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COIN Tool (beta version)

A quality assurance Excel-based tool for developers and users of composite indicators and scoreboards

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Abstract

The COIN Tool provides a practical Excel-based guide to the development of composite indicators and scoreboards, for policy-makers and researchers alike.

The COIN Tool aims to contribute to a better understanding of key methodological issues underpinning the development of composite indicators and to an improvement in the techniques currently used to build them. In particular, it contains a set of technical guidelines that can help **constructors** of composite indicators and scoreboards to improve the quality of their outputs. The COIN Tool is also helpful to **users** of composite indicators that wish to get a better understanding of the statistical properties of composite indicators and scoreboards.

The COIN Tool has been prepared by the Competence Centre on Composite Indicators and Scoreboards (COIN) at the European Commission's Joint Research Centre. The COIN Tool implements many of the suggestions and recommendations provided in the 2008 OECD/JRC 'Handbook on Constructing Composite Indicators: Methodology and User Guide'.

Further information on the topics treated in the COIN Tool and on other issues related to composite indicators and scoreboards can be found in the web page:

https://ec.europa.eu/jrc/en/coin

The COIN Tool starts from the premise that the developers of a composite indicator or scoreboard have already conducted a thorough literature review on the topic of interest, namely: definition(s) of the phenomenon, relevant studies, conceptual framework, methodological concerns.

The features included in the COIN Tool are the following:

- ✓ calculating descriptive statistics of the data,
- ✓ spotting and treating potentially problematic indicators that present highly skewed distributions,
- ✓ analysing the data correlation structure,
- ✓ estimating missing data,
- ✓ normalizing indicators (z-scores, min-max, ranks),
- ✓ aggregating indicators using (weighted) arithmetic averages, geometric averages, trimmed mean, median rank, summation of ranks, Borda rule, Copeland rule;
- ✓ conducting a simplified uncertainty analysis.

The COIN Tool in its current beta version is being tested by European Commission officials. The COIN Tool will be formally released in the fall of 2017.

1 Introduction

The use of composite indicators and scoreboards for designing and monitoring policies gained much interest in recent decades. Over 120 documents in the EU law online platform – EUR-Lex – include a reference to a composite indicator and over 1500 documents refer to a scoreboard of indicators. The first composite indicator from the Commission dates back to 1987. Today, the Commission services have developed more than 100 composite indicators and even more scoreboards. Examples are the Europe 2020 Index, the Regional Human Development Index and the Regional Poverty Index of DG REGIO, the European Innovation Union Scoreboard and the Small Business Act Principles of DG GROW, the Research Excellence Index and the Innovation Output Indicator of DG RTD, the Consumer Conditions Index and the Market Performance Index of DG JUST, the Digital Economy and Society Index of DG CNECT, the Banks' contribution to EU Single Resolution Fund of DG FISMA, the Index for Risk Management of DG ECHO and the Cultural and Creative City Monitor of DG JRC.

In a nutshell, composite indicators are built by simplifying a policy concept into a summary figure by means of a conceptual framework and statistical analysis. Composite indicators are aggregations of observable indicators that aim to quantify underlying concepts that are not directly observable, such as competitiveness, freedom of the press or climate hazards. The resulting figures facilitate cross-country, -region, or -city comparisons and benchmarking. They help monitoring progress over time and evaluating ex-ante policy options based on multi-criteria analysis. Scoreboards of indicators have, to some extent, similar objectives to composite indicators, yet they do not consist of a mathematical aggregation.

Composite indicators are powerful practical tools that can help policy makers summarize complex and interdependent phenomena. They provide the big picture, are easy to interpret, easy to communicate, and attractive for the public. They are also drivers of behaviour and of change by forcing institutions and governments to question their standards. On the other hand, caution is needed to avoid situations where composite indicators may send misleading or partial policy messages because they are poorly constructed or misinterpreted.

1.1 Ten Step guide for constructing a composite indicator or gaining insights into the properties of a scoreboard

The table below presents a 'decalogue' for the construction of a composite indicator, or for assessing, *inter alia*, the statistical associations of the indicators in a scoreboard. The table which has been rearranged and extended from the information contained in the 2008 OECD/JRC Handbook. These steps have been put in practice in the JRC audits, conducted upon request of developers of multidimensional measures such as the INSEAD-WIPO-Cornell Global Innovation Index, UN Multidimensional Poverty Assessment Tool, the Composite Learning Index, the Environmental Performance Index, the Corruptions Perceptions Index, and the EU Competitiveness Index Index just to name a few.

This short ten-step 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. Second, it stresses that there is a trade-off between multidimensionality and robustness in a composite indicator. One could have a very robust yet mono-dimensional index or a very volatile yet multi-dimensional one. This does not imply that the first index is better than the second one. In fact, this table suggests treating robustness analysis NOT as an attribute of a composite indicator but of the inference which the composite indicator has been called upon to support. Third, it highlights the iterative nature of the ten steps, which although presented consecutively in the OECD/JRC Handbook, the benefit to the developer is in the iterative nature of the steps.

Table 1. Ten Step Guide for Developing Composite Indicators and Scoreboards

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 treatment consists of imputing missing data, (eventually) treating outliers and/or making scale adjustments. ✓ 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 countries based on the individual indicators and other auxiliary variables (e.g., by cluster analysis). *(back to Step 1)*

Step 5. Normalisation

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

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.

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).
- ✓ 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. Important to note 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 through regressions. ✓ 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.

([1]) Rearranged and notably extended from OECD/JRC, 2008 Handbook 'Handbook on Constructing Composite Indicators: Methodology and User Guide'.

Source: JRC, 2017.

1.2 COIN Tool – How it is organized

The COIN Tool (beta version) is organised around three sections:

The first section "Computation of the composite indicator" guides the user through the different steps needed in order to:

- create the database and the conceptual framework (yellow tabs),
- how to go about treating the outliers (green tabs), and
- how to "statistically" adjust the weights in order to obtain coherence between an indicator's importance and how it actually affects the ranking.

The second section "Scenaria" (blue tabs) guides the user through the normalisation and aggregation phases in constructing a composite indicator.

Finally, the third section "Advanced features" (gold tabs) currently includes insightful illustrations on the "no imputation" choice and how it is equivalent to a sort of "shadow imputation".

Many more features and functionalities will be available in the COIN Tool when officially released in the fall of 2017.

2 Computation of the composite indicator

2.1 Database and conceptual framework (yellow tabs)

2.1.1 Organisation of the data

The dataset underpinning a scoreboard or a composite indicator should be copy-pasted in the tab "Database". The user should:

- Organise the data in units (rows) x indicators (columns), grouping the indicators according to the conceptual framework.
- Indicate all dimensions pertaining to each indicator.
- Report relative weights assigned to each indicator and dimension, the COIN tool does not require weights to add up to one.
- Report the desired direction for each indicator (good = 1, bad = -1). Dimensions are all assumed to have positive direction (the higher the score, the better).
- Report the indicator and unit names.
- Report missing values as "n/a".

Figure 1. 'Database' tab

	Weight	1	1	1	1	1	1	1
	Direction	1	1	1	1	1	1	1
	Index	Index	Index	Index	Index	Index	Index	Index
	Sub-index	si.1	si.1	si.1	si.1	si.1	si.1	si.1
	Pillar	p.01	p.01	p.01	p.01	p.01	p.01	p.01
	Sub-pillar	sp.01	sp.01	sp.01	sp.02	sp.02	sp.02	sp.03
	Indicator name	Political stability and absence of violence/terrorism	Government effectiveness	Press freedom (lack of)	Regulatory quality	Rule of law	Cost of redundancy dismissal	Ease of starting a Business (distance to frontier)
Unit name	Unit/Indicator	ind.01	ind.02	ind.03	ind.04	ind.05	ind.06	ind.07
CHE	unit.001	1.3	1.9	9.9	1.6	1.8	10.1	86.0
SWE	unit.002	1.3	2.0	9.2	1.8	1.9	14.4	92.6
GBR	unit.003	0.4	1.5	16.9	1.6	1.7	8.4	88.4
NLD	unit.004	1.1	1.8	6.5	1.8	1.8	8.7	89.1
USA	unit.005	0.5	1.4	18.2	1.5	1.6	8.0	89.8
FIN	unit.006	1.4	2.2	6.4	1.8	2.0	10.1	93.2
HKG	unit.007	1.0	1.7	26.2	1.9	1.5	8.0	95.8
SGP	unit.008	1.2	2.2	43.4	1.8	1.7	8.0	95.9
DNK	unit.009	1.1	2.2	7.1	1.9	1.9	8.0	92.4
IRL	unit.010	1.0	1.4	10.1	1.6	1.8	8.0	92.7
CAN	unit.011	1.0	1.8	12.7	1.7	1.8	10.0	99.1
LUX	unit.012	1.3	1.7	6.7	1.9	1.8	21.7	86.0
ISL	unit.013	1.2	1.6	8.5	1.0	1.7	10.1	91.1
ISR	unit.014	(1.3)	1.2	33.0	1.3	1.0	27.4	88.2
DEU	unit.015	0.9	1.5	10.2	1.5	1.6	21.6	82.2
NOR	unit.016	1.3	1.8	6.5	1.4	1.9	8.7	91.1
NZL	unit.017	1.3	1.9	8.4	1.9	1.9	8.0	100.0
KOR	unit.018	0.2	1.2	24.5	1.0	1.0	27.4	89.9

User's Guide | Database | Framework | Original | Winsorization | Box-Cox | Scatterplots

Source: JRC, 2017.

The *COIN tool* supports the following structure:

- a maximum of 250 units (e.g. countries, universities, etc.), coded unit.001 to unit.250;
- a maximum of 99 indicators, coded ind.01 to ind.99;
- four dimension levels:
    - a maximum of 33 sub-pillars, coded sp.01 to sp.33;
    - a maximum of 11 pillars, coded p.01 to p.11;
    - a maximum of three sub-indices, coded si.1 to si.3; and
    - one final index, coded index.

<u>Notes</u> (1) For composite indicators with less than four dimension levels, the user should assign all dimensions to one supra-dimension (example, a framework with 10 sub-pillars, 3 pillars, no sub-index, one index, becomes sp.01 to sp.10, p.01 to p.03, si.1, index (si.1 and index results will be identical). Adding the "intermediary" level si.1 is crucial for all features to function.

