3. JRC statistical audit on the Elcano Global Presence Index 2016

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Introduction

The Elcano Global Presence Index offers an annual measurement of the projection in the world of —in the 2016 edition— 100 countries. The global presence as measured by the Index is based on the assessment of each country performance across three different dimensions: economic (flows of energy, flows of primary goods, flows of manufactures, etc.); military (troops deployed and military equipment); and soft (migration, tourism, sports, culture, etc.).

The philosophy behind the development of the 2016 edition of the Index is that, in order to make each country's performance across the indicators included in the framework comparable to that of another country, individual indicators need to be computed firstly as intensive variables[10] (i.e. denominated by Gross Domestic Product (GDP) or population). These intensive/denominated variables can thus be added up and combined together to obtain the dimension scores. Only at a later stage the dimension scores should be scaled-up taking into consideration the relative share of a country in global GDP (the economic dimension) or population (both the military and soft dimensions). These scaling coefficients are calculated as the ratio between GDP (or population) of the country and the average GDP (or population) of all the countries considered in the 2016 edition of the Index. This final scaling-up step is deemed necessary by the Index developers to fulfil the goal pursued by the Elcano Global Presence Index, i.e. to grasp the global projection of individual countries.

As reported by the development team, the Elcano Global Presence Index should be regarded as a "positive (not a normative) Index", in the sense that countries might increase their global presence by undertaking additional efforts on any of the three dimensions considered. This stance translates into fully compensatory aggregation formulas (i.e. arithmetic averages) being used in the calculation of global presence scores and ranks. However, such an assumption will be challenged in the uncertainty/sensitivity analysis presented at the end of this audit, by simulating the impact of the use of partially compensatory aggregation formulas in the Elcano Global Presence Index results.

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[9] European Commission, Joint Research Centre (JRC), Competence Centre on Composite Indicators and Scoreboards (COIN).

[10] For an in depth discussion on intensive/extensive variables, see e.g. Giampietro, Mario (2014), "Mono-dimensional Accounting and Multidimensional Measures of Sustainable Growth", *Final deliverable*. *Appointment letter* No. 258573 (October 25th, 2013) EC-JRC-G03.

The Elcano Global Presence Index 2016 has a very high statistical reliability at the scaled-up dimensions level (Cronbach-alpha value at 0.97), and captures the single latent phenomenon characterised by the conceptual framework. Country ranks are also relatively robust to methodological changes related to the treatment of missing values, weighting, aggregation rule and selection of indicators (less than ± 5 positions shift with respect to the simulated median in 77% of the countries). The added value of the Index lies in its ability to summarize different aspects of global presence in a more efficient and parsimonious manner than is possible with the indicators and dimensions taken separately. In fact, the Index and the economic and soft dimension rankings differ by ten positions or more in one quarter of the countries; differences between the Index and the military dimension rankings exceed ten positions in 52% of the countries. This is a much desired outcome, because it evidences the added value of the Index as a benchmarking tool, inasmuch as it helps to highlight aspects of global presence that do not emerge directly by looking into the dimensions separately. A seemingly reassuring result is obtained when comparing the differences in ranks between this Index and those that would emerge from looking only at the relative share of a country in either the global population or global GDP. Differences in rankings between Elcano Global Presence Index and rankings based exclusively in GDP shares exceed ten positions for 38% of the countries; this percentage goes up to 78% when considering rankings based only on shares in the global population.

The present audit represents the first collaboration between the Elcano Royal Institute and the European Commission's Joint Research Centre, specifically the Competence Centre on Composite Indicators and Scoreboards. This statistical assessment aims to contribute to ensure the transparency and reliability of the Elcano Global Presence Index and thus to enable policy makers to derive more accurate and meaningful conclusions, and to potentially guide choices on priority setting and policy formulation. The JRC assessment of the 2016 edition of this Index has focused on two main issues: the statistical coherence of the structure, and the impact of key modelling assumptions on the Elcano Global Presence Index scores and ranks.[11] For instance, the JRC analysis complements the reported country rankings for the Index with estimated confidence intervals, in order to better appreciate the robustness of these ranks to the computation methodology (in particular missing data estimation, weights, aggregation formula and the selection of the variables included in the Index). Overall, the main conclusions of the present audit can be summarised as follows: the Elcano Global Presence Index 2016 is sufficiently robust and reliable, with a statistically coherent and balanced multi-level structure. Some minor issues related to the further development of the conceptual framework are also recommended for examination in the next version of the Index.

The practical items addressed in this assessment relate to the statistical soundness of the Index, which is a necessary—but not sufficient—condition for a sound index. Given that the present statistical analysis of the Elcano Global Presence Index will mostly, though not exclusively, be based on correlations, the correspondence of the Index with a real world

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[11] The JRC analysis was based on the recommendations of the OECD & JRC (2008), *Handbook on Constructing Composite Indicators: Methodology and User Guide*, Paris, OECD (http://www.oecd.org/std/42495745.pdf) and on more recent research from the JRC. The JRC auditing studies of composite indicators are available at https://ec.europa.eu/jrc/en/coin (all audits were carried upon request of the index developers).

phenomenon needs to be critically addressed as correlations need not necessarily represent the real influence of the individual indicators on the phenomenon being measured. The point is that the validity of the Elcano Global Presence Index relies on the interplay between both statistical and conceptual soundness. In this respect, prior to undertaking the final audit of the Index, JRC COIN and the developing team from the Elcano Royal Institute engaged in fruitful and enriching iterative rounds of discussions. These exchanges led to a revision of different aspects of the conceptual framework and methodology of the Index, when compared to that of previous editions. Major modifications relate to the use of denominated variables, the calculation of the scaling coefficients, and normalisation approaches.

Statistical coherence in the Elcano Global Presence Index framework

The pre-audit phase of the Elcano Global Presence Index 2016 started in March 2016. Following on the iterative process during which the Index has been fine-tuned, the current assessment of the statistical coherence in this final version of the 2016 Index followed the following steps.

Data checks

Candidate indicators were selected by the developers for their relevance to a specific dimension, on the basis of the literature review, expert opinion, country coverage, and timeliness. To represent a fair picture of country differences, the Elcano Global Presence Index team denominated the indicators in the economic dimension by GDP, whilst population was chosen to denominate the indicators from the military and soft dimensions.

