}$ is the matrix defined above and $\lim_{\varepsilon \rightarrow 0}$ includes both the upper and lower limit.

Ideally, a synthetic indicator should take into account the heterogeneity between accomplishments for a single unit. Individuals with significant differences between their achievements should be penalised by the synthetic indicator. We therefore require the function to satisfy the following third property.

3.3 Heterogeneity Penalisation

Let $x_{i1} > x_{i2}$ be two generic achievements for a generic unit. For each $\varepsilon > 0, I(x_{i1}, x_{i2}) > I(x_{i1} + \varepsilon, x_{i2} - \varepsilon)$, *ceteris paribus*.

The last property introduced is the manageability of the elasticity of substitution between sub-indexes, a property entailed in many synthetic indicators based on higher-order means (Biggeri and Mauro 2010; Klugman et al. 2011; UNDP 2013). In addition, the new Human Development Index (HDI) takes it into account through its geometric mean (see Klugman et al. 2011). The issue with all these synthetic indicators is that the elasticity of substitution between basic indicators is strictly dependent on the choice of parameter[13] α (usually the order of the mean). Anand and Sen (1997) underline how there is no flexibility in the rate of substitutability between indicators once this parameter is set. They refer to this problem as "inescapable arbitrariness in the choice of α" (1997: 16).

The idea advanced in this paper is that a full degree of substitutability can be retained by directly linking to a function of the general level of well-being for each person. A lower degree of substitutability assigns implicitly a higher relative weight to the lowest score achievements, especially for poor people.

[13] For $\alpha = 1$, there is perfect substitutability between the sub-indexes, and as α increases from 1 the elasticity of substitution decreases monotonically from ∞ to 0.

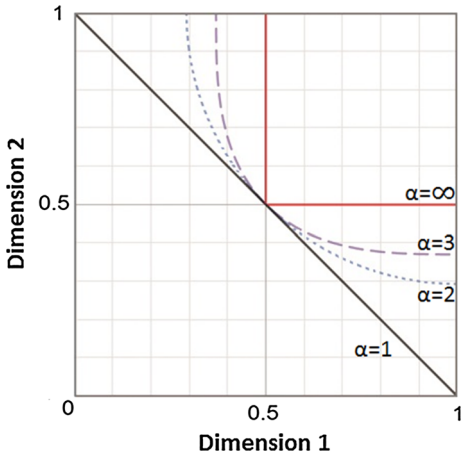

Fig. 1 Iso-capabilities curves (combination of two achievements yielding the same level of the index) assuming $\alpha = 1, 2, 3, \infty$

4 A New Approach to Synthesis of Indicators: The Multidimensional Synthesis Indicator (MSI)

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

$$MSI_i = 1 - \left[\frac{1}{k}\sum_{j=1}^{k}\left(1 - x_{ij}\right)^{\frac{1}{g(x_i)}}\right]^{g(x_i)}$$

where k is the total number of dimensions and $g(x_i)$ is a generic real-valued function of the i-th row of matrix X, with $g(\cdot) \geq 1$.[14]

The function $g(\cdot)$ allows a high degree of flexibility of the *MSI*. As a result, theoretical considerations regarding the structure of substitutability rates between achievements can be taken into account (see Fig. 1). If the function is $g(\cdot) = \alpha$, with α constant, then

If $\alpha = 1$ the synthesis is based upon an arithmetic mean (i.e., there is perfect substitutability between dimensions).

If $\alpha = 2$ the synthesis is the Euclidean distance from the ideal unit achieving top scores in all dimensions (with a lower degree of substitutability; Foster et al. 1984; Biggeri and Mauro 2010).

If $\alpha > 2$ the synthesis becomes a higher-degree average (with a lower degree of substitutability; see case of $\alpha > 2$ in Anand and Sen 1997). As α increases, the iso-capabilities curves mapping the levels of individual capabilities consistent with a given level of well-being tend to a Leontief functional form where there is no substitutability between achievements (see Fig. 1).

Although these scenarios represent important cases presented in literature, the value added by the proposed approach is that the degree of substitutability can be directly linked to the general level of well-being of each person through a non-constant function $g(\cdot)$. Given the instrumental value of most dimensions, this means that a sharp deprivation in a specific dimension might not only cause an overall deprivation (intrinsic value) but also negatively effects other dimensions as well. Put simply, this synthesis penalises

[14] The hypothesis of $g(\cdot) > 1$ is required to imply the convexity of the curves to the origin.

heterogeneity. This consideration also reflects the absence of available choice and mirrors Sen's notion of "development as freedom" (Sen 1999).

There is no upper limit to the flexibility of function $g(\cdot)$. In fact, such flexibility is in line with Aristotle and Sen where opportunities or capabilities are intended as freedoms of a person and can be easily linked to their flourishing. As the level of well-being increases (in many dimensions) a person can choose freely among dimensions.

Further information (or assumptions) on the structure of substitutability rates relating to the population can lead to more detailed and complex reiterations of the functional form[15] of $g(\cdot)$.