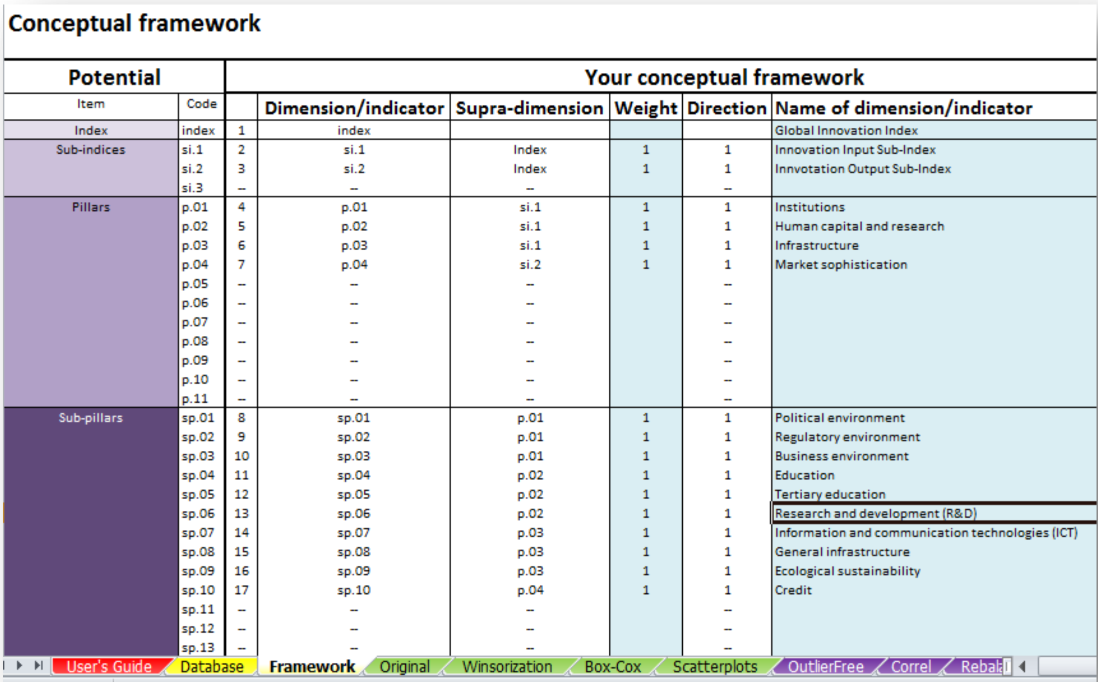
(2) Cells in light blue need to be filled in with the index data (or left blank).

(3) Excel assigns a value of 0 to blank cells, it is therefore crucial to double check for blanks that could be taken as zero values in original data sources.

2.1.2 Conceptual Framework

The *COIN tool* "automatically" summarizes the information provided by the user in the tab "Database" into the tab "Framework" in the white cells.

Figure 2. 'Framework' tab



Conceptual framework

Potential		Your conceptual framework					
Item	Code		Dimension/indicator	Supra-dimension	Weight	Direction	Name of dimension/indicator
Index	index	1	index				Global Innovation Index
Sub-indices	si.1	2	si.1	Index	1	1	Innovation Input Sub-Index
	si.2	3	si.2	Index	1	1	Innovtation Output Sub-Index
	si.3	–	–	–		–	
Pillars	p.01	4	p.01	si.1	1	1	Institutions
	p.02	5	p.02	si.1	1	1	Human capital and research
	p.03	6	p.03	si.1	1	1	Infrastructure
	p.04	7	p.04	si.2	1	1	Market sophistication
	p.05	–	–	–		–	
	p.06	–	–	–		–	
	p.07	–	–	–		–	
	p.08	–	–	–		–	
	p.09	–	–	–		–	
	p.10	–	–	–		–	
	p.11	–	–	–		–	
Sub-pillars	sp.01	8	sp.01	p.01	1	1	Political environment
	sp.02	9	sp.02	p.01	1	1	Regulatory environment
	sp.03	10	sp.03	p.01	1	1	Business environment
	sp.04	11	sp.04	p.02	1	1	Education
	sp.05	12	sp.05	p.02	1	1	Tertiary education
	sp.06	13	sp.06	p.02	1	1	Research and development (R&D)
	sp.07	14	sp.07	p.03	1	1	Information and communication technologies (ICT)
	sp.08	15	sp.08	p.03	1	1	General infrastructure
	sp.09	16	sp.09	p.03	1	1	Ecological sustainability
	sp.10	17	sp.10	p.04	1	1	Credit
	sp.11	–	–	–		–	
	sp.12	–	–	–		–	
	sp.13	–	–	–		–	

User's Guide | Database | Framework | Original | Winsorization | Box-Cox | Scatterplots | OutlierFree | Correl | Rebal

Source: JRC, 2017.

In this tab, the user should:

- Report the desired relative weights assigned to each dimension within its respective supra-dimension (cells in blue); the COIN tool does not require weights to add up to one (summing to one is done "automatically" within the COIN tool).
- Report the names of dimensions.

Notes (1) The direction of each dimension is assumed to be one (i.e. the higher the score, the better). If it is not the case, then the COIN tool will not function properly.

2.2 Treatment of outliers (green tabs)

2.2.1 Original dataset – detection of outliers

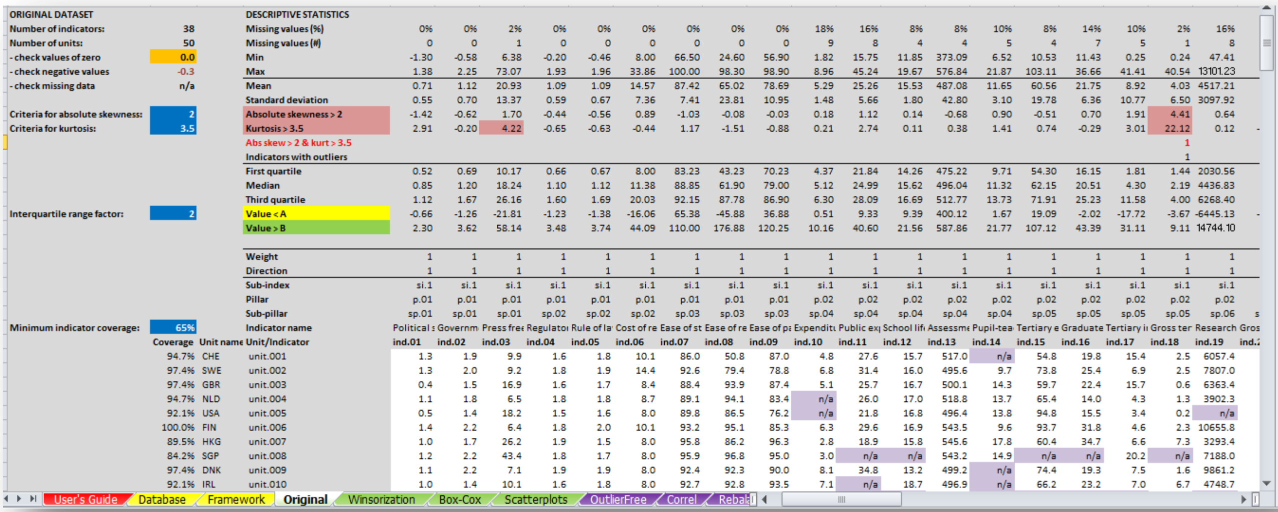
The COIN tool extracts the information provided in the tab "Database" and performs a series of computations and conditional formatting:

- The COIN tool detects zero values, missing data, and negative values.
- For each indicator, it calculates descriptive statistics: missing values, min, max, mean, standard deviation, skewness, kurtosis, median and first and third quartile.
- For each unit, it calculates the indicator coverage.

Indicators with potential outliers are detected by checking their third and fourth moments, i.e. absolute *skewness > 2 AND kurtosis > 3.5* (the COIN tool includes an option to change these values). The COIN tool also detects potential outliers on the basis of the interquartile range, but this is for reference only.

Indicators with outliers should be treated either by winsorization or by transformation of the indicator.

Figure 3. 'Original' tab



Source: JRC, 2017.

Notes (1) It is recommended to require at least 65 percent indicator coverage per unit and dimension (this requirement can be relaxed or stricter depending on the degree of correlation between indicators within a dimension).

(2) Excel assigns a value of 0 to blank cells, it is therefore crucial to double check for blanks that could be taken as zero values in original data sources.

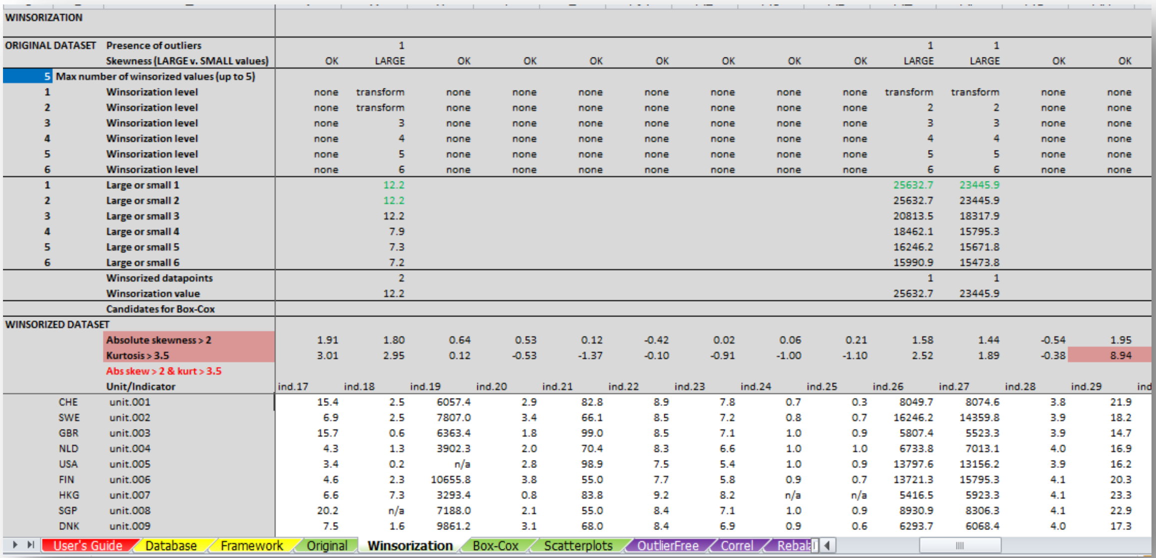
2.2.2 Winsorization

This tab helps the user to treat indicators with skewness > 2 AND kurtosis > 3.5 AND less than 5 outliers by winsorization.