The 2016 dataset comprises 100 countries and 16 variables. Missing values (prior to imputations) were reported by the development team for only a few of the variables included in the framework. In the economic dimension, services and investments are affected by missing values (1% and 7% of the country cases, respectively). In the soft dimension, apart from tourism (with 1% of missing values), missing values reached significantly high levels in some of the variables included therein (13% in the case of development cooperation, 17% in education, and 41% in culture).

As regards normalisation, the 'min-max' approach was applied by the developers to the whole Elcano Global Presence Index data series, i.e. global maximum and minimum values (across all countries and periods) were used in these calculations. This normalisation strategy allows making meaningful comparisons over time, provided that the calculation of the normalised values for the previous years is repeated with each new release of the Index. The final range of values corresponding to each individual indicator was then set to 0-1000.

Outlier treatment

Potentially problematic variables that could bias the overall results were identified as those having absolute skewness greater than 2 and kurtosis greater than 3.5,[12] and were treated

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[12] Groeneveld, Richard A. & Glen Meeden (1984), "Measuring Skewness and Kurtosis" *The Statistician*, 33: 391–399 set the criteria for absolute skewness above one and kurtosis above 3.5. The skewness criterion was relaxed to account for the small sample (100 countries).

by winsorisation. The winsorisation treatment implies that we set the highest values to the next highest ones up until the point that skewness and kurtosis drop within acceptable ranges. Treated variables included services and investments in the economic dimension, as well as migration, tourism and culture in the soft dimension. The number of winsorised values ranged from three to five, except for the investments variable, in which a total of eight country values underwent treatment.

Statistical assessment

(i) Correlation structure

The correlation analysis is based on pair-wise correlations between variables. With 100 countries in the dataset, the threshold for a significant (1% significance level) Pearson correlation coefficient is r = 0.25. Correlation coefficient values lying within the 0.60-0.90 range are considered as representative of strong and significant correlations. From a theoretical perspective, correlations above 0.90 between variables from the same dimension should be treated with caution, since they are indicative of a redundancy in the information supplied by the indicators affected. On another hand, significantly negative correlations between variables in the same dimension, and between individual variables and the overall Index, should be avoided due to its potentially distorting effects.[13] The full set of statistically significant pair-wise correlations between individual indicators and its own dimension (as well as to the others) is presented in Tables 3.1 to 3.3.

Most of the individual variables in the framework are more strongly correlated to their own dimension than to any other dimension. Accordingly, we can conclude that the allocation of indicators to the individual dimensions is consistent both from a conceptual and statistical perspective. The only exception to this rule is the variable of tourism, which appears to be slightly less correlated to the soft dimension (0.66) than to the economic dimension (0.68).

Table 3.1.
Pair-wise correlation structure at the dimension level: economic dimension variables

	Variables					Dimensions		
	Energy	Primary	Manufact.	Services	Invest.	Eco.	Military	Soft
Energy	1.00							
Primary		1.00				0.25		
Manufact.			1.00	0.43	0.38	0.66		0.36
Services			0.43	1.00	0.63	0.82		0.54
Invest.			0.38	0.63	1.00	0.83	0.28	0.77

Notes: (1) Numbers represent Pearson correlation coefficients. (2) Non-significant correlations (<0.25) are shown as blanks. (3) Correlations between 0.25-0.60 are highlighted in blue. (4) Correlations between 0.60-0.90 are highlighted in green.
Source: European Commission, Joint Research Centre (JRC), 2017

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[13] See OECD & JRC (2008), *op. cit.*

Table 3.2.
Pair-wise correlation structure at the dimension level: military dimension variables

	Variables		Dimensions		
	Troops	Military equip.	Economic	Military	Soft
Troops	1.00	0.31		0.67	0.37
Military equip.	0.31	1.00		0.91	0.41

Notes: (1) Numbers represent Pearson correlation coefficients. (2) Non-significant correlations (<0.25) are shown as blanks. (3) Correlations between 0.25-0.60 are highlighted in blue. (4) Correlations between 0.60-0.90 are highlighted in light green. (5) Correlations above 0.90 are highlighted in darker green.
Source: European Commission, Joint Research Centre (JRC), 2017

Table 3.3.
Pair-wise correlation structure at the dimension level: soft dimension variables

	Variables									Dimensions		
	Mig.	Tou.	Spo.	Cult.	Info.	Tech.	Sci.	Edu.	Dev co.	Eco.	Milit.	Soft
Mig.	1.00	0.35	0.30	0.24	0.40		0.41	0.66	0.52	0.48	0.32	0.60
Tou.	0.35	1.00	0.70	0.41	0.61	0.29	0.61	0.46	0.33	0.68		0.66
Spo.	0.30	0.70	1.00	0.43	0.51	0.25	0.54	0.36	0.33	0.51		0.58
Cult.		0.41	0.43	1.00	0.57	0.60	0.68	0.44	0.48	0.50	0.45	0.74
Info.	0.40	0.61	0.51	0.57	1.00	0.54	0.82	0.55	0.67	0.69	0.34	0.86
Tec.		0.29	0.25	0.60	0.54	1.00	0.65	0.41	0.61	0.33	0.42	0.72
Sci.	0.41	0.61	0.54	0.68	0.82	0.65	1.00	0.67	0.67	0.63	0.41	0.92
Edu.	0.66	0.46	0.36	0.44	0.55	0.41	0.67	1.00	0.54	0.50	0.43	0.76
Dev co.	0.52	0.33	0.33	0.48	0.67	0.61	0.67	0.54	1.00	0.42	0.37	0.80

Notes: (1) Numbers represent Pearson correlation coefficients. (2) Non-significant correlations (<0.25) are shown as blanks. (3) Correlations between 0.25-0.60 are highlighted in blue. (4) Correlations between 0.60-0.90 are highlighted in light green. (5) Correlations above 0.90 are highlighted in darker green.
Source: European Commission, Joint Research Centre (JRC), 2017

A special mention should be made to the indicator on energy, that appears to be neither significantly correlated to its own dimension nor to any other dimension in the framework. In fact, it happens to be significantly correlated only to the migration variable from the soft dimension (0.38). This situation is indicative of a highly differentiated behaviour of this variable with respect to all the remaining indicators in the Elcano Global Presence Index. This result will be taken into account when undertaking the uncertainty/sensitivity analysis, since one of the assumptions to be factored into the robustness checks will be the impact of the exclusion of the variable energy from the indicator framework. A similar result is observed for the variable on primary goods, which has only a borderline statistically significant correlation to the economic dimension.

