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Aggregating Multidimensional Indicators in Europe

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Aim of the presentation

The aim of this paper is to briefly introduce some of the main issues of multidimensional indexes and their development processes

A composite indicator is formed when Indicators are compiled into a single index, on the basis of an underlying model of the multi-dimensional concept that is being measured

Outline of the presentation

Premises

1. Introduction
2. 10 (and more…) steps to build a composite index
3. Normalisation and Substitutability between indicators
4. Some examples (MPI, HDI, SDGs)
5. Conclusions

Premises

- Synthesis as a way to measure multidimensional phenomena
- Complexity, multidimensionality *vs* usability
- From unidimensional, to multidimensionality…and back
- Monitoring outcomes e.g. 17 SDGs and sub-Indicators/targets, including effectiveness
- The Capability Approach and Sustainable Human Development → HDI, MPI

Background

Which is the class of synthesis of indicator to be used?

Synthesis as a tool to measure, summarise, and rank observations, usually based on multiple data items

In the context introduced, it is usually a function

$$I: \mathbf{X} \longrightarrow R$$

where X is the data matrix with generic entry x_{ij} representing the *j*-th achievement for individual *i*

Background

Horizontal and vertical aggregation

0.2	0.5	0.2
0.5	0.5	0.8
0.8	0.6	0.4

Data matrix

Background

Horizontal and vertical aggregation

0.2	0.5	0.2	**0.3**
0.5	0.5	0.8	**0.6**
0.8	0.6	0.4	**0.6**

Within-unit aggregation

Background

Horizontal and vertical aggregation

0.2	0.5	0.2	**0.3**
0.5	0.5	0.8	**0.6**
0.8	0.6	0.4	**0.6**
			0.5

Between-unit aggregation

Background

Horizontal and vertical aggregation

0.2	0.5	0.2	**0.3**
0.5	0.5	0.8	**0.6**
0.8	0.6	0.4	**0.6**
			0.5

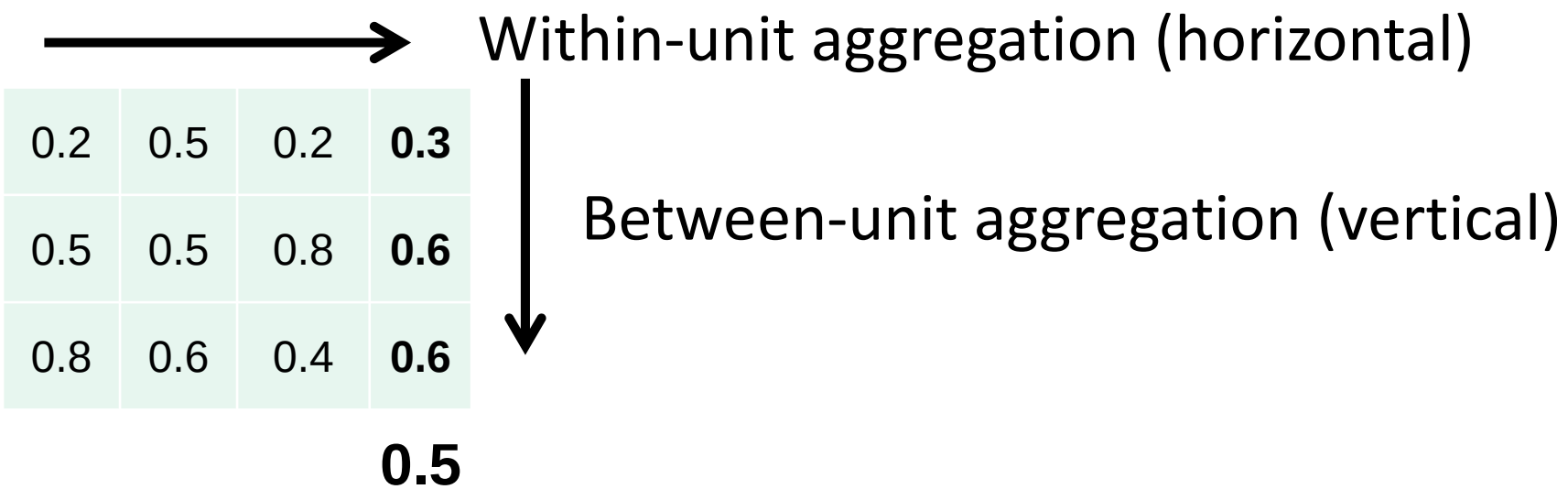
Background

Horizontal and vertical aggregation

0.2	0.5	0.2	**0.3**
0.5	0.5	0.8	**0.6**
0.8	0.6	0.4	**0.6**
			0.5

Background

Horizontal and vertical aggregation



These two phases are very different and should be kept separated (e.g. inequality)

In this presentation we focus on horizontal aggregation only

Background

Common distinction:

- Counting measures (e.g. MPI)
- Index measures (e.g. HDI)

Formal distinction? They are both functions from the set of X_{nxk} matrices to a real value

- Central role of the underlying assumptions (sometimes not very transparent)

From desirable properties of the synthesis to the function

These assumptions sometimes appear more as inevitable consequences of the methodology chosen than the result of philosophical and theoretically sound considerations.

Assumptions (properties) ⟹ Function (index)

What are the main properties?

Main properties

- Full sensitivity of the synthesis to any change in the data for any subgroup and in any dimension (strict monotonicity required for monitoring)