Winsorizing implies transforming the statistical series by limiting its extreme values (at the upper, lower or both ends) by assigning them the next best value. The method is usually used in the presence of few outlier values (roughly 5 percent of units).

- For problematic indicators detected in the tab "OD", the COIN tool winsorizes 1 to 5 outlier values; the process stops at the level where absolute skewness and kurtosis enter into the required ranges.
- When winsorization is not effective in dealing with outliers, the COIN tool reports the indicator as being a candidate for Box-Cox transformation.

Figure 4. 'Winsorization' tab



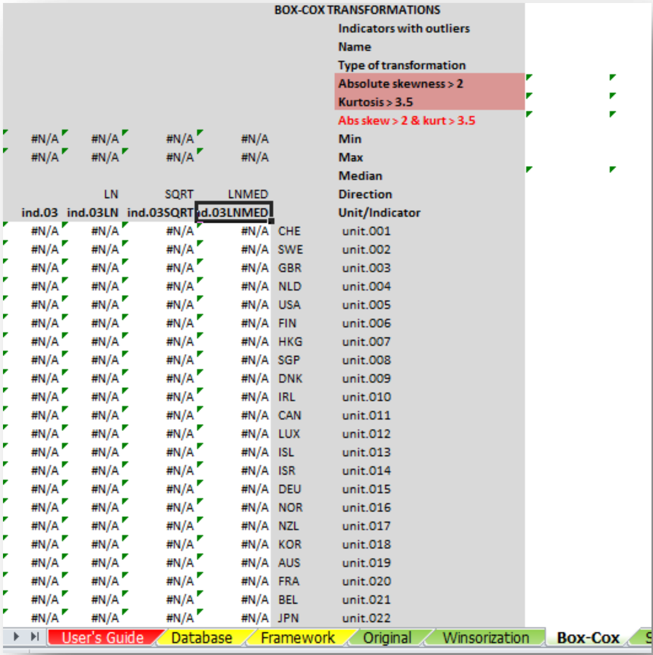
WINSORIZATION														
ORIGINAL DATASET	Presence of outliers		1								1	1		
	Skewness (LARGE v. SMALL values)	OK	LARGE	OK	OK	OK	OK	OK	OK	OK	LARGE	LARGE	OK	OK
5	Max number of winsorized values (up to 5)													
1	Winsorization level	none	transform	none	none	none	none	none	none	none	transform	transform	none	none
2	Winsorization level	none	transform	none	none	none	none	none	none	none	2	2	none	none
3	Winsorization level	none	3	none	none	none	none	none	none	none	3	3	none	none
4	Winsorization level	none	4	none	none	none	none	none	none	none	4	4	none	none
5	Winsorization level	none	5	none	none	none	none	none	none	none	5	5	none	none
6	Winsorization level	none	6	none	none	none	none	none	none	none	6	6	none	none
1	Large or small 1		12.2								25632.7	23445.9		
2	Large or small 2		12.2								25632.7	23445.9		
3	Large or small 3		12.2								20813.5	18317.9		
4	Large or small 4		7.9								18462.1	15795.3		
5	Large or small 5		7.3								16246.2	15671.8		
6	Large or small 6		7.2								15990.9	15473.8		
	Winsorized datapoints		2								1	1		
	Winsorization value		12.2								25632.7	23445.9		
	Candidates for Box-Cox													
WINSORIZED DATASET														
	Absolute skewness > 2	1.91	1.80	0.64	0.53	0.12	-0.42	0.02	0.06	0.21	1.58	1.44	-0.54	1.95
	Kurtosis > 3.5	3.01	2.95	0.12	-0.53	-1.37	-0.10	-0.91	-1.00	-1.10	2.52	1.89	-0.38	8.94
	Abs skew > 2 & kurt > 3.5													
	Unit/Indicator	ind.17	ind.18	ind.19	ind.20	ind.21	ind.22	ind.23	ind.24	ind.25	ind.26	ind.27	ind.28	ind.29
CHE	unit.001	15.4	2.5	6057.4	2.9	82.8	8.9	7.8	0.7	0.3	8049.7	8074.6	3.8	21.9
SWE	unit.002	6.9	2.5	7807.0	3.4	66.1	8.5	7.2	0.8	0.7	16246.2	14359.8	3.9	18.2
GBR	unit.003	15.7	0.6	6363.4	1.8	99.0	8.5	7.1	1.0	0.9	5807.4	5523.3	3.9	14.7
NLD	unit.004	4.3	1.3	3902.3	2.0	70.4	8.3	6.6	1.0	1.0	6733.8	7013.1	4.0	16.9
USA	unit.005	3.4	0.2	n/a	2.8	98.9	7.5	5.4	1.0	0.9	13797.6	13156.2	3.9	16.2
FIN	unit.006	4.6	2.3	10655.8	3.8	55.0	7.7	5.8	0.9	0.7	13721.3	15795.3	4.1	20.3
HKG	unit.007	6.6	7.3	3293.4	0.8	83.8	9.2	8.2	n/a	n/a	5416.5	5923.3	4.1	23.3
SGP	unit.008	20.2	n/a	7188.0	2.1	55.0	8.4	7.1	1.0	0.9	8930.9	8306.3	4.1	22.9
DNK	unit.009	7.5	1.6	9861.2	3.1	68.0	8.4	6.9	0.9	0.6	6293.7	6068.4	4.0	17.3

Source: JRC, 2017.

2.2.3 Box-cox transformations

This tab helps the user to treat indicators with skewness > 2 AND kurtosis > 3.5 AND six or more outliers by a Box-Cox transformation, which transforms the whole series of values in a non-linear way.

Figure 5. 'Box-Cox' tab



Source: JRC, 2017.

Formulas:

- new value = old value ^ lambda if -5 < lambda < 5; and
- new value = ln (old value) if lambda = 0 and old value > 0

Statistical packages check for the lambda value that provides the smallest standard deviation; but the Box-Cox power transformation is not a guarantee for normality, an analysis of skewness and kurtosis is still required.

The COIN tool includes three transformations based on Box-Cox:

Formulas:

- LN: ln transformation such that new min = 0: new value = ln (old value - old min + 1)
- SQRT: square root such that new min = 0: new value = (old value - old min) ^ 0.5
- LNMED: ln transformation and normalization such that min = 0, max = 1, median = 0.5:

  new value = 0.5 [ln [1 + (old value – min) (max + min – 2 sample median) / ((sample median – min) ^ 2)] / ln [(max – sample median) / (sample median – min)] * direction + 0.5 (1 - direction)

The third transformation, LNMED, is akin to the following two steps: first, a linear normalization to the (0, 1) range; and second a non-linear transformation aimed at bringing the median to 0.5. By bringing the median to 0.5, this normalization procedure generally solves for potential outliers. Formula in two steps:

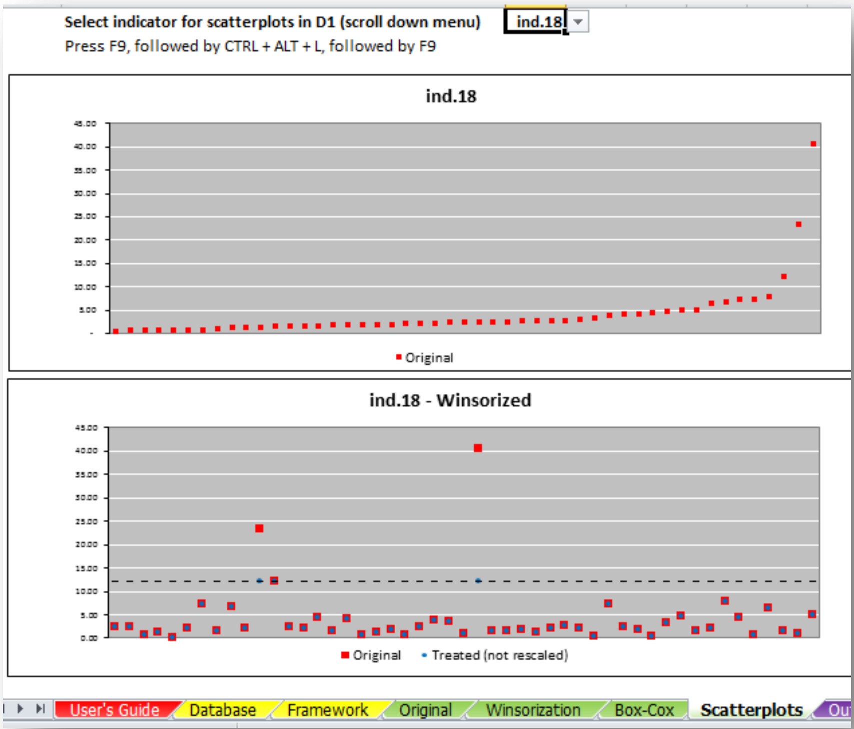
- Linear min-max: Y = (old value – min) / (max – min) * direction + 0.5 (1 – direction)
- Non-linear transformation: Z = ln (1 + aY) / ln (1 + a), where a is such that Z (sample median) = 0.5, so that a = (1 – 2 sample median) / sample median ^ 2

The COIN tool indicates which indicators still present problems, if any, for these an alternative transformation should be found outside of the COIN tool and copy-pasted in the corresponding column in the tab "Database".

2.2.4 Scatterplots

The tab "Scatterplots" includes a scroll down menu to visualize each indicator, as well as its winsorized and transformed versions. This tab helps to evidence the outliers.

Figure 6. 'Scatterplots' tab



Source: JRC, 2017.