It is also worth noting the unbalance between the two variables included in the military dimension. As shown in Table 3.2, the military dimension is much more strongly correlated to the military equipment (r = 0.91) indicator than to the troops (r = 0.67) indicator.

As explained when describing the underlying conceptual framework of the Index, the weighted average scores for each individual dimension have to be scaled-up by either GDP or population before calculating the overall Index scores. As shown in Table 3.4, the three scaled-up dimensions are strongly correlated; moreover, correlation values are also very high between the three of them and the overall final score —in spite of having assigned twice as much weight in the aggregation process to the economic and soft dimensions (0.4) than to the military dimension (0.2). The main drawback of the scaling-up process needed to obtain a final global presence score is the fact that many of the individual indicators eventually are not significantly correlated to the final Index (see Table 3.5). This drawback is particularly relevant for the economic dimension, where none of the original denominated variables is significantly correlated to the final overall scaled-up Index. In addition, only the two of the original (non-scaled up) dimensions —the economic and the soft dimension— remain significantly correlated to the final Elcano Global Presence Index score. Comparatively, stronger correlations are found between the non-scaled variables and the non-scaled version of the Index, calculated as the weighted average of the dimension scores prior to being scaled-up.

Table 3.4.
Correlation between the scaled dimensions, the overall Index and the scaling factors

	Scaled-economic	Scaled-military	Scaled-soft	Elcano Global Presence Index
Scaled-economic	1.00	0.87	0.97	0.99
Scaled-military	0.87	1.00	0.93	0.93
Scaled-soft	0.97	0.93	1.00	0.99
GDP scaling factor	0.95	0.87	0.94	0.95
POP scaling factor	0.36	0.31	0.30	0.34

Notes: (1) Numbers represent Pearson correlation coefficients. (2) Non-significant correlations (<0.25) are shown as blanks. (3) Correlations between 0.25-0.60 are highlighted in blue. (4) Correlations between 0.60-0.90 are highlighted in light green. (5) Correlations above 0.90 are highlighted in darker green.
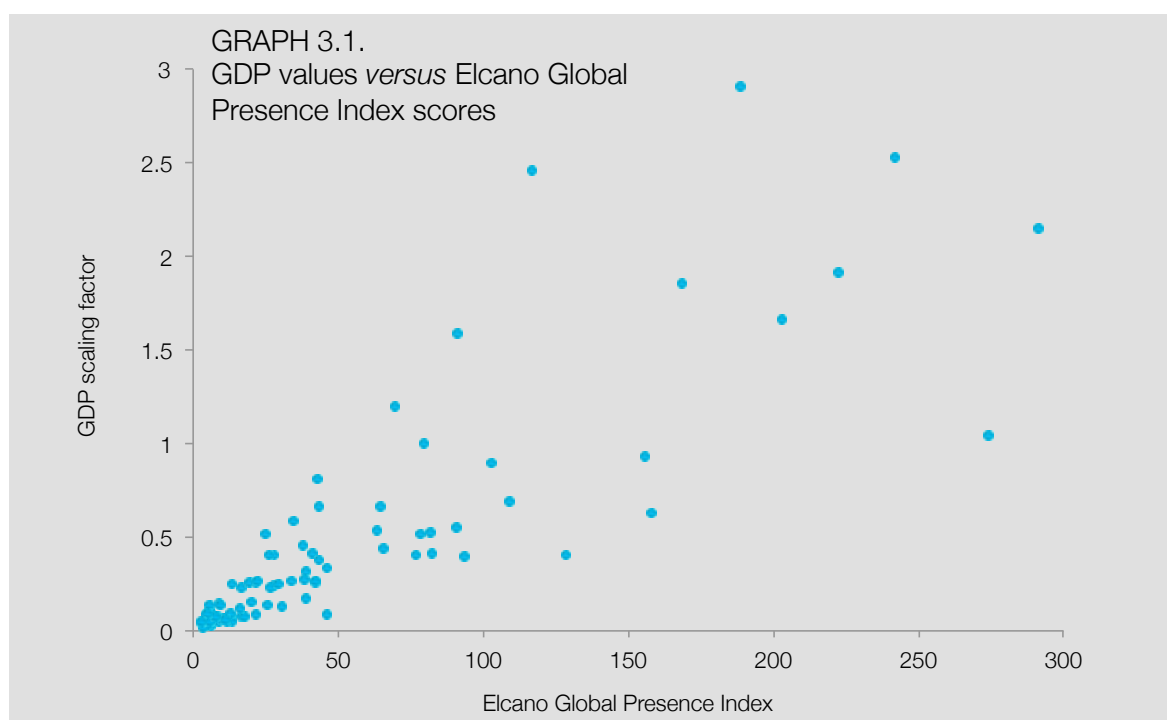Source: European Commission, Joint Research Centre (JRC), 2017

A final word of caution should be given to the impact of the scaling factors on the Elcano Global Presence Index. The importance of the scale factors in the overall Index is made evident when calculating the values of the coefficient of determination (R^2) associated to GDP and population. As measured by the R^2, cross-country variations in GDP explain up to 90% of the variation observed in the Index scores —whilst only 12% of the variation would be explained by variations in country population values alone. However, as graphically shown in Graph 3.1, similar GDP values (scaling factors) might still translate into quite different Index scores and *vice-versa*.