A generic choice for the function $g(\cdot)$ is

$$g(x_i) = \begin{cases} \frac{b}{a} & if \quad \mu < a \\ \frac{b}{\mu} & if \quad a \leq \mu < b \\ 1 & if \quad \mu \geq b \end{cases}$$

where μ is the arithmetic mean of x_i and a and b $(0 \leq a < b \leq 1)$ are two thresholds selected so that all units above b (or below a) have their achievements aggregated under the assumption of a perfect (or almost complementary) substitutability rate (see an example in Fig. 2). This is a simple and intuitive way to allow a flexible penalisation of heterogeneity in personal achievements: for example, people with higher levels of well-being are less penalised, as the heterogeneity associated with their achievements it is more likely to be the result of a subjective choice, while poorest people are more heavily penalised, as heterogeneity (or lack thereof) is interpreted as lack of effective freedom or opportunities.

The particular case with $a = 0$ and $b = 1$ implies $g(x_i) = \mu^{-1}(x_i)$, and the degree of substitutability is a function of the overall achievement of the unit estimated through an arithmetic mean, as suggested by Bourguignon and Chakravarty (2003).[16]

In Fig. 2 is represented an example with fixed parameters a and b. Each iso-capabilities curve represents the infinite combinations of achievements x and y that result in the same level of *MSI*. The lower the curve, the lower the associated score of the index. The figure shows that as the units achieve better results in the arithmetic mean (top right area), the curves tend to linearity. On the opposite, units with a low overall level (bottom left area) lie on higher-degree curves, that penalise their *MSI* score. As a result, the degree of substitutability moves from almost perfect complements (for poorest units) to perfect substitutes when it becomes linear at the upper corner of the graph. The negative slope of all the curves reflects the assumption of strict monotonicity (a combination with higher achievements in at least one dimension is therefore always preferred, *ceteris paribus*), as well as the assumption that the marginal rate of substitution is always positive.

This extension in the potential use of the synthesis (choosing a and b), opens up new possibilities for different types of applications. In addition, it is possible to measure the performance of single persons or units and then consider population subgroups in order to measure horizontal inequality and compare either different units or the entire population.

[15] The choice of μ for measuring the level of individual well-being used to characterise the heterogeneity structure is not purely arbitrary. A sensitivity analysis using different measures (e.g. an iterative method leading to a sufficient degree of convergence after 3–4 iterations) showed no significant differences in the final measurements, so that a simple function as the arithmetic mean seems the most natural choice in absence of additional information on the structure of substitutability rates.

[16] When $\alpha = 0$ the function is not defined for $\mu < 0$, but since all variables are assumed to be bounded between 0 and 1, their arithmetic mean is non-negative, so that the function is defined in the domain.

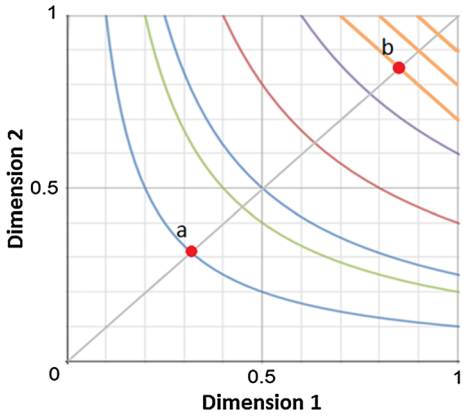

Fig. 2 Geometric representation of the *MSI* with generic a and b

In order to test the validity and the sensitivity of the proposed index, in Table 1 is provided an example with the results of the most common indexes and the *MSI* calculated on a matrix of simulated data. These data include ten dimensions over two possible levels of variance and three levels of well-being, for a total of six different profiles. The arithmetic mean implies perfect substitutability between dimensions, and therefore does not penalise heterogeneity, while the other three indexes produce lower scores (the last three columns report the magnitude of the decrease with respect to the arithmetic mean). As expected, the quadratic mean is not sensitive to changes in the overall level of well-being, and it registers a reduction only for units with high degree of heterogeneity. Both geometric mean and the *MSI*, on the other hand, are sensitive to the level of well-being, with poorest units that are more penalised than others. These two indexes produce similar results in case of low heterogeneity, while appear significantly different when a high variability is observed. For profile 4 (low well-being and high heterogeneity), the penalisation of the geometric mean appears excessively sensitive (−52.7%) to the dimensions more deprived (this is due to the functional form of the index that is too sensitive to values close to 0). The *MSI*, still penalising this extreme situation of poverty and heterogeneity (−27.0%) appears more robust to these "small" values in the achievements.

Although the *MSI* helps overcoming the "inescapable arbitrariness" issues mentioned by Anand and Sen (1997), it still maintains some elements of subjectivity in the choice of the functional form of $g(\cdot)$ or its parameters. We do not claim to have solved this arbitrariness issue, but rather to have proposed an index that allows a more flexible approach towards the management of the relationships between the dimensions of interest. In our opinion, the tools provided by the *MSI* can be important for a better understanding of the crucial dynamics of the synthesis. Even if a certain degree of arbitrariness in some choices is still inescapable, a deep understanding and a flexible approach that can significantly increase the awareness and consciousness of these choices.