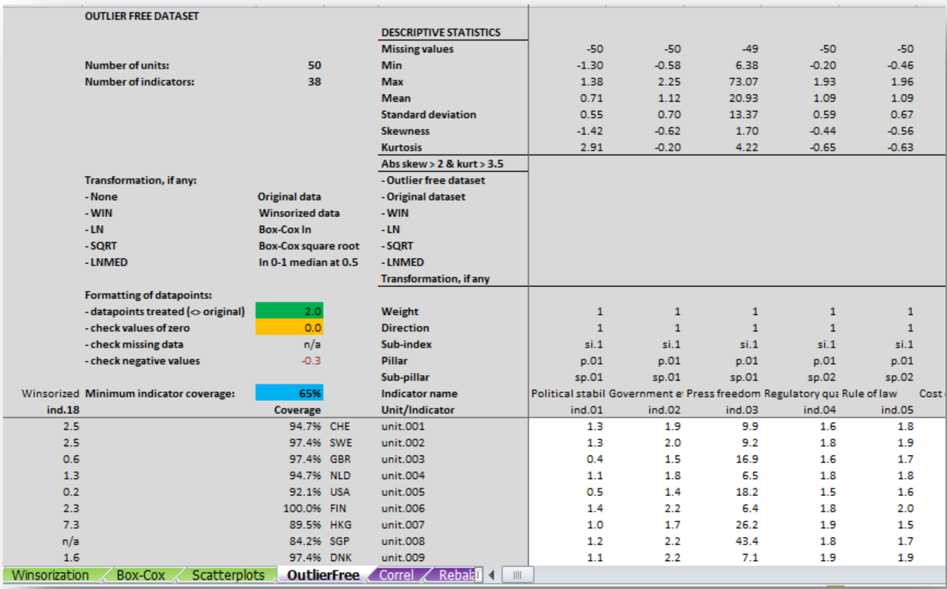
2.3 Weight adjustments and final ranking (purple tabs)

2.3.1 Outlier free dataset – descriptive statistics

The tab "OutlierFree" recovers the information from the green tabs and constructs a new dataset without outliers. This dataset is used for the adjustment made to the framework itself, i.e. adjustment of weights (including deletion of indicators, i.e. weights of 0). Descriptive statistics are computed again.

Tabs linking to this dataset are coloured in purple.

Figure 7. 'OutlierFree' tab



Source: JRC, 2017.

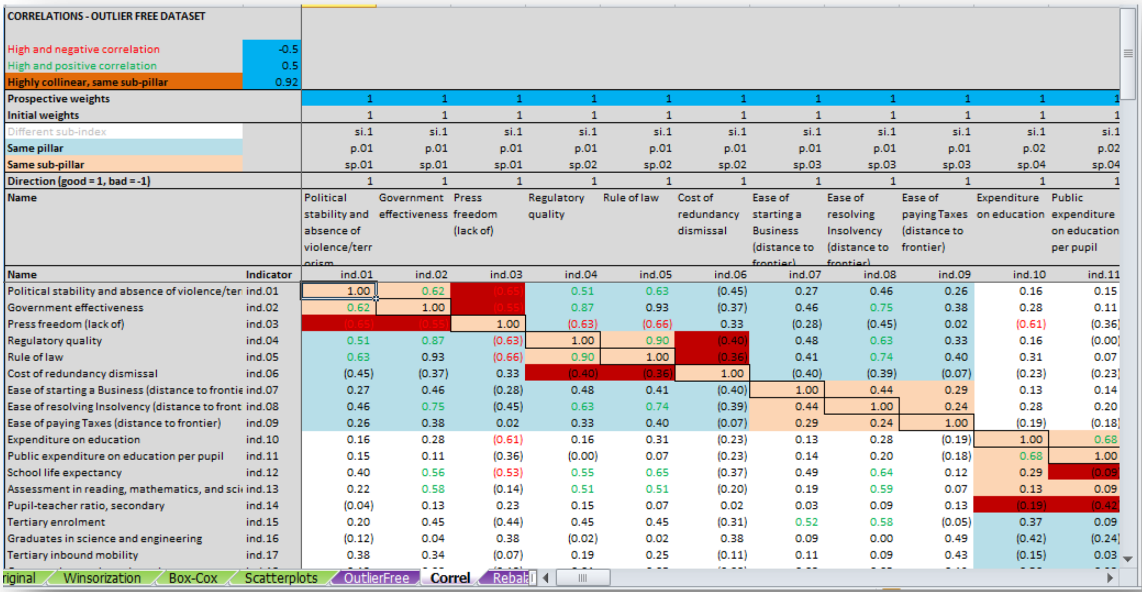
2.3.2 Indicator correlations and prospective weights

The COIN Tool calculates correlations between indicators (Pearson coefficients r), taking into account the direction of effects:

- At this point all correlations are expected to be positive. Negative correlations imply either that the desired direction of the indicator is wrong; that there are trade-offs between indicators; that the sample is too small and not representative; or that there is random correlation (if the level of correlation is low). It is desirable not to have negative correlations within the same dimension. Note, however, that small samples might lead to spurious negative correlations.
- In composite indicators, weights must be understood as 'scaling coefficients (as opposed to 'importance coefficients'), with the aim of arriving at dimension scores that are balanced in their underlying components.
    - The user may decide to eliminate indicators that are randomly associated to any of the remaining indicators in the dimension (e.g. assign a weight of 0).
    - Highly collinear indicators (r > 0.92 roughly) within a given dimension need to be treated (either by eliminating one of the two, or counting them as a single

indicator, i.e. adjusting their relative weight); otherwise they will influence all principal component analysis and dominate the unit scores in the respective dimension.

Figure 8. 'Correl' tab



CORRELATIONS - OUTLIER FREE DATASET												
High and negative correlation	-0.5											
High and positive correlation	0.5											
Highly collinear, same sub-pillar	0.92											
Prospective weights		1	1	1	1	1	1	1	1	1	1	1
Initial weights		1	1	1	1	1	1	1	1	1	1	1
Different sub-index		si.1	si.1	si.1	si.1	si.1	si.1	si.1	si.1	si.1	si.1	si.1
Same pillar		p.01	p.01	p.01	p.01	p.01	p.01	p.01	p.01	p.01	p.02	p.02
Same sub-pillar		sp.01	sp.01	sp.01	sp.02	sp.02	sp.02	sp.03	sp.03	sp.03	sp.04	sp.04
Direction (good = 1, bad = -1)		1	1	1	1	1	1	1	1	1	1	1
Name		Political stability and absence of violence/terrorism	Government effectiveness	Press freedom (lack of)	Regulatory quality	Rule of law	Cost of redundancy dismissal	Ease of starting a Business (distance to frontier)	Ease of resolving Insolvency (distance to frontier)	Ease of paying Taxes (distance to frontier)	Expenditure on education	Public expenditure on education per pupil
Name	Indicator	ind.01	ind.02	ind.03	ind.04	ind.05	ind.06	ind.07	ind.08	ind.09	ind.10	ind.11
Political stability and absence of violence/ter	ind.01	1.00	0.62	(0.65)	0.51	0.63	(0.45)	0.27	0.46	0.26	0.16	0.15
Government effectiveness	ind.02	0.62	1.00	(0.55)	0.87	0.93	(0.37)	0.46	0.75	0.38	0.28	0.11
Press freedom (lack of)	ind.03	(0.65)	(0.55)	1.00	(0.63)	(0.66)	0.33	(0.28)	(0.45)	0.02	(0.61)	(0.36)
Regulatory quality	ind.04	0.51	0.87	(0.63)	1.00	0.90	(0.40)	0.48	0.63	0.33	0.16	(0.00)
Rule of law	ind.05	0.63	0.93	(0.66)	0.90	1.00	(0.36)	0.41	0.74	0.40	0.31	0.07
Cost of redundancy dismissal	ind.06	(0.45)	(0.37)	0.33	(0.40)	(0.36)	1.00	(0.40)	(0.39)	(0.07)	(0.23)	(0.23)
Ease of starting a Business (distance to frontie	ind.07	0.27	0.46	(0.28)	0.48	0.41	(0.40)	1.00	0.44	0.29	0.13	0.14
Ease of resolving Insolvency (distance to front	ind.08	0.46	0.75	(0.45)	0.63	0.74	(0.39)	0.44	1.00	0.24	0.28	0.20
Ease of paying Taxes (distance to frontier)	ind.09	0.26	0.38	0.02	0.33	0.40	(0.07)	0.29	0.24	1.00	(0.19)	(0.18)
Expenditure on education	ind.10	0.16	0.28	(0.61)	0.16	0.31	(0.23)	0.13	0.28	(0.19)	1.00	0.68
Public expenditure on education per pupil	ind.11	0.15	0.11	(0.36)	(0.00)	0.07	(0.23)	0.14	0.20	(0.18)	0.68	1.00
School life expectancy	ind.12	0.40	0.56	(0.53)	0.55	0.65	(0.37)	0.49	0.64	0.12	0.29	(0.09)
Assessment in reading, mathematics, and sci	ind.13	0.22	0.58	(0.14)	0.51	0.51	(0.20)	0.19	0.59	0.07	0.13	0.09
Pupil-teacher ratio, secondary	ind.14	(0.04)	0.13	0.23	0.15	0.07	0.02	0.03	0.09	0.13	(0.19)	(0.42)
Tertiary enrolment	ind.15	0.20	0.45	(0.44)	0.45	0.45	(0.31)	0.52	0.58	(0.05)	0.37	0.09
Graduates in science and engineering	ind.16	(0.12)	0.04	0.38	(0.02)	0.02	0.38	0.09	0.00	0.49	(0.42)	(0.24)
Tertiary inbound mobility	ind.17	0.38	0.34	(0.07)	0.19	0.25	(0.11)	0.11	0.09	0.43	(0.15)	0.03

Source: JRC, 2017.