Table 3.5.
Correlation between individual indicators, non-scaled dimensions, the overall Index and the non-scaled version of the overall Index

	Elcano Global Presence Index	Non-scaled Elcano Global Presence Index
Energy		
Primary goods		
Manufactures		0.50
Services		0.64
Investments		0.84
Troops	0.35	0.39
Military equipment	0.52	0.50
Migrations		0.61
Tourism		0.69
Sports		0.55
Culture	0.38	0.72
Information		0.85
Technology	0.47	0.63
Science		0.87
Education		0.73
Development cooperation		0.70
Economic		0.84
Military	0.56	0.56
Soft		0.95

Notes: (1) Numbers represent Pearson correlation coefficients. (2) Non-significant correlations (<0.25) are shown as blanks. (3) Correlations between 0.25-0.60 are highlighted in blue. (4) Correlations between 0.60-0.90 are highlighted in light green. (5) Correlations above 0.90 are highlighted with darker green.
Source: European Commission, Joint Research Centre (JRC), 2017

GRAPH 3.1.
GDP values *versus* Elcano Global Presence Index scores

Notes: Elcano Global Presence Index values above 300 and GDP scaling factor values above three have been omitted from the plot.
Source: European Commission, Joint Research Centre (JRC), 2017

(ii) Principal components analysis and reliability analysis

Principal component analysis (PCA) and reliability analysis (RA) have been used to assess the extent to which the conceptual framework agrees with the statistical properties of the data. The PCA and the RA have been carried out at the relevant level of analysis, which in this particular case study corresponds to be the level of the denominated variables and dimensions. Ideally, PCA should confirm the presence of a single statistical dimension amongst the variables subject to analysis (i.e., no more than one principal component with eigenvalue greater than 1.0); similarly, a Cronbach-alpha value above 0.7 would confirm the reliability and internal consistency of a particular grouping of variables (i.e. whether or not they are measuring the same underlying construct).[14] Note that neither PCA nor RA would be meaningful for the military dimension, as it comprises only two variables.

Within the economic dimension, two principal components have been found with eigenvalues above the defined threshold (2.013 and 1.184, respectively). The combination of these two principal components explains 63% of the total variance in the underlying indicators. The variables of energy and primary goods load mainly on the second principal component, as opposed to the rest of the variables in the dimension, which load mainly on the first principal component. RA results confirm those of the PCA, since the Cronbach-alpha value (0.426) is below the limit threshold of 0.7. It is also worth noting that the

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[14] See Jum C. Nunnally, Jum C. (1978), *Psychometric Theory*, New York, McGraw-Hill.

Cronbach-alpha would increase significantly in case the indicator on energy was omitted from the framework; the same would happen in case of excluding the indicator on primary goods.

Up to three principal components have been identified in the soft dimension. However, except for the first one (eigenvalue 5.027, explaining 56% of the variance), the other two have eigenvalues, which are very close to the 1.0 threshold value (1.094 and 1.041). The view that the conceptual grouping of the indicators in the soft dimension might be considered statistically sound is further supported by the RA results. The Cronbach-alpha value calculated for this dimension is clearly above the threshold (0.898), and could not be improved by the omission of any of the variables present therein.

The three resulting dimensions also share a single statistical dimension that summarises 95% of the total variance, and the three loadings (correlation coefficients) are very similar to each other, ranging from 0.95 to 0.99. The reliability of the three dimensions, measured by the Cronbach-alpha value, is also very high at 0.97, which is well above the 0.7 threshold for a reliable aggregate.

Overall, the tests so far show the Elcano Global Presence Index has a balanced structure, whereby all three scaled-up dimensions are equally important in explaining the same underlying concepts. For the economic dimension, recommendations have also been made pointing towards the possibility of excluding or substituting some of the underlying indicators in future versions of the Index, so as to render it even sounder from both a conceptual and statistical point of view.

(iii) Added value of the Elcano Global Presence Index

A very high statistical reliability among the main components of an Index can be the result of redundancy of information. This is not the case in the Elcano Global Presence Index. In fact, for in between ¼ and ½ of the 100 countries included in the 2016 Index, the overall ranking differs by ten positions or more from any of the underlying dimensions. In the most extreme cases, differences in ranking go up to 61 positions in the economic and 46 in the soft for Ethiopia, and up to 59 positions in the military dimension in the case of Switzerland. This is a desired outcome, because it evidences the added value of the Elcano Global Presence Index ranking, which helps to highlight other components of global presence that do not emerge directly by looking into the three dimensions separately.

Qualitative review

The Elcano Global Presence Index outputs are evaluated by both the development team and external experts to verify that the overall results are, to a great extent, consistent with current evidence, existing research or prevailing theory.

Notwithstanding the results of the statistical tests already undertaken on the Index, it is important to mention that it should remain open for future improvements as better data, more comprehensive surveys and assessments, and new relevant research studies become available.

Impact of modelling assumptions on the Elcano Global Presence Index results

The robustness analysis presented in this section is aimed at assessing the simultaneous and joint impact of the underlying modelling choices on the Index scores and rankings. The data used for this exercise are assumed to be error-free since potential outliers and any errors and typos have already been corrected during the computation phase.

The robustness assessment of the Elcano Global Presence Index is based on a combination of a Monte Carlo experiment and a multi-modelling approach that deals with three underlying methodological issues: dimension weights, missing data imputation (for missing values in the economic and soft dimension), and the aggregation formula of the dimension scores. Additionally it was decided to investigate the impact of excluding variables which do not seem to be related to the rest of the variables in the conceptual framework. This is for example the case of the energy indicator from the economic dimension. In general, this robustness assessment aims to respond to some extent to eventual criticism that the country scores associated with aggregate measures are generally not calculated under conditions of certainty, even though they are frequently presented as such.

The robustness analysis is executed at a relevant higher level of aggregation. In this case study, the focus has been put on the three scaled-up dimensions, for which alternative set of weights have been generated using Monte Carlo simulations (1,000 runs, each corresponding to a different set of weights). The weights are randomly sampled from uniform continuous distributions. The range of the weights' variation was chosen to ensure a wide enough interval to have meaningful robustness checks. The limit values considered for uncertainty intervals for the dimension weights are 15% to 50% (see Table 3.6). In all simulations, sampled weights are rescaled to unity sum.

Two alternative strategies for the imputation of missing values have been considered in the uncertainty analysis: the one proposed by the developers —based on expert knowledge— and the one tested by JRC COIN, which is based on the Expectation Maximisation (EM) algorithm. Regarding the aggregation formula, two different approaches have been factored into the robustness analysis (arithmetic *versus* geometric).[15] Whilst the simple arithmetic average is fully compensatory, geometric averages allow only for a partial compensation for comparative disadvantages in some of the dimensions. Consequently, geometric averages reward countries with similar performance in all dimensions, and could be signalling those countries with uneven performance to increase their external projection in those dimensions (in case these are aligned with national priorities) in which they perform with lower scores, and not just in any dimension. Finally, the option of excluding a problematic variable (energy) from the first dimension has also been tested. Excluding a variable implies a proportional reallocation of the weight assigned to the excluded variable among the rest of the variables within the dimension.