5 Research and Policy Implications

The research and policy implications of applying this new approach to the synthesis of indicators are relevant for academics, policymakers and practitioners alike.

Table 1 Comparison between the MSI and some common synthesis: a simulation based on ten domains. Source: Our elaboration

Profiles			Values			Synthesis				Distance from arithmetic mean (%)		
#	General wellbeing	Heterogeneity	Min	Max	SD	Arithmetic mean (μ)	Quadratic mean	Geometric mean	MSI	Quadratic mean (%)	Geometric mean (%)	MSI (%)
1	Low	Low	0.08	0.51	0.15	0.30	0.29	0.26	0.27	−5	−14	−11
2	Average	Low	0.28	0.71	0.15	0.50	0.48	0.48	0.48	−4	−4	−4
3	High	Low	0.48	0.91	0.15	0.70	0.67	0.68	0.69	−5	−2	−2
4	Low	High	0.01	0.76	0.25	0.30	0.26	0.14	0.22	−13	−53	−27
5	Average	High	0.23	0.83	0.25	0.50	0.45	0.44	0.45	−11	−12	−11
6	High	High	0.31	0.98	0.25	0.70	0.62	0.65	0.66	−12	−7	−6

The first research implication is linked to the research design and initial efforts to facilitate the harmonization and alignment of the indicators and dimensions using value judgements and public scrutiny (Decancq et al. 2015; Decancq 2016; Menon et al. 2016; Mauro et al. 2017). Specifically, there is a need for coherent and consistent research design in the construction of tools and questionnaires. This requires special attention and techniques in order to collect information and data. The academic literature shows a need to increase dialogue across similar perspectives to find common solutions. For instance, the research on equivalences scales and well-being indicators can dialogue more fruitfully from within the synthesis of indicators for an individual/unit and the alignment of indicators.

The *MSI* is designed for horizontal aggregation in order to capture any change in the well-being of a person/unit and allows for comparisons over time within and between individuals. Among the most relevant features, is the possibility to monitor the outcomes of a single person/unit. The new synthesis of indicators permits the analysis of the entire distribution for all individuals or units with respect to time and geographical space.

It is important to note that, although the theory behind our metric is grounded on capabilities and opportunities, the proposed approach can be used in conjunction with any framework that is concerned with gauging achievements and final outcomes (such as the basic needs approach to development or human rights approach or prudential value based approaches).

Moreover, the presented approach can have implications for policy and practice. In particular, it can help identify and target beneficiaries for public welfare programmes. It can also help us to monitor development in multidimensional terms and contribute to evaluating development policies and programmes.

These considerations are especially relevant in the context of broader debates concerning the adoption of the Sustainable Development Goals. In fact, this approach can support policymakers to monitor risk, resilience and vulnerability (above and below given thresholds). In other words, the proposed synthesis can not only be used to monitor dimensions of poverty and well-being over time at both individual and aggregate level but can also chart their progress in terms of duration of poverty, the risk of falling into poverty and resilience to poverty, in line with various contributions to the development literature (Qizilbash 2003; Clark and Qizilbash 2008; Clark and Hulme 2010).

6 Conclusions

The new approach to the synthesis of indicators proposed in this paper draws on the theoretical foundations of the capability approach and the sustainable human development paradigm. This approach views "human beings as the "primary ends" of the process of development [and] calls for emphasis to be placed on what people get from development, not only what they put into it" (Anand and Sen 2000: 84). In the capability approach what people get from development is linked to the freedoms to live the kind of life that each and every person has reason to value.

The new synthesis proposed in this paper challenges the research design and methodologies typically applied and opens up new possibilities for different types of applications, including monitoring and evaluating development programmes. It allows for an easy comparison across territories and groups over time, which includes drawing comparisons at different levels of observation—micro, meso and macro. It is possible, for instance, to

monitor a person within a country, or a territory within a country, or a community within a territory (amongst other possible clusters involving individuals or groups of individuals within a geographical space).

Following alignment, the synthesis of indicators proposed can be used to measure poverty and explore vulnerability, resilience and risk. It is worth emphasising that the synthesis of indicators is not just one particular way of applying the capability approach. It is also relevant as a framework for embracing complexity that is capable of embracing time and multidimensionality.

We acknowledge that this is a seminal piece of work that introduces a class of indicators and that further work is required. The first extension is to move from the analysis of the distributions (of horizontal syntheses) to vertical aggregation. With this new synthesis of indicators, it is possible to take the entire population into account and consider population sub-groups in order to measure inequality (Stewart 2002; Jayaraj and Subramanian 2006). It is also possible to compare different units or the population. Indeed, comparisons of the total distribution are also relevant.

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