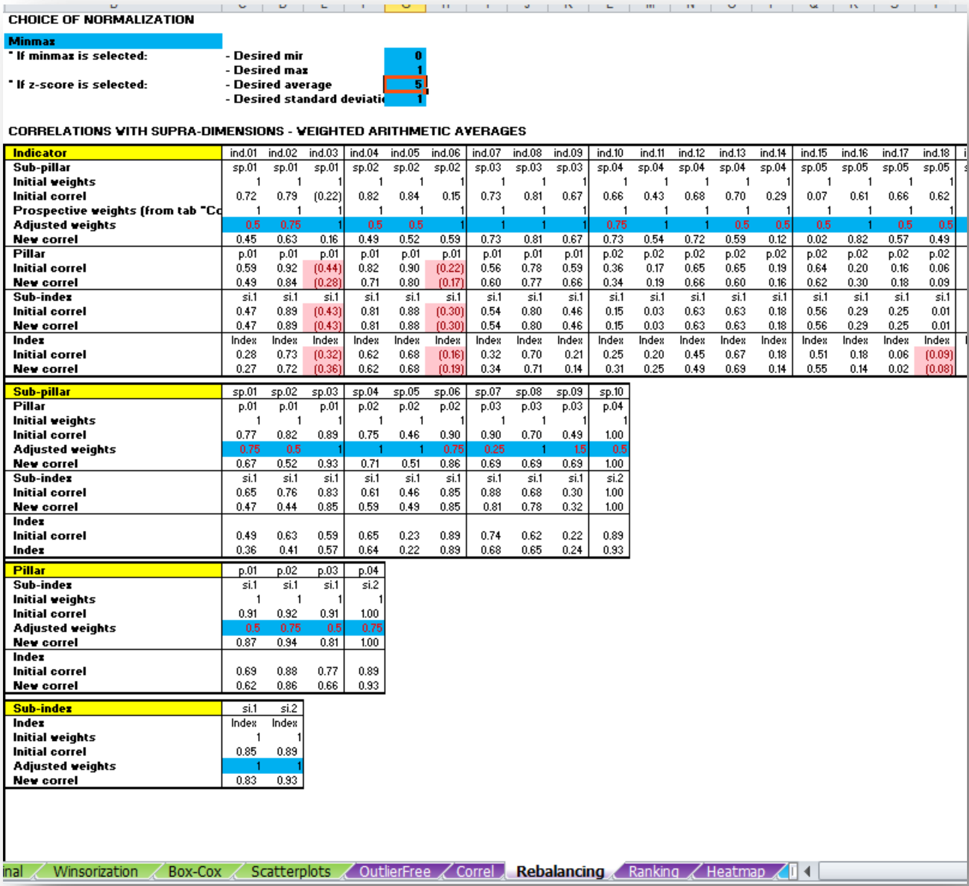
The COIN tool allows users to adjust relative weights (row: "prospective weights") on the basis of this analysis. These prospective weights are reproduced in the tab "Correl rebalancing" (explanations below); the final determination of relative weights needs to be made in the context of the computation of the index.

Note: (1) Correlations of raw data adjusted for direction and outliers are the same as z-score and min-max correlations.

2.3.3 Adjustment of weights on the basis of upper-level correlations

The overall purpose of this tab is to help the user to arrive at a model that is balanced in its underlying components, i.e. with correlations of dimensions with its components that are of a similar range. Under somewhat strong assumptions, squared correlation coefficients give an indication of explained variance.

Figure 9. 'Rebalancing' tab



Source: JRC, 2017.

Composite indicator aggregates need to be computed for the purpose of adjusting weights:

- First, normalize each indicator taking into account the direction of indicators. Two options are available in the tab: min-max scores and z-scores (details in heading 4 Normalization). These computations are included in the hidden tabs "AggOldWeights" and "AggNewWeights").
- Second, compute all aggregates. The COIN tool uses weighted arithmetic averages, widely used in constructing composite indicators (details in heading 5 Aggregates).
- Third, compute correlations of each indicator/dimension with its supra-dimension(s).

<u>Formula</u>: Correlation = correlation (ind.xx, dim.yy)

Weights are then adjusted as follows:

- Weighting down dimensions with HIGH correlations (example: weight of 0.5 instead of 1);
- Weighting up dimensions with LOW correlations (example: weight of 2 instead of 1);
- Assign weights of 0 for indicators with negative correlations or correlations close to 0.
- Weights do not need to add up to 1 (they are "internally" adjusted to a unity sum).

2.3.4 Ranking with adjusted weights

The tab "Ranking" presents the ranking and scores computed with adjusted weights from the outlier free dataset. There the ranking with initial weights is also reported, together with the difference in ranks between the two for each unit.

Figure 10. 'Ranking' tab

RANKING AND SCORES - ADJUSTED WEIGHTS - WEIGHTED ARITHMETIC AVERAGES
Minmax [0, 1]

Name	Name Unit/Indicator	New weights Rank	Initial weights Rank	Difference Rank	Global Innovation Index index	Innovation Input Sub-Index si.1	Innvotation Output Sub-Index si.2	Institutions p.01	Human capital and research p.02	Infrastructure p.03	Market sophistication p.04	Political environment sp.01	Regulatory environment sp.02	Business environment sp.03	Education sp.04	Tertiary education sp.05
CHE	unit.001	1	2	1	0.61	0.52	0.71	0.53	0.47	0.57	0.71	0.53	0.49	0.55	0.48	0.34
KOR	unit.018	2	1	-1	0.60	0.58	0.63	0.63	0.61	0.47	0.63	0.46	0.66	0.74	0.51	0.58
FIN	unit.006	3	3	0	0.57	0.60	0.55	0.66	0.60	0.53	0.55	0.56	0.52	0.81	0.56	0.56
SWE	unit.002	4	4	0	0.57	0.58	0.56	0.62	0.53	0.61	0.56	0.53	0.61	0.68	0.53	0.43
DEU	unit.015	5	6	1	0.51	0.51	0.51	0.55	0.50	0.49	0.51	0.45	0.68	0.57	0.49	0.43
DNK	unit.009	6	5	-1	0.51	0.55	0.46	0.65	0.51	0.50	0.46	0.53	0.50	0.83	0.55	0.32
JPN	unit.022	7	9	2	0.49	0.48	0.51	0.50	0.44	0.51	0.51	0.54	0.31	0.55	0.41	0.27
USA	unit.005	8	7	-1	0.49	0.49	0.49	0.54	0.50	0.44	0.49	0.47	0.41	0.66	0.46	0.26
NLD	unit.004	9	8	-1	0.47	0.48	0.46	0.60	0.40	0.48	0.46	0.48	0.49	0.75	0.53	0.20
GBR	unit.003	10	11	1	0.46	0.54	0.39	0.59	0.50	0.55	0.39	0.46	0.44	0.77	0.50	0.36
ISL	unit.013	11	10	-1	0.45	0.52	0.39	0.56	0.54	0.44	0.39	0.48	0.40	0.70	0.66	0.44
NZL	unit.017	12	12	0	0.45	0.52	0.38	0.67	0.50	0.39	0.38	0.53	0.49	0.86	0.66	0.36
NOR	unit.016	13	13	0	0.42	0.56	0.28	0.62	0.49	0.60	0.28	0.50	0.45	0.81	0.60	0.31
ISR	unit.014	14	16	2	0.41	0.44	0.39	0.48	0.45	0.38	0.39	0.39	0.71	0.44	0.36	0.37
CHN	unit.035	15	15	0	0.41	0.29	0.53	0.32	0.28	0.26	0.53	0.58	0.38	0.10	0.39	0.07
CAN	unit.011	16	17	1	0.41	0.51	0.31	0.69	0.43	0.45	0.31	0.52	0.49	0.92	0.50	0.15
AUT	unit.023	17	19	2	0.40	0.49	0.31	0.50	0.51	0.47	0.31	0.49	0.42	0.54	0.47	0.53
SGP	unit.008	18	14	-4	0.40	0.57	0.23	0.77	0.49	0.50	0.23	0.78	0.46	0.92	0.46	0.49
IRL	unit.010	19	21	2	0.40	0.54	0.26	0.63	0.57	0.42	0.26	0.45	0.45	0.86	0.77	0.45
AUS	unit.019	20	18	-2	0.40	0.52	0.27	0.63	0.53	0.42	0.27	0.51	0.53	0.76	0.55	0.34
BEL	unit.021	21	22	1	0.39	0.45	0.33	0.56	0.41	0.40	0.33	0.49	0.37	0.70	0.50	0.27
FRA	unit.020	22	23	1	0.38	0.47	0.29	0.47	0.47	0.47	0.29	0.49	0.43	0.47	0.47	0.41
LUX	unit.012	23	24	1	0.37	0.48	0.25	0.56	0.43	0.46	0.25	0.49	0.74	0.53	0.27	0.73
ESP	unit.026	24	26	2	0.36	0.47	0.25	0.50	0.41	0.52	0.25	0.40	0.51	0.57	0.44	0.39
HKG	unit.007	25	20	-5	0.36	0.60	0.12	0.69	0.50	0.65	0.12	0.59	0.45	0.88	0.40	0.63
CZE	unit.028	26	27	1	0.35	0.41	0.30	0.42	0.36	0.47	0.30	0.41	0.56	0.35	0.37	0.37
EST	unit.025	27	25	-2	0.34	0.39	0.28	0.42	0.37	0.41	0.28	0.39	0.45	0.42	0.46	0.33
SVN	unit.030	28	28	0	0.33	0.42	0.25	0.49	0.39	0.40	0.25	0.46	0.32	0.59	0.48	0.36
PRT	unit.034	29	30	1	0.33	0.46	0.19	0.59	0.43	0.38	0.19	0.42	0.75	0.64	0.46	0.38
ITA	unit.029	30	31	1	0.32	0.40	0.25	0.36	0.34	0.52	0.25	0.41	0.20	0.40	0.41	0.27
CYP	unit.027	31	33	2	0.30	0.40	0.20	0.50	0.37	0.35	0.20	0.45	0.32	0.62	0.50	0.47
BRB	unit.047	32	32	0	0.30	0.32	0.28	0.56	0.34	0.04	0.28	0.82	0.40	0.43	0.61	0.33
MDA	unit.045	33	34	1	0.27	0.22	0.33	0.28	0.27	0.08	0.33	0.23	0.31	0.30	0.47	0.23
LTU	unit.040	34	36	2	0.27	0.39	0.15	0.47	0.32	0.40	0.15	0.39	0.58	0.47	0.38	0.34
HRV	unit.037	35	35	0	0.27	0.32	0.21	0.40	0.25	0.36	0.21	0.42	0.29	0.43	0.30	0.27
HUN	unit.031	36	39	3	0.27	0.35	0.18	0.43	0.29	0.36	0.18	0.45	0.38	0.43	0.40	0.21
SVK	unit.036	37	41	4	0.26	0.35	0.17	0.41	0.30	0.37	0.17	0.40	0.33	0.45	0.31	0.38
POL	unit.049	38	38	0	0.26	0.33	0.19	0.41	0.28	0.32	0.19	0.39	0.47	0.40	0.39	0.22

