## Supplementary File 2

### Technical description of the robustness analyses

In composite indicator analysis, the setting up of the final index is based upon a series of choices. The aim of the robustness (or uncertainty) analysis is to examine the extent to which the final ranking depends on the set of choices made during the selection and transformation of the variables (Van Roy-Nepelski 2016, Saisana et al. 2005).

The indicators which populate the pillars in the framework are generally chosen by integrating experts' judgment, data availability and checks on statistical consistency.

Robustness analysis in our case involves the following:

- compensability effect analysis;
- drop out effect of the pillars.

In connection with the analysis of the effect of excluding one pillar at a time the next question is the amount of compensability effects. Compensability is the "existence of trade-off, i.e. the possibility of offsetting a disadvantage on some criteria by a sufficiently large advantage on another criterion" (Munda, 2008: 71). The Composite Social Capital Index (CSCI) will be the base for the comparison. Several methods are applied. Ordered Weighted Averaging (OWA) approach is used for the pillars to present one aspect of compensability in case of CSCI (Yager, 1996). This technique looks for different scenarios of weights to put together more variables into a single index. The variables are to be in descending order. From our point of view there are three special cases defined for the OWA operators (set of weights, where the sum of the weights is 1).

- Purely optimistic operator (o): the highest variable (in our case pillar) gets all of the weight (1). So the sub-index gets the highest pillar value. This concept expresses an "or" multiple criteria condition, where the satisfaction of at least one criterion is enough to have a good position.
- Purely pessimistic operator (p): the lowest pillar gets the weight 1. So the overall index will include only the value of the lowest pillar. It can be understood as an "and" condition. No compensation is allowed, all criteria must be satisfied at the same time.

In each case, the final index value is calculated as a simple arithmetic mean from the sub-indices. So OWA operators are applied for the pillars. Going further the best/worst/average possible outcomes two other well-known weighting schemes are also considered:

- Equal weights for the pillars (simple arithmetic mean) to get the sub-indices and geometric mean to receive the final index values (arithmetic+arithmetic).
- Geometric mean of the pillars to get the sub-indices and arithmetic mean to receive the final index values (geometric+arithmetic).
- Geometric mean of the pillars to get the sub-indices and also geometric mean to receive the final index values (geometric+geometric).

Our CSCI applies an arithmetic+geometric mean together with a final adjustment by dividing the final index value with its maximum to obtain the maximum of 1. The results of the different scenarios will be compared without this final adjustment.

Geometric mean supports the "and" condition as it gives lower results if the distribution of the pillar values is uneven, while arithmetic mean supports an "or" condition as it gives higher value as the sum of the scores increase, independent from its distribution.

Altogether we have five weighting scenarios, which will be compared to our (original) CSCI values. Besides comparing the final CSCI values, the ranks based on the different scenarios are also confronted. The results are presented in the Figures 1-3 below.