Six models were tested based on the combination of expert imputation *versus* EM imputation, arithmetic *versus* geometric average, and exclusion of variables,[16] combined with

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[15] Calculated as the weighted generalized mean of the dimension scores.
[16] The option of excluding the energy indicator has been considered only in combination with the expert imputation option. Accordingly, the six scenarios considered are: expert imputation with energy and arithmetic aggregation, expert imputation with

1,000 simulations per model (random weights *versus* fixed weights), for a total of 6,000 simulations (see Table 3.6 for a summary of the uncertainties considered in the 2016 edition).

Table 3.6.
Uncertainty analysis for the Elcano Global Presence Index 2016: weights, missing data, aggregation and omission of selected variables

I. Uncertainty in the treatment of missing values		
Reference: imputation by developers	Alternative: Expectation Maximization (EM)	
II. Uncertainty in the aggregation formula at dimension level		
Reference*: arithmetic average*	Alternative: geometric average	
III. Uncertainty in the selection of variables		
Reference*: energy included*	Alternative: energy excluded	
IV. Uncertainty in the weights		
Dimension	Reference value for the weight	Distribution assigned for robustness analysis
Economic	0.40	U[0.15 - 0.50]
Military	0.20	U[0.15 - 0.50]
Soft	0.40	U[0.15 - 0.50]

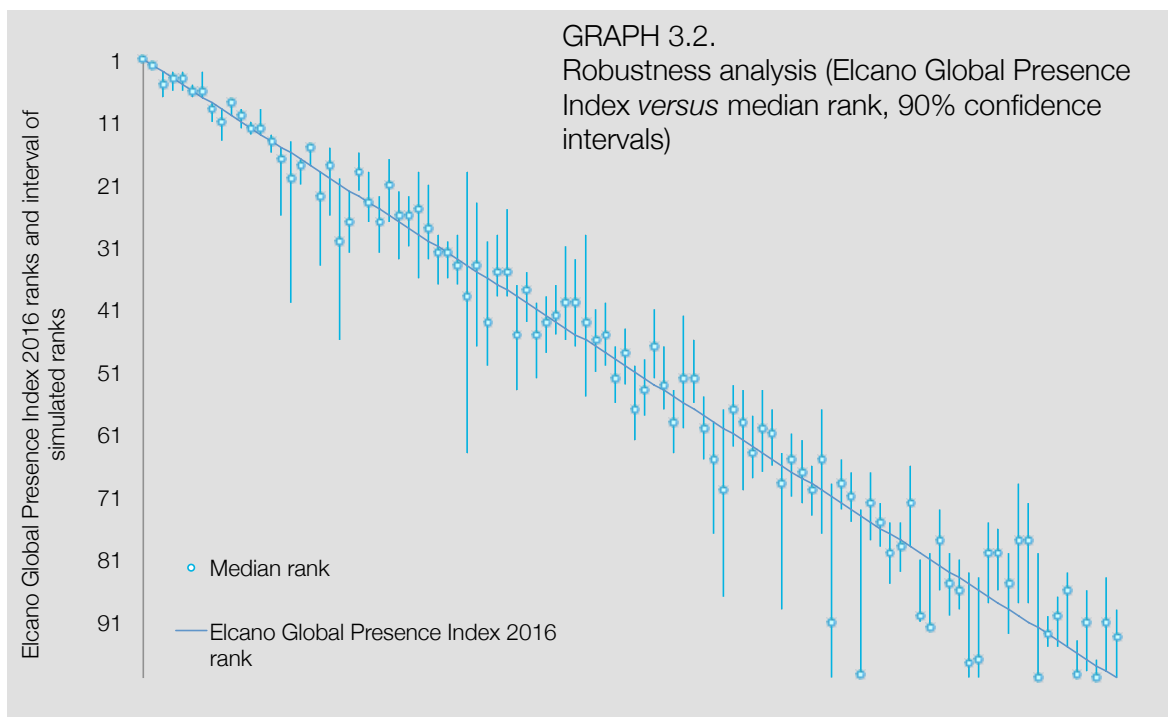Source: European Commission, Joint Research Centre (JRC), 2017

Uncertainty analysis results

The main results of the robustness analysis are shown in Graph 3.2, with median ranks and 90% confidence intervals computed across the 6,000 Monte Carlo simulations for the Index. Countries are ordered from higher to lower global presence according to their reference rank (blue line), the dot being the median rank. Error bars represent, for each country, the 90% interval across all simulations. Table 3.7 reports the published rankings and the 90% confidence intervals that account for uncertainties in the imputation of missing data, allocation of dimension weights, aggregation formula and inclusion/exclusion of specific variables. Only for seven countries (Thailand, Morocco, Peru, Côte d'Ivoire, Sri Lanka, Sudan and Democratic Republic of Congo) the published ranks lie outside the simulated intervals. For these countries, ranks resulting from the Index should be treated with caution, since they prove to be highly sensitive to changes in the underlying assumptions of the framework. In general, the ranks are relatively robust to changes in the underlying assumptions, as illustrated by the fact that for a majority of the countries the simulated intervals are narrow enough (less than ten positions for 57% of the countries analysed).

Ranks are shown to be relatively robust to changes in the imputation method, the dimension weights, the aggregation formula and the selection of variables. If one considers the median rank across the simulated scenarios as being representative of these scenarios, then the fact that the Index rank is relatively close to the median rank (less than five positions away) for

energy and geometric aggregation, expert imputation without energy and arithmetic aggregation, expert imputation without energy and geometric aggregation, EM imputation with arithmetic aggregation, and EM imputation with geometric aggregation.

77% of the countries suggests also that the Elcano Global Presence Index is a suitable summary measure. Furthermore, only for seven countries (Lebanon, Angola, Cyprus, Costa Rica, Dominican Republic, Sudan and Democratic Republic of Congo) the difference between the published and the median rank exceeds ten positions, with the maximum divergence corresponding to Angola (26 positions below its published rank). Once again, the global presence of this particular country as assessed by the Index merits special attention from the developers.