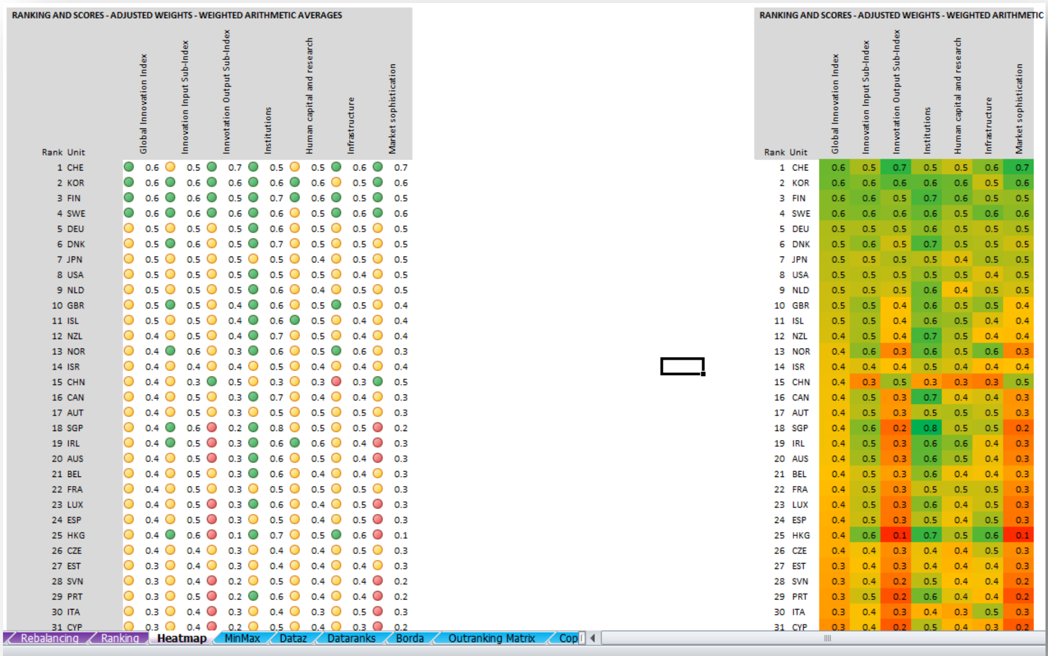
Free / Correl / Rebalancing / Ranking / Heatmap / MinMax / Dataz / Dataranks / Borda / Outranking Matrix / Cop

Source: JRC, 2017.

2.3.5 Heatmap of scores with adjusted weights

The tab "Heatmap" includes three examples of visual presentation of the final ranking and scores for index, sub-indices and pillars. These charts are using conditional formatting.

Figure 11. 'Heatmap' tab



RANKING AND SCORES - ADJUSTED WEIGHTS - WEIGHTED ARITHMETIC AVERAGES

Rank	Unit	Global Innovation Index	Innovation Input Sub-Index	Innvotation Output Sub-Index	Institutions	Human capital and research	Infrastructure	Market sophistication
1	CHE	0.6	0.5	0.7	0.5	0.5	0.6	0.7
2	KOR	0.6	0.6	0.6	0.6	0.6	0.5	0.6
3	FIN	0.6	0.6	0.5	0.7	0.6	0.5	0.5
4	SWE	0.6	0.6	0.6	0.6	0.5	0.6	0.6
5	DEU	0.5	0.5	0.5	0.6	0.5	0.5	0.5
6	DNK	0.5	0.6	0.5	0.7	0.5	0.5	0.5
7	JPN	0.5	0.5	0.5	0.5	0.4	0.5	0.5
8	USA	0.5	0.5	0.5	0.5	0.5	0.4	0.5
9	NLD	0.5	0.5	0.5	0.6	0.4	0.5	0.5
10	GBR	0.5	0.5	0.4	0.6	0.5	0.5	0.4
11	ISL	0.5	0.5	0.4	0.6	0.5	0.4	0.4
12	NZL	0.4	0.5	0.4	0.7	0.5	0.4	0.4
13	NOR	0.4	0.6	0.3	0.6	0.5	0.6	0.3
14	ISR	0.4	0.4	0.4	0.5	0.4	0.4	0.4
15	CHN	0.4	0.3	0.5	0.3	0.3	0.3	0.5
16	CAN	0.4	0.5	0.3	0.7	0.4	0.4	0.3
17	AUT	0.4	0.5	0.3	0.5	0.5	0.5	0.3
18	SGP	0.4	0.6	0.2	0.8	0.5	0.5	0.2
19	IRL	0.4	0.5	0.3	0.6	0.6	0.4	0.3
20	AUS	0.4	0.5	0.3	0.6	0.5	0.4	0.3
21	BEL	0.4	0.5	0.3	0.6	0.4	0.4	0.3
22	FRA	0.4	0.5	0.3	0.5	0.5	0.5	0.3
23	LUX	0.4	0.5	0.3	0.6	0.4	0.5	0.3
24	ESP	0.4	0.5	0.3	0.5	0.4	0.5	0.3
25	HKG	0.4	0.6	0.1	0.7	0.5	0.6	0.1
26	CZE	0.4	0.4	0.3	0.4	0.4	0.5	0.3
27	EST	0.3	0.4	0.3	0.4	0.4	0.4	0.3
28	SVN	0.3	0.4	0.2	0.5	0.4	0.4	0.2
29	PRT	0.3	0.5	0.2	0.6	0.4	0.4	0.2
30	ITA	0.3	0.4	0.3	0.4	0.3	0.5	0.3
31	CYP	0.3	0.4	0.2	0.5	0.4	0.3	0.2

RANKING AND SCORES - ADJUSTED WEIGHTS - WEIGHTED ARITHMETIC

Rank	Unit	Global Innovation Index	Innovation Input Sub-Index	Innvotation Output Sub-Index	Institutions	Human capital and research	Infrastructure	Market sophistication
1	CHE	0.6	0.5	0.7	0.5	0.5	0.6	0.7
2	KOR	0.6	0.6	0.6	0.6	0.6	0.5	0.6
3	FIN	0.6	0.6	0.5	0.7	0.6	0.5	0.5
4	SWE	0.6	0.6	0.6	0.6	0.5	0.6	0.6
5	DEU	0.5	0.5	0.5	0.6	0.5	0.5	0.5
6	DNK	0.5	0.6	0.5	0.7	0.5	0.5	0.5
7	JPN	0.5	0.5	0.5	0.5	0.4	0.5	0.5
8	USA	0.5	0.5	0.5	0.5	0.5	0.4	0.5
9	NLD	0.5	0.5	0.5	0.6	0.4	0.5	0.5
10	GBR	0.5	0.5	0.4	0.6	0.5	0.5	0.4
11	ISL	0.5	0.5	0.4	0.6	0.5	0.4	0.4
12	NZL	0.4	0.5	0.4	0.7	0.5	0.4	0.4
13	NOR	0.4	0.6	0.3	0.6	0.5	0.6	0.3
14	ISR	0.4	0.4	0.4	0.5	0.4	0.4	0.4
15	CHN	0.4	0.3	0.5	0.3	0.3	0.3	0.5
16	CAN	0.4	0.5	0.3	0.7	0.4	0.4	0.3
17	AUT	0.4	0.5	0.3	0.5	0.5	0.5	0.3
18	SGP	0.4	0.6	0.2	0.8	0.5	0.5	0.2
19	IRL	0.4	0.5	0.3	0.6	0.6	0.4	0.3
20	AUS	0.4	0.5	0.3	0.6	0.5	0.4	0.3
21	BEL	0.4	0.5	0.3	0.6	0.4	0.4	0.3
22	FRA	0.4	0.5	0.3	0.5	0.5	0.5	0.3
23	LUX	0.4	0.5	0.3	0.6	0.4	0.5	0.3
24	ESP	0.4	0.5	0.3	0.5	0.4	0.5	0.3
25	HKG	0.4	0.6	0.1	0.7	0.5	0.6	0.1
26	CZE	0.4	0.4	0.3	0.4	0.4	0.5	0.3
27	EST	0.3	0.4	0.3	0.4	0.4	0.4	0.3
28	SVN	0.3	0.4	0.2	0.5	0.4	0.4	0.2
29	PRT	0.3	0.5	0.2	0.6	0.4	0.4	0.2
30	ITA	0.3	0.4	0.3	0.4	0.3	0.5	0.3
31	CYP	0.3	0.4	0.2	0.5	0.4	0.3	0.2

Rebalancing | Ranking | Heatmap | MinMax | Dataz | Dataranks | Borda | Outranking Matrix | Cop

Source: JRC, 2017.

3 Scenaria (blue tabs)

The tabs that follow are aimed at assessing the robustness and sensitivity of rankings to changes in modelling assumptions. Excel only allows for a limited number of assessments, advanced featured (Section 4) are presented for completeness, but other statistical packages should be used.

3.1 Normalization

3.1.1 Min-max normalization

Normalization is required to obtain indicator scores and compute composite indicator aggregates. To normalise indicators, the most commonly used is min-max normalization; at the indicator level, the direction of effects need to be taken into account.

The discussion of aggregates is left for the heading "Aggregates" below, however note that geometric averaging necessitates strictly positive values; this implies that normalized scores need to be strictly positive (for example set a minimum at 0.1).

<u>Formulas</u>:

- Normalization in the range [0, 1]: new value = (old value - min) / (max - min) * direction + 0.5 * (1 - direction)
- Normalization in the range [desired min, desired max]: new value = [(old value - min) / (max - min) * direction + 0.5 * (1 - direction)] * (desired max – desired min) + desired min

3.1.2 Z-score normalization

Z-score is another widely used normalization method; at the indicator level, the direction of effects need to be taken into account as well.

The discussion of aggregates is left for the heading "Aggregates" below, however note that geometric averaging necessitates strictly positive values; this implies that normalized scores need to be strictly positive (for example set a minimum at 0.1). Z-scores have mean 0 and standard deviation 1; to obtain strictly positive values the mean has to be increased (for example to 5 or even 10 as some outliers in the negative tail of the distribution might still get negative values).

<u>Formulas</u>:

- [mean 0, std 1]: z-score = (old value – indicator mean) / indicator std * direction
- [desired mean, desired std]: new value = (old value – indicator mean) / indicator std * direction * desired std + desired mean

3.2 Aggregation methods and rankings

Once the data has been normalized, to obtain scores and ranks the different indicators are aggregated into each supra-dimension (indicator scores into sub-pillar scores, sub-pillar scores into pillar scores, pillar scores into sub-index scores, and sub-pillar scores into the final index scores).