- Continuity
- A straightforward interpretation of the obtained synthetic score (not only through a comparison)
- A theoretically-coherent structure of substitutability between achievements, based on theoretical considerations

10-Step guide for the construction of a composite indicator

A good starting point is the 2008 OECD/JRC Handbook on how to build a composite indicator. It suggest 10 steps to follow

It represents a ‘decalogue’ for the construction of a composite indicator, which has been rearranged and extended from the information contained in the 2008 OECD/JRC Handbook.

This short guide stresses the importance of conducting an internal coherence assessment prior to the uncertainty and sensitivity analysis, so as to further refine and eventually correct the composite indicator structure.

Expert opinion is needed in this phase in order to assess the results of the statistical analysis.

It also highlights the iterative nature of the ten steps (although presented consecutively in the handbook)

Step 1. Theoretical/Conceptual framework

provides the basis for the selection and combination of variables into a meaningful composite indicator under a fitness-for-purpose principle (involvement of experts and stakeholders is important).

- Clear understanding and definition of the multidimensional phenomenon to be measured.

- Discuss the added-value of the composite indicator.

- Nested structure of the various sub-groups of the phenomenon (if relevant).

- List of selection criteria for the underlying variables, e.g., input, output, process.

Step 2. Data selection

should be based on the analytical soundness, measurability, country coverage, and relevance of the indicators to the phenomenon being measured and relationship to each other. The use of proxy variables should be considered when data are scarce (involvement of experts and stakeholders is important).

- Quality assessment of the available indicators.
- Discuss strengths and weaknesses of each selected indicator.
- Summary table on data characteristics, e.g., availability (across country, time), source, type (hard, soft or input, output, process), descriptive statistics (mean, median, skewness, kurtosis, min, max, variance, histogram).

Step 3. Data cleaning

it consists of imputing missing data, consistency checking, treating outliers etc.

- Confidence interval for each imputed value that allows assessing the impact of imputation on the composite indicator results.
- Discuss and treat outliers, so as to avoid that they become unintended benchmarks (e.g., by applying Box-Cox transformations such square roots, logarithms, and other).
- Make scale adjustments, if necessary (e.g., taking logarithms of some indicators, so that differences at the lower levels matter more).

(back to step 2)

Step 4. Multivariate analysis

should be used to study the overall structure of the dataset, assess its suitability, and guide subsequent methodological choices (e.g., weighting, aggregation).