GRAPH 3.2.
Robustness analysis (Elcano Global Presence Index *versus* median rank, 90% confidence intervals)

○ Median rank

—— Elcano Global Presence Index 2016 rank

Notes: The Spearman rank correlation between the median rank and the Elcano Global Presence Index 2016 rank is 0.981. Median ranks and intervals are calculated over 6,000 simulated scenarios combining random weights, expert-based imputation versus no imputation of missing values, geometric versus arithmetic average, and exclusion of variables from the framework, at the dimension level.
Source: European Commission, Joint Research Centre (JRC), 2017

Table 3.7.
Elcano Global Presence Index ranks, simulated median ranks and simulated 90% intervals

Country	Elcano Global Presence Index 2016		
	Rank	Median rank	Interval
United States	1	1	[1, 1]
China	2	2	[2, 2]
Germany	3	5	[3, 7]
United Kingdom	4	4	[3, 6]
France	5	4	[3, 6]

Table 3.7.
Elcano Global Presence Index ranks, simulated median ranks and simulated 90% intervals

Country	Elcano Global Presence Index 2016		
	Rank	Median rank	Interval
Japan	6	6	[5, 7]
Russia	7	6	[3, 7]
Canada	8	9	[8, 11]
Netherlands	9	11	[9, 14]
Italy	10	8	[8, 10]
South Korea	11	10	[9, 12]
Spain	12	12	[11, 13]
India	13	12	[9, 13]
Australia	14	14	[13, 16]
Belgium	15	17	[15, 26]
Switzerland	16	20	[14, 40]
Singapore	17	18	[17, 21]
Brazil	18	15	[15, 18]
Sweden	19	23	[19, 34]
Saudi Arabia	20	18	[15, 26]
Ireland	21	30	[20, 46]
Mexico	22	27	[22, 32]
Thailand	23	19	[16, 22]
Malaysia	24	24	[19, 27]
Austria	25	27	[23, 32]
Turkey	26	21	[17, 27]
United Arab Emirates	27	26	[22, 33]
Denmark	28	26	[23, 31]
Indonesia	29	25	[19, 36]
South Africa	30	28	[21, 33]
Poland	31	32	[29, 37]
Norway	32	32	[30, 36]
Chile	33	34	[29, 37]
Ethiopia	34	39	[19, 64]
Pakistan	35	34	[24, 47]
Nigeria	36	43	[30, 50]
Argentina	37	35	[29, 39]

Table 3.7.
Elcano Global Presence Index ranks, simulated median ranks and simulated 90% intervals

Country	Elcano Global Presence Index 2016		
	Rank	Median rank	Interval
Greece	38	35	[25, 39]
Czech Republic	39	45	[37, 54]
Israel	40	38	[35, 43]
Finland	41	45	[40, 52]
Hungary	42	43	[39, 48]
Portugal	43	42	[37, 45]
Egypt	44	40	[31, 46]
Iran	45	40	[33, 47]
Bangladesh	46	43	[29, 55]
Ukraine	47	46	[41, 51]
Romania	48	45	[40, 50]
New Zealand	49	52	[47, 56]
Colombia	50	48	[44, 53]
Qatar	51	57	[50, 62]
Philippines	52	54	[49, 58]
Morocco	53	47	[41, 52]
Venezuela	54	53	[47, 57]
Vietnam	55	59	[54, 64]
Kenya	56	52	[42, 60]
Peru	57	52	[46, 56]
Kuwait	58	60	[55, 65]
Kazakhstan	59	65	[59, 77]
Luxembourg	60	70	[57, 87]
Belarus	61	57	[53, 63]
Algeria	62	59	[54, 70]
Slovakia	63	64	[58, 68]
Ghana	64	60	[54, 67]
Bulgaria	65	61	[57, 66]
Iraq	66	69	[64, 89]
Oman	67	65	[61, 71]
Jordan	68	67	[62, 72]
Croatia	69	70	[66, 74]

Table 3.7.
Elcano Global Presence Index ranks, simulated median ranks and simulated 90% intervals

Country	Elcano Global Presence Index 2016		
	Rank	Median rank	Interval
Tanzania	70	65	[57, 77]
Lebanon	71	91	[69, 100]
Slovenia	72	69	[65, 73]
Ecuador	73	71	[67, 75]
Angola	74	100	[73, 100]
Serbia	75	72	[67, 78]
Lithuania	76	75	[72, 79]
Azerbaijan	77	80	[75, 85]
Panama	78	79	[75, 83]
Uruguay	79	72	[66, 79]
Côte d'Ivoire	80	90	[81, 91]
Cyprus	81	92	[80, 92]
Tunisia	82	78	[73, 86]
Cuba	83	85	[80, 90]
Estonia	84	86	[81, 89]
Costa Rica	85	98	[83, 100]
Dominican Republic	86	97	[84, 100]
Myanmar	87	80	[75, 88]
Sri Lanka	88	80	[76, 86]
Libya	89	85	[80, 93]
Sudan	90	78	[69, 88]
Congo, Democratic Republic	91	78	[72, 88]
Turkmenistan	92	100	[80, 100]
Uzbekistan	93	93	[90, 95]
Latvia	94	90	[87, 95]
Guatemala	95	86	[83, 95]
Iceland	96	100	[94, 100]
Bolivia	97	91	[86, 99]
Malta	98	100	[97, 100]
Yemen	99	91	[84, 99]
Syria	100	94	[89, 100]