**Figure 1. SCI values calculated with different weighting scenarios**

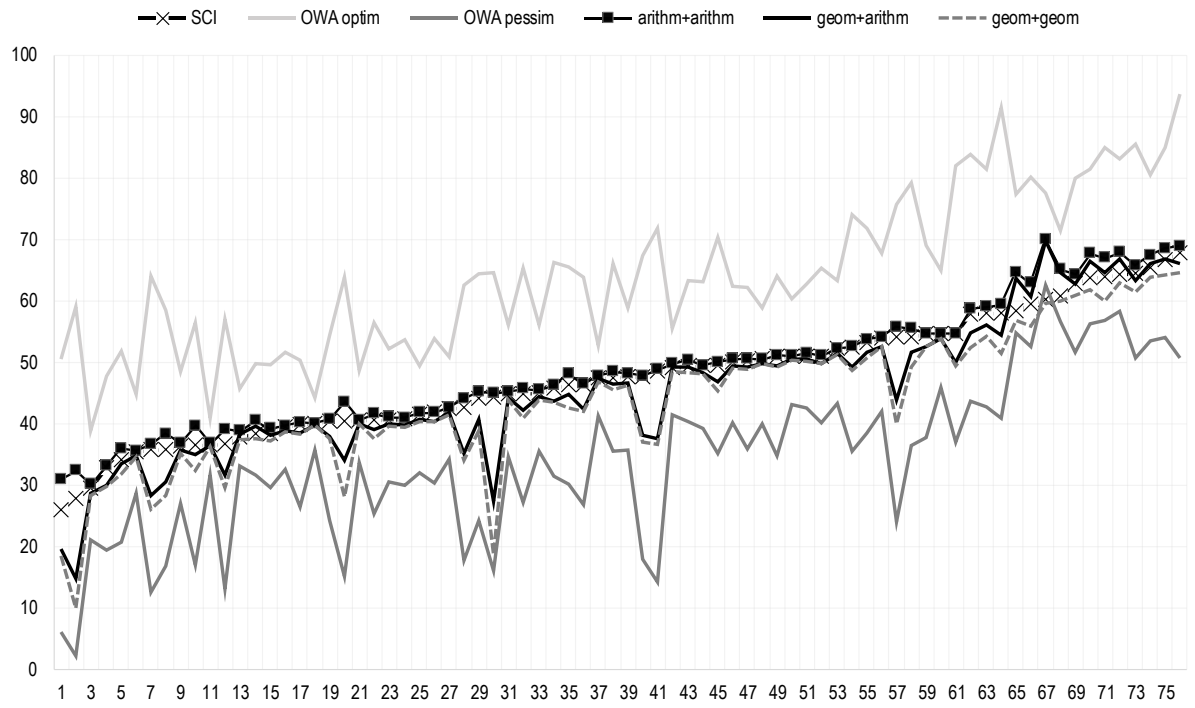


Figure 1. focuses on the scores. It is clear that the original weighting scheme performs similarly as the arithmetic+arithetic weighting, however it is rather different from the other two non-extreme (OWA optimistic and OWA pessimistic are the extremes) weighting scenarios. As soon as the three social capital indexes are calculated by the geometric mean, the final results can be very far from the original CSCI scores. This indicates that the decision on the weighting of the pillars in the subindexes have crucial effect on the final score of CSCI.

**Figure 2. Rank differences of non-extreme weighting scenarios compared to the original SCI ranks**

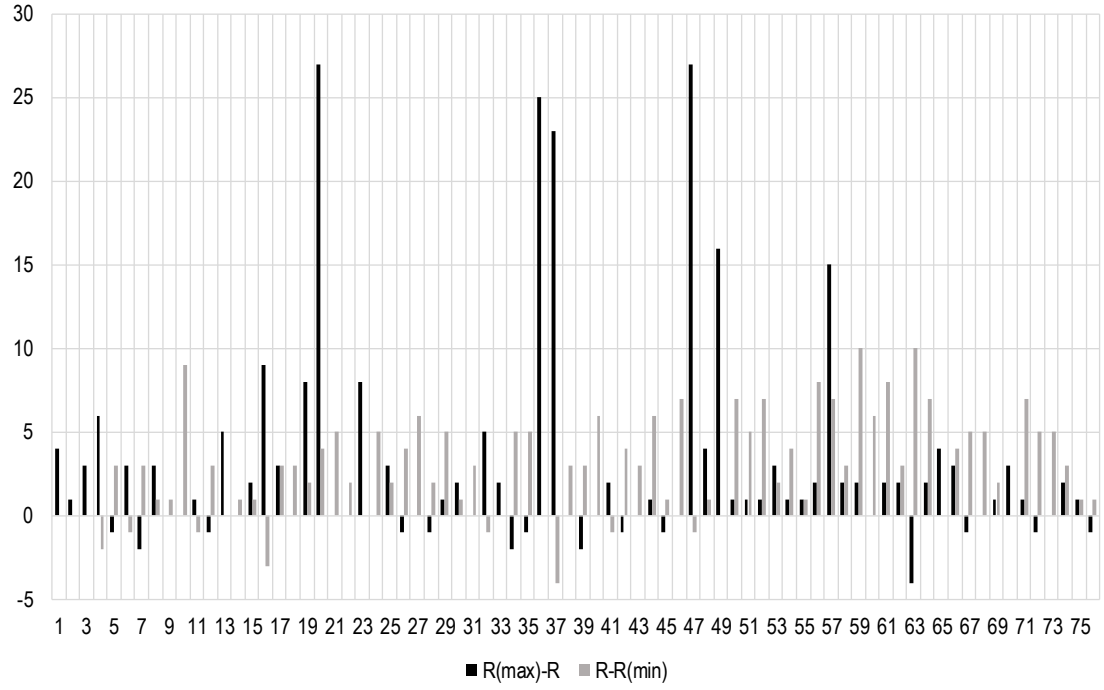


Figure 2. represents the differences of the maximum and minimum ranks by the non-extreme weighting scenarios compared to the original CSCI rank (R). In most of the cases (43 countries out of 76) the ranks differ by more than 3 positions. More than 10 per cent of the countries have 10 or more positions difference by different scenarios. These countries are: Mali, Ethiopia, Zambia, Rwanda, Nigeria, Burkina Faso, Serbia, Guatemala. The following countries perform differences between 6 and 9 positions: Norway, Japan, Estonia, Cyprus, Romania, Bulgaria, Colombia, Ukraine, Azerbaijan, Armenia, Algeria, New Zealand, Kazakhstan, Georgia, Mexico, Ecuador.