- Assess the statistical and conceptual coherence in the structure of the dataset (e.g., by principal component analysis and correlation analysis).

- Identify peer groups of units based on the individual indicators and other auxiliary variables (e.g., by cluster analysis).

(back to Step 1 and Step 2)

Step 5. Normalisation

Crucial step that should be carried out to render the variables comparable.

- Make directional adjustment, so that higher values correspond to better performance in all indicators (or vice versa). Positive vs negative polarity

- Select a suitable normalisation method (e.g., min-max, z-scores, distance to best performer etc) that respects the conceptual framework and the data properties.

Normalisation issues

Implicit weighting issue

- For the standardization, in order to avoid implicit weighting issues, the minimum and maximum bounds are not data-driven but set theoretically for each dimensions
  → This allows for space and time comparability

→ Democratic processes, public reasoning (choice and weights, impartial spectator)

→ Alignment techniques to be used

Step 6. Weighting and aggregation

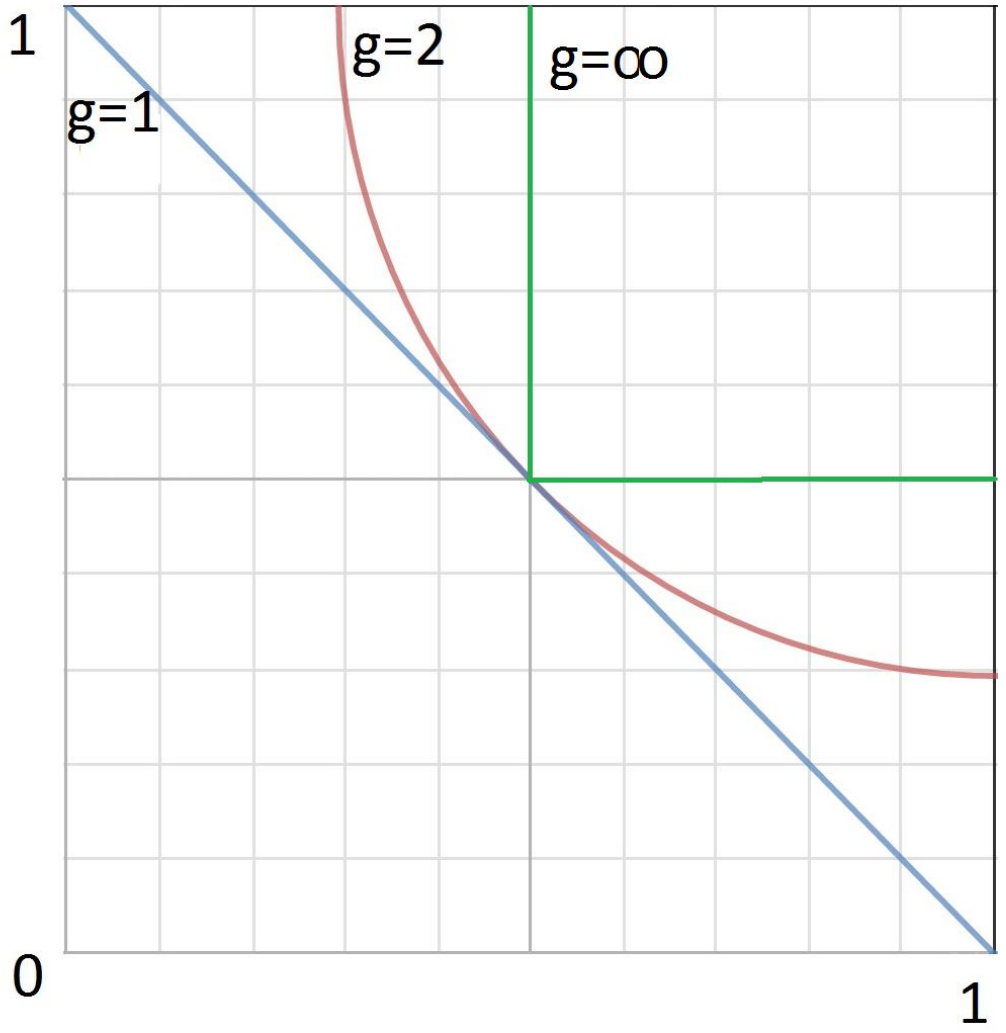
should be done along the lines of the theoretical/conceptual framework