Source: European Commission, Joint Research Centre (JRC), 2017
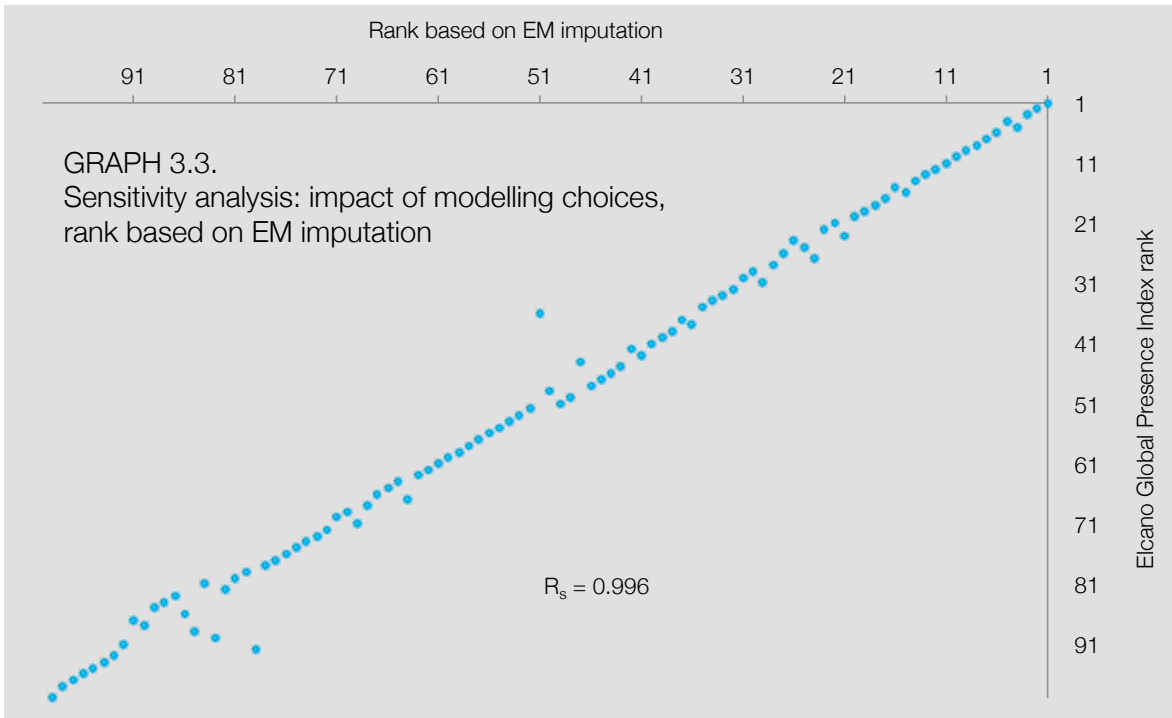
Sensitivity analysis results

Complementary to the uncertainty analysis, sensitivity analysis has been used to identify which of the modelling assumptions have the highest impact on certain country ranks. Graphs 3.3 to 3.5 plots the Elcano Global Presence Index *versus* one-at-a-time changes of the imputation method, the geometric aggregation formula or the exclusion of variables from the model.

The most influential methodological assumption appears to be the choice of the aggregation formula. The use of a geometric averaging (allowing for only partial compensation across dimension scores) has the largest impact on differences in ranking when compared to the published rankings. In total, ten countries experience shifts of ten or more positions when geometric averaging is used, as opposed to only two when either EM imputation is applied or when energy is removed from the framework. For example, in the most extreme case, a country (Ethiopia) fell by 30 positions when geometric averaging is applied, yet the country falls by three positions if the energy indicator is removed from the framework, and moves by zero places when EM imputation is used. When looking at the impact of removing the indicator on energy from the economic dimension, the two countries that would experience the most severe fall in ranking would be Iraq (25 positions) and Angola (21 positions). The two countries most affected by the choice of EM imputation would be Nigeria, which would fall by 15 positions, and Turkmenistan, which would improve by 13. Note however that these assumptions concern methodological choices only and might overall be less influential than choices related to the background assumptions in the conceptual framework.[17]
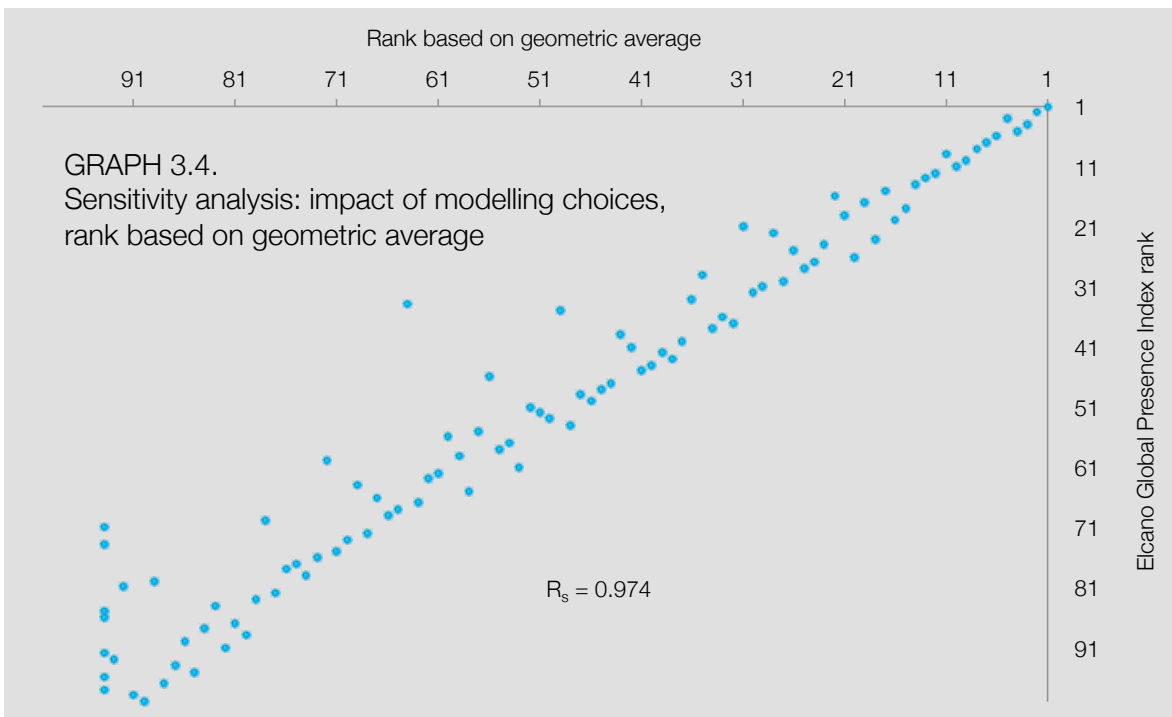
Overall, in order to better communicate to what degree a country's rank depends on the modelling choices, it might be worthwhile to present together with the Index scores and ranks the 90% confidence intervals, as reported in Table 3.7. It is reassuring that for over three quarters of the countries, their ranks are mainly attributable to the underlying data and not to the modelling choices[18].