Several aggregation functions exist, the following are the formulas for the most commonly used (example for a total of M indicators):

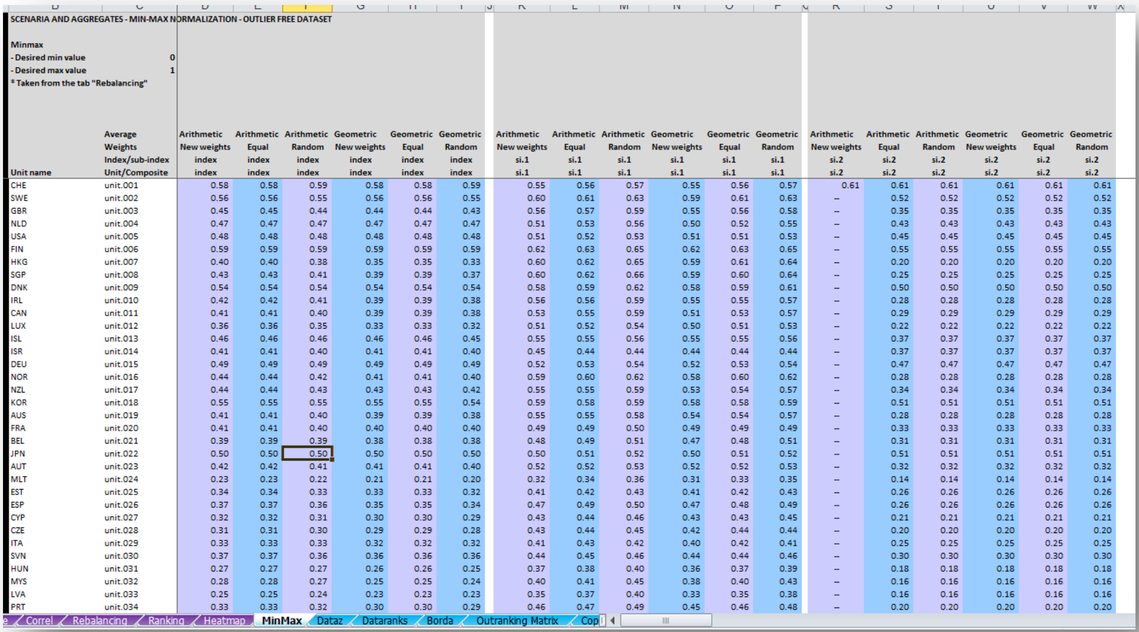
3.2.1 Arithmetic and geometric averages

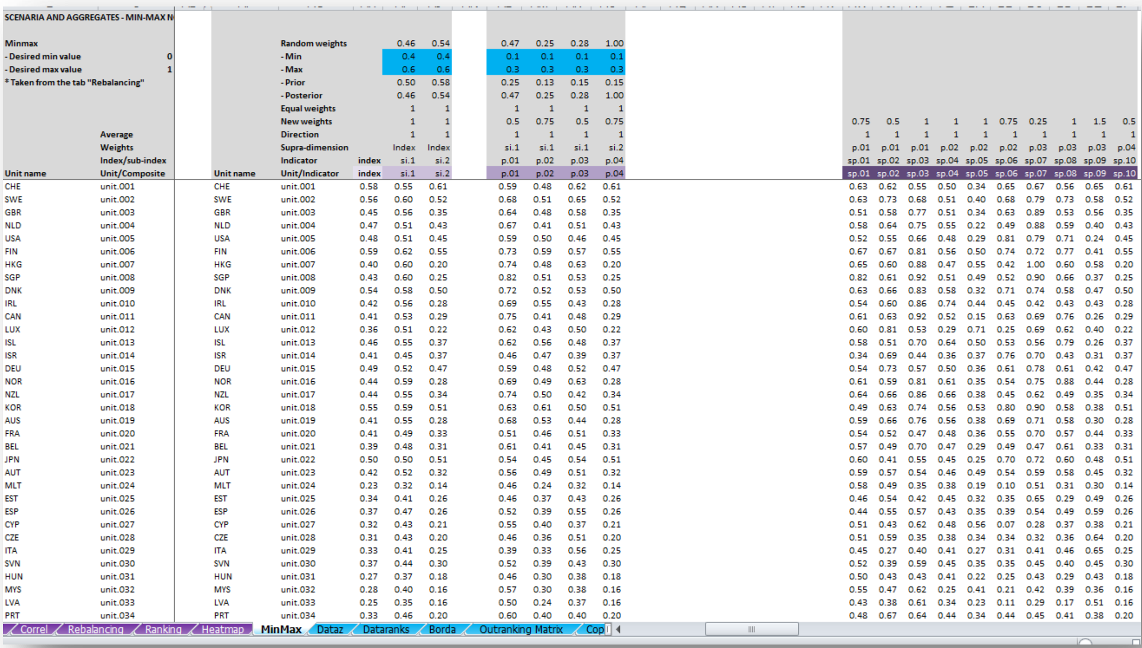
The “Minmax” and “Dataz” tabs compute weighted arithmetic for sub-pillar, pillar, sub-index and index scores (default scores). In addition, for index and sub-index scores, the tab computes arithmetic and geometric averages, for, in each case, new, equal and random weights.

- Arithmetic mean (equal weights): score = AVERAGE (normalised values)
- Weighted arithmetic mean (unequal or random weights): score = SUMPRODUCT (weights * normalised values)
- Geometric mean (equal weights): score = PRODUCT (normalised values) ^ (1 / M)
- Weighted geometric mean (unequal or random weights): score = EXP [SUMPRODUCT (weights, LN(normalised values))]

A ranking is then computed for each aggregate in the tab “Scenaria” (arithmetic mean rank, weighted geometric mean rank, etc.).

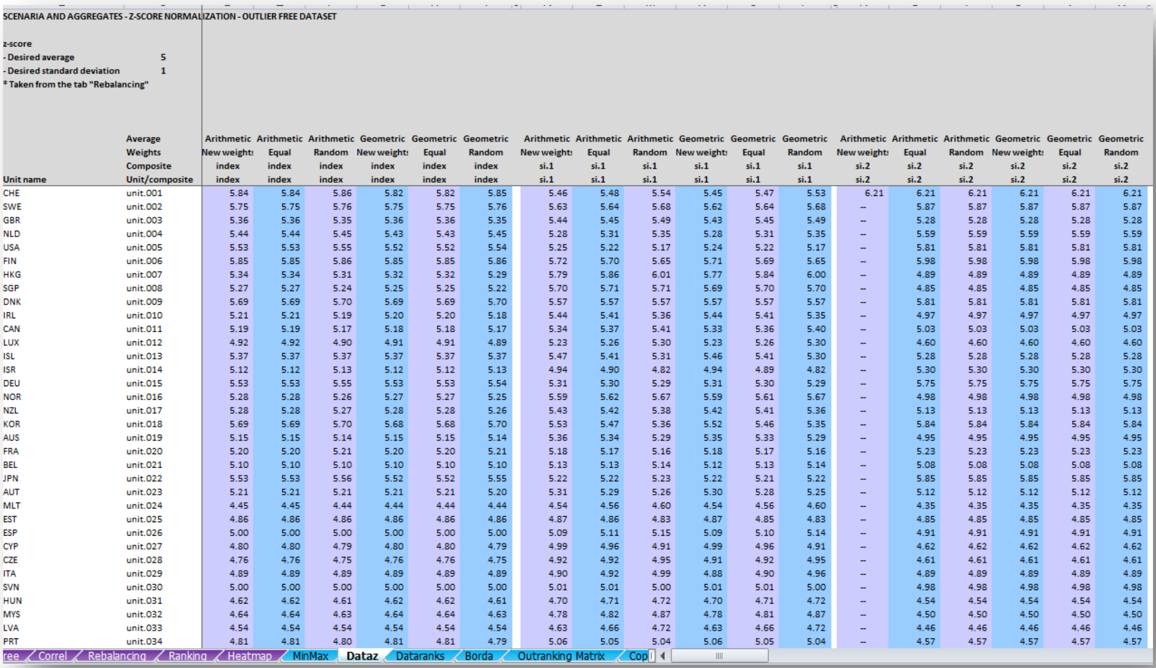
Figure 12. 'Minmax' tab

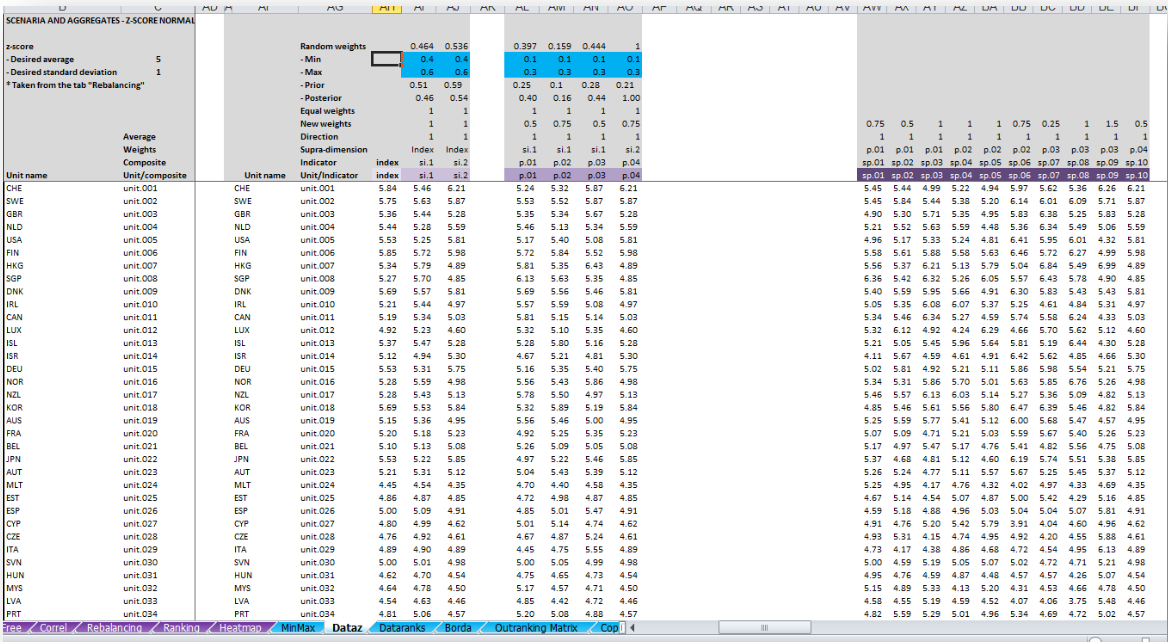




Source: JRC, 2017.