- Discuss whether compensability among indicators should be allowed and up to which level of aggregation.
- Discuss whether correlation among indicators should be taken into account during the assignment of weights.
- Select a suitable weighting and aggregation method that respect the conceptual framework and the data properties. Popular weighting methods include equal weights, factor analysis derived weights, expert opinion, and data envelopment analysis. Popular aggregation methods include arithmetic average, geometric average, Borda, Copeland.

Recent developments: the substitutability between dimensions

«*…there is an inescapable arbitrariness in the choice of the order α…*»
(Anand and Sen, 1997)

Substitutability between dimensions
(a simple example)



There is an inescapable arbitrariness in the choice of the order α (Anand and Sen, 1997)

A possible escape from arbitrariness?

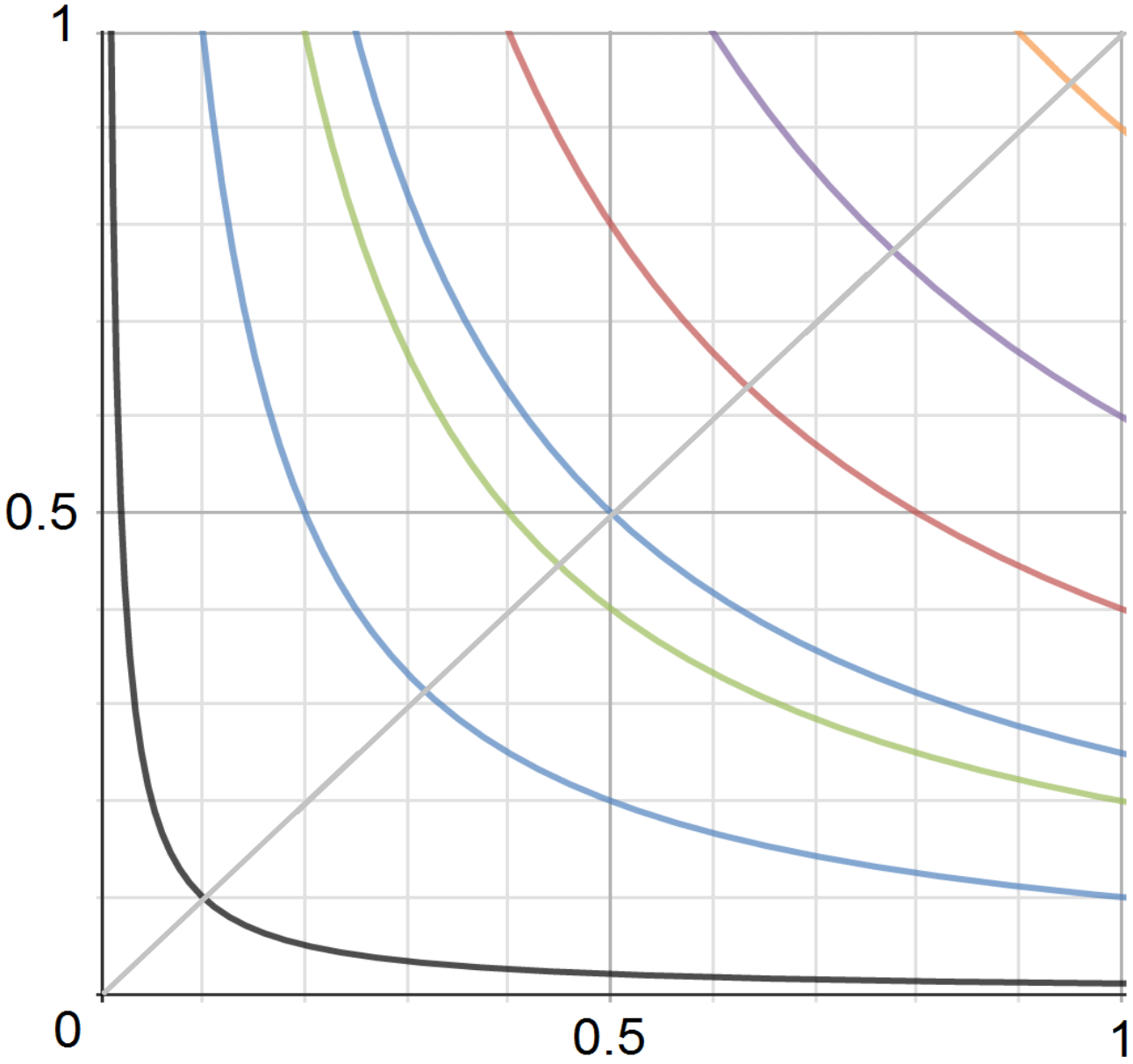


Figure: Geometric representation of the new synthesis of indicators

Internal coherence assessment (intermediate step)

This step is briefly listed under step 9 in the Handbook but not thoroughly discussed. This assessment needs to be undertaken prior to the uncertainty and sensitivity analysis, so as to further refine the composite indicator structure (upon consultation with experts on the issue).

- Assess whether dominance problems are present, namely the composite indicator results are overly dominated by a small number of indicators and quantify the relative importance of the underlying components (e.g., by global sensitivity analysis, correlation ratios).

Internal coherence assessment (intermediate step)

- Assess eventual "noise" added to the final composite indicator results by non-influential indicators.

- Assess the direction of impact of indicators and sub-dimensions, namely whether all components point to the same direction as the composite indicator (sign of correlation) and explain trade-offs.

- Assess whether certain indicators are statistically grouped under different dimensions than conceptualised and whether certain dimensions should be merged or split.

- Assess eventual bias introduced in the index (e.g., due to population size, population density)
(back to Step 1 and Step 2)