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[17] Andrea Saltelli & Silvio O. Funtowicz (2014), "When all Models are Wrong", *Issues in Science and Technology*, Winter, 79–85.
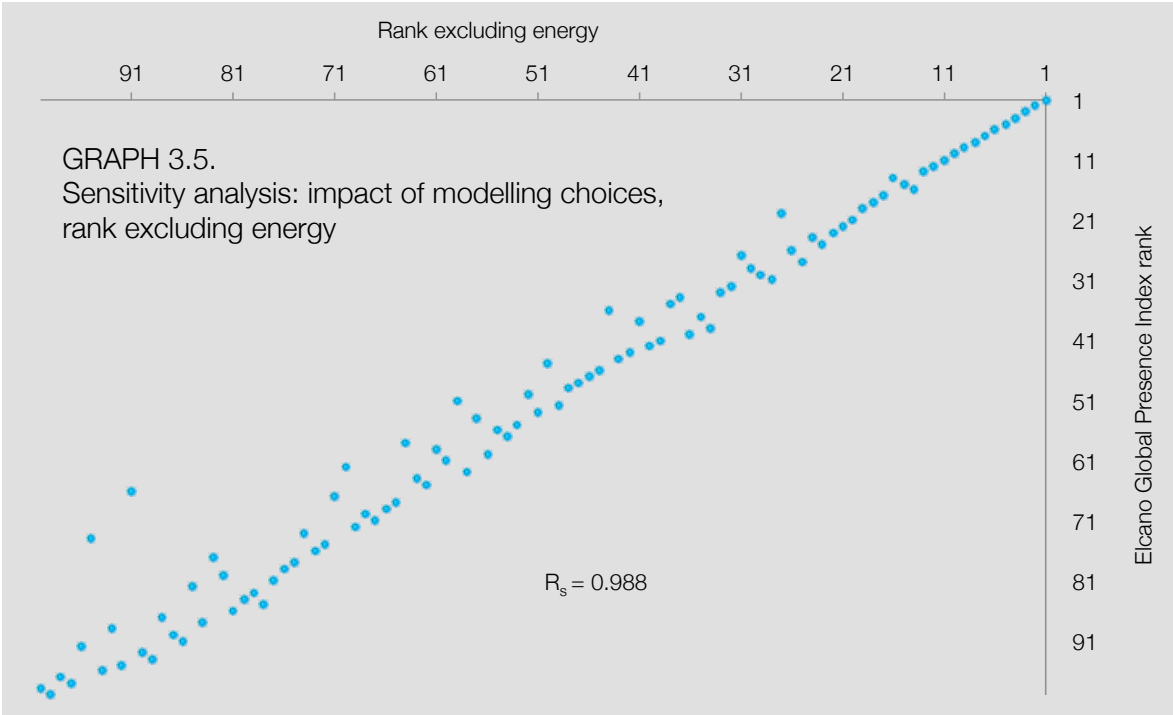[18] As already mentioned in the uncertainty analysis, at least 77% of the simulated median ranks for the Elcano Global Presence Index are less than five positions away from the reported 2016 rank.

Rank based on EM imputation

GRAPH 3.3.
Sensitivity analysis: impact of modelling choices,
rank based on EM imputation

$R_s = 0.996$

Elcano Global Presence Index rank

Source: European Commission, Joint Research Centre (JRC), 2017

Rank based on geometric average

GRAPH 3.4.
Sensitivity analysis: impact of modelling choices,
rank based on geometric average

$R_s = 0.974$

Elcano Global Presence Index rank

Source: European Commission, Joint Research Centre (JRC), 2017

Rank excluding energy

| 91 | 81 | 71 | 61 | 51 | 41 | 31 | 21 | 11 | 1 |

GRAPH 3.5.
Sensitivity analysis: impact of modelling choices,
rank excluding energy

$R_s = 0.988$

Elcano Global Presence Index rank

Source: European Commission, Joint Research Centre (JRC), 2017

Conclusion

The JRC analysis suggests that the Elcano Global Presence Index 2016 is sufficiently robust and reliable, with a statistically coherent and balanced multi-level structure. The statistical assessment has shown that it has a very high statistical reliability at the scaled-up dimensions level (Cronbach-alpha value at 0.97), and captures the single latent phenomenon characterised by the conceptual framework.

Points that call for possible refinements of the framework were also identified. These refinements regard mainly to the energy indicator from the economic dimension —and to a lesser extent also to the primary goods indicator from the same dimension. Although present in the conceptual framework, these variables have different behaviour from the rest of the variables in the dimension —and from the immense majority of the remaining variables in the indicator framework. The possibility of excluding the current variable from the framework (or the search for a proxy much better related to the rest of the indicators, in particular to those in the economic dimension) merits further reflection from the developers in preparation of future editions of the Index. Another conceptual issue to be reflected upon by the developers is the possibility to move the tourism indicator from the soft to the economic dimension, as suggested by the similar magnitude of the correlation coefficient between this variable and the two dimensions. This could be an interesting option in case any (or both) of the above mentioned problematic indicators were excluded from the economic dimension.

Overall, the analysis of the correlations at the dimension level reveals that the statistical structure is coherent with its conceptual framework, given that the individual indicators tend

to correlate strongly with their respective dimensions. However, the correlation structure and the individual impact of the variables on the final Index gets blurred once the otherwise necessary scaling-up process is undertaken. This situation is particularly relevant at the level of the economic dimension variables. Given the inescapable bias towards bigger countries —with largest shares of GDP and population— in the Elcano Global Presence Index, the development team should consider for example the option of calculating an additional complementary index based on the aggregation of the dimension scores without scaling them up. In this fashion, the intensity of the effort and the degree of openness achieved by smaller countries could also be properly acknowledged. This alternative Index (and the corresponding rankings) might be presented alongside the standard global presence results.

The Elcano Global Presence Index ranks are also relatively robust to methodological changes related to the treatment of missing values, weighting, aggregation rule and selection of indicators (less than ± 5 positions shift with respect to the simulated median in 77% of the countries). The value added of the Index is also highlighted by the differences in rankings that emerge from a comparison between this Index and each of the three dimensions: the economic and soft dimension rankings differ by ten positions or more in one quarter of the countries, whilst differences between the Index and the military dimension rankings exceed ten positions in 52% of the countries.

All in all, the audit conducted herein has shown that inferences can be drawn for most countries in the Elcano Global Presence Index. However, some caution may be needed for a few countries, which appear to be highly sensitive to changes in the underlying assumptions in the Index framework. Moreover, the impact of the scaling coefficients (in particular GDP) in the overall Index scores needs to be taken into account when discussing and reflecting upon the global projection of countries around the world.