Figure 13. 'Dataz' tab





Source: JRC, 2017.

3.2.1.1 Note on arithmetic v. geometric averages

Arithmetic averages are fully compensatory, an important comparative advantage in few indicators can compensate comparative disadvantages in many indicators; geometric averages, in contrast, reward units with balanced profiles, and motivates them to improve in the dimensions in which their perform poorly, and not just in any dimension.

Note: Geometric means require pillar values above zero; a zero pillar value is highly improbable, but if computations were to break down, for Minmax the desired minimum should be set at 0.1, and for "Dataz" the mean should be set at minimum 5 (refer to heading 4 Normalization for details).

3.2.1.2 Note on random weights

It is advisable to assess the sensitivity of ranks to random weights. One can also use some other software and run a number of Monte Carlo simulations (e.g. 1'000) to obtain a confidence interval for ranks (e.g. range of 90% of ranks).

In Excel, weights can be randomly selected using a uniform distribution in a given range [desired min, desired max]:

Formula:

- Prior weight = RANDBETWEEN (desired min *100, desired max * 100) / 100
- Posterior weight = weight / sum (weights)

Note: This RANDBETWEEN Excel formula requires the desired min and max (Excel calls these the bottom and top values) to be greater than 1; thus the multiplication and division by 100 allows ranges with two decimals. For aggregation, the prior weights have to be re-scaled to unity sum; these posterior weights are obtained by dividing each weight by the sum of weights within the same dimension. By pressing F9, the weights are automatically changed and computations are automatically updated.

3.2.1.3 Note on trimmed means

For composite indicators with only one or two levels of aggregation, an alternative aggregation method is the computation of trimmed means for each unit (and the corresponding ranking); this method, however, is not advisable for dimensions with few components (e.g. less than 5 or 6):

- Trimmed mean, equal weights (the best and worst values are discarded): score = [SUM(normalised values) – LARGE (normalised values, 1) – SMALL (normalised values, 1)] / COUNT(normalised values – 2)

3.2.2 Median and average rank

In the ‘Dataranks’ tab, the computation of ranks on individual indicators from the original dataset helps in the interpretation of results when trying to argue why one unit is doing better than another within a given dimension:

- Rank: rank = RANK [original value, range, 0.5 * (1 - direction)]
- Median rank: median rank = MEDIAN (ranks for the same unit across all indicators)
- Average rank: average rank = AVERAGE (ranks for the same unit across all indicators)

A ranking is then computed for each aggregate (median rank rank, average rank rank – no mistake in the double word “rank”), include in the tab “Scenaria”.

Figure 14. ‘Dataranks’ tab

DATARANKS - ORIGINAL DATASET

Median rank rank	Average rank rank	Median rank	Average rank	Name	Unit/Indicator	ind.01	ind.02	ind.03	ind.04	ind.05	ind.06	ind.07	ind.08	ind.09	ind.10	ind.11	ind.12	ind.13	ind.14	ind.15	ind.16	ind.17	ind.18	ind.19	ind.20	ind.21	ind.22
					Min	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
					Max	50	50	49	50	50	36	50	50	50	41	42	46	46	45	46	43	45	49	42	47	39	49
					Mean	25.50	25.50	24.98	25.50	25.50	23.26	25.44	25.48	25.48	21.00	21.50	23.50	23.50	23.00	23.50	22.00	23.00	25.00	21.50	24.00	24.18	25.00
					Direction	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	7	12.5	16.28	CHE	unit.001	6	6	39	12	11	28	35	34	13	24	12	23	11	–	34	26	9	21	12	7	6	2
2	3	11	13.92	SWE	unit.002	7	4	42	6	2	20	11	20	27	8	5	19	25	34	11	11	18	19	6	4	14	6
14	13	16	18.16	GBR	unit.003	39	16	27	13	15	35	27	8	11	21	19	12	18	9	27	17	8	46	10	20	1	7
8	9	13.5	17.42	NLD	unit.004	12	8	48	5	6	33	23	6	20	–	17	7	10	12	19	41	23	40	24	18	12	10
23	20	22	21.57	USA	unit.005	36	21	26	16	17	36	22	15	30	–	32	11	23	11	2	39	30	49	–	10	2	23
1	1	9	12.87	FIN	unit.006	1	1	49	9	1	28	9	5	16	11	6	9	3	35	3	5	22	23	2	2	18	17
17	10	17	17.62	HKG	unit.007	21	12	13	3	18	36	5	16	4	40	39	21	2	2	26	2	19	5	26	33	5	1
3	2	11.5	13.53	SGP	unit.008	10	3	3	7	13	36	4	2	5	39	–	–	4	6	–	–	6	–	7	16	19	8
4	6	12	15.86	DNK	unit.009	14	2	45	1	3	36	12	10	9	2	3	42	19	–	9	27	15	34	3	6	13	9
21	18	20	20.26	IRL	unit.010	17	20	38	11	10	36	10	9	6	6	–	3	21	–	16	16	17	7	20	22	16	20
14	11	16	17.81	CAN	unit.011	16	7	34	10	12	31	2	4	7	27	–	–	7	16	–	–	–	28	–	23	3	22
11	22	15	21.89	LUX	unit.012	4	11	46	4	8	11	35	37	14	–	–	41	33	39	46	4	1	2	13	26	39	3
14	16	16	19.57	ISL	unit.013	8	15	43	29	14	28	17	11	29	1	16	4	16	18	7	37	21	3	1	11	39	4
24	23	23	23.18	ISR	unit.014	50	26	6	20	32	3	28	35	35	15	35	22	36	32	23	–	–	22	–	1	21	24
10	8	14.5	17.32	DEU	unit.015	25	17	36	15	16	12	40	18	31	26	–	–	13	14	–	10	–	27	14	8	8	5
5	4	12.5	15.03	NOR	unit.016	3	9	47	18	5	33	17	3	12	9	10	5	17	–	10	34	16	11	4	24	20	12
9	12	14	17.84	NZL	unit.017	2	5	44	2	4	36	1	13	14	5	25	1	8	8	5	29	10	36	11	28	17	21
7	5	13	15.38	KOR	unit.018	43	24	18	32	31	4	21	14	17	34	29	6	5	3	1	6	34	13	–	3	11	11
11	14	15	18.28	AUS	unit.019	24	10	29	8	9	26	3	17	26	25	36	2	9	–	6	31	5	43	–	13	4	19
19	17	19	19.95	FRA	unit.020	30	22	22	25	19	23	15	32	39	20	18	15	22	15	32	9	12	38	18	15	10	13
18	21	18	21.62	BEL	unit.021	23	13	33	22	20	36	7	7	37	10	8	14	14	45	13	33	13	31	17	17	15	18
19	19	19	20.32	JPN	unit.022	19	23	17	34	23	36	42	1	43	–	28	28	6	22	28	22	25	44	9	5	7	16
11	15	15	18.55	AUT	unit.023	11	14	40	17	7	36	44	12	33	13	7	24	29	30	15	8	7	20	8	9	24	15
43	42	34	30.59	MLT	unit.024	18	28	19	21	22	36	47	38	19	16	14	29	37	36	42	32	44	14	31	38	39	14
22	24	21.5	23.61	EST	unit.025	32	25	41	19	25	22	20	40	38	18	13	18	12	37	21	21	35	15	15	14	34	26
25	25	24.5	23.74	ESP	unit.026	45	29	23	26	24	17	46	19	21	28	23	10	32	25	8	12	31	42	19	27	22	28
36	34	32	28.81	CYP	unit.027	35	18	30	24	27	36	29	22	23	7	2	37	–	33	36	42	4	1	33	44	39	39
27	28	26.5	26.32	CZE	unit.028	13	30	37	23	30	13	45	26	45	35	30	20	26	24	22	15	14	32	22	19	29	36
31	30	29	27.45	ITA	unit.029	33	42	14	35	43	36	31	24	50	29	20	17	31	29	20	28	26	37	30	29	23	29
26	26	25	24.26	SVN	unit.030	26	32	24	39	26	25	6	31	25	17	11	8	20	44	4	19	36	29	16	12	36	25
28	36	27	29.13	HUN	unit.031	27	37	15	27	35	21	13	39	42	23	22	26	24	27	25	38	24	39	25	30	32	37
36	33	32	28.47	MYS	unit.032	44	31	4	37	39	8	8	36	10	30	37	44	43	13	39	1	20	25	39	37	26	43
39	40	32.5	30.53	LVA	unit.033	42	38	21	31	33	32	16	25	22	–	21	33	30	40	30	36	33	17	27	39	39	41
30	27	28	25.87	PRT	unit.034	28	33	28	38	29	1	14	21	32	14	9	16	27	43	18	13	32	24	5	25	28	30
49	43	42	30.69	CHN	unit.035	49	44	1	50	50	4	49	41	48	–	–	45	1	4	43	–	45	47	35	21	9	49
39	41	32.5	30.55	SVK	unit.036	20	35	31	28	38	24	33	29	40	36	38	32	28	21	33	20	29	6	21	36	39	40
41	39	33	30.29	HRV	unit.037	37	41	11	42	44	19	30	45	24	33	24	36	35	41	35	23	43	18	28	35	37	33
32	29	30	27.00	ARE	unit.038	22	34	5	45	41	36	25	47	1	–	–	–	40	20	–	14	3	30	–	–	30	32
48	50	41	36.58	CRI	unit.039	31	43	35	43	42	16	50	50	47	12	40	40	41	5	38	43	38	48	38	41	39	48
32	35	30	28.84	LTU	unit.040	29	39	25	33	36	7	37	30	28	19	26	25	34	38	14	18	37	16	23	32	33	35

Heatmap | MinMax | Dataz | Dataranks | Borda | Outranking Matrix | Copeland | Scenaria | MinmaxFakeImp | DatazFake1

Source: JRC, 2017.

Note: Missing data distort results because for indicators with low unit-coverage, ranks will be lower (thus better).

3.2.3 Borda rule