Step 7. Uncertainty and sensitivity analysis

should be undertaken to assess the robustness of the composite indicator scores/ranks to the underlying assumptions and to identify which assumptions are more crucial in determining the final classification.

The trade-off between multidimensionality and robustness in a composite indicator, given that a mono-dimensional index is likely to be more robust than a multi-dimensional one. This does not imply that the first index is better than the second one. In fact, robustness analysis should NOT be treated as an attribute of the composite indicator but of the inference which the composite indicator has been called upon to support.

- Consider different methodological paths to build the index, and if available, different conceptual frameworks.

- Identify the sources of uncertainty underlying in the development of the composite indicator and provide the composite scores/ranks with confidence intervals.

- Explain why certain countries notably improve or deteriorate their relative position given the assumptions.

- Conduct sensitivity analysis to show what sources of uncertainty are more influential in determining the scores/ranks.

Step 8. Relation to other indicators

should be made to correlate the composite indicator (or its dimensions) with existing (simple or composite) indicators and to identify linkages.

- Correlate the composite indicator with relevant measurable phenomena and explain similarities or differences.
- Develop data-driven narratives on the results.
- Perform causality tests (if time series data are available).

Step 9. Decomposition into the underlying indicators

should be carried out to reveal drivers for good/bad performance.

- Profile country performance at the indicator level to reveal strengths and limitations.
- Perform causality tests (if time series data are available).

Step 10. Visualisation of the results

should receive proper attention given that it can influence (or help to enhance) interpretability.

- Identify suitable presentational tools for the targeted audience.

- Select the visualisation technique which communicates the most information without hiding vital information.

- Present the results in a clear, easy to grasp and accurate manner.