**Figure 3. Rank differences of non-extreme weighting scenarios compared to the original SCI ranks**

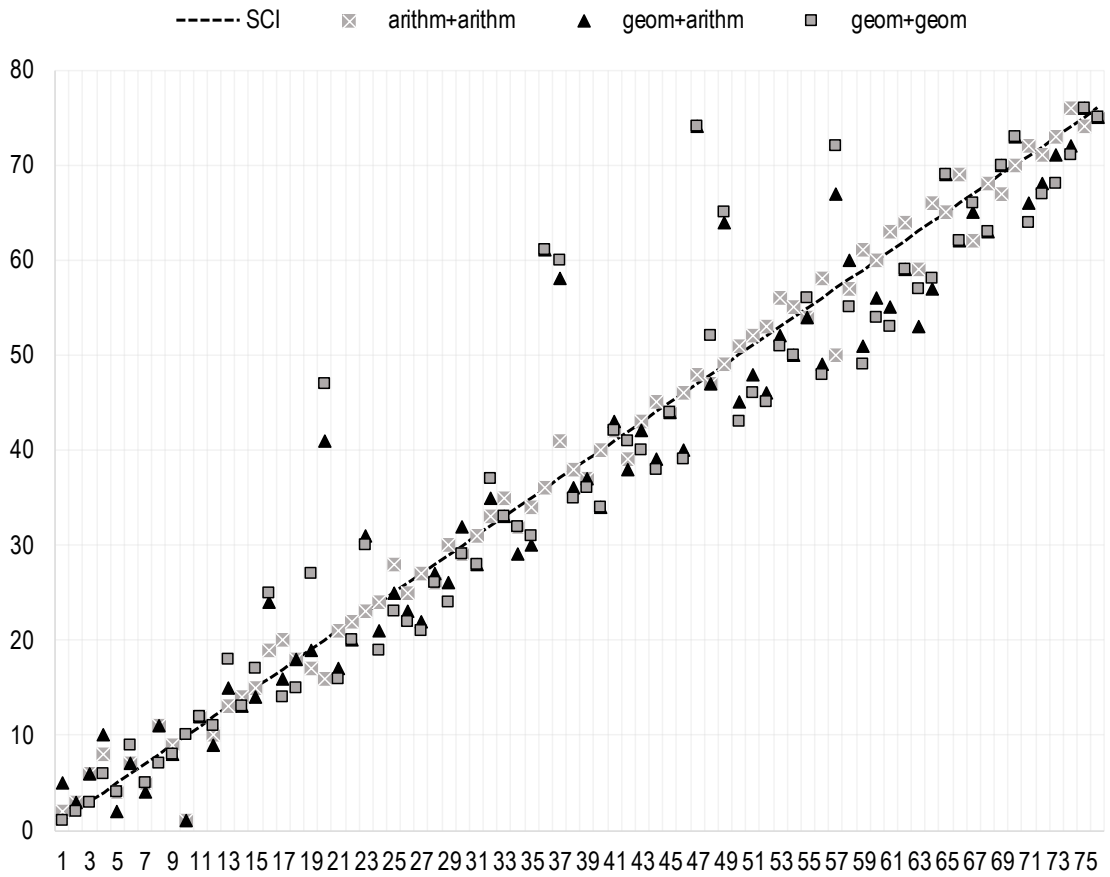


Figure 3. presents the ranks according to the non-extreme weighting scenarios. The same conclusion can be drawn as based on Figure 2. Geometric weighting of the pillars results in rather diverse final ranks. The position of most countries is sensitive to the weighting applied. This supports the fact that the decision behind the weighting scheme has a determining role, so its justification is best supported as empirical contrast, not as a valid independent index.

**Acknowledgment:**

The authors are grateful for assistance with robustness tests provided by Mónika Tiszberger, Faculty of Business and Economics, University of Pécs.

**References:**

Munda, G. (2008). *Social Multi-Criteria Evaluation for a Sustainable Economy*. Berlin Heidelberg: Springer-Verlag.

Saisana, M., Saltelli, A., Tarantola, S. (2005). Uncertainty and sensitivity analysis techniques as tools for the quality assessment of composite indicators. *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, 168(2), 307-323.

Van Roy, V., Nepelski, D. (2016). *Assessment of Framework Conditions for the Creation and Growth of Firms in Europe*. Joint Research Centre, JRC Scientific and Policy Reports – EUR 28167 EN; doi:10.2791/2811

Yager, R. R. (1996). Quantifier guided aggregating using OWA operators. *International Journal of Intelligent Systems*, 11(1), 49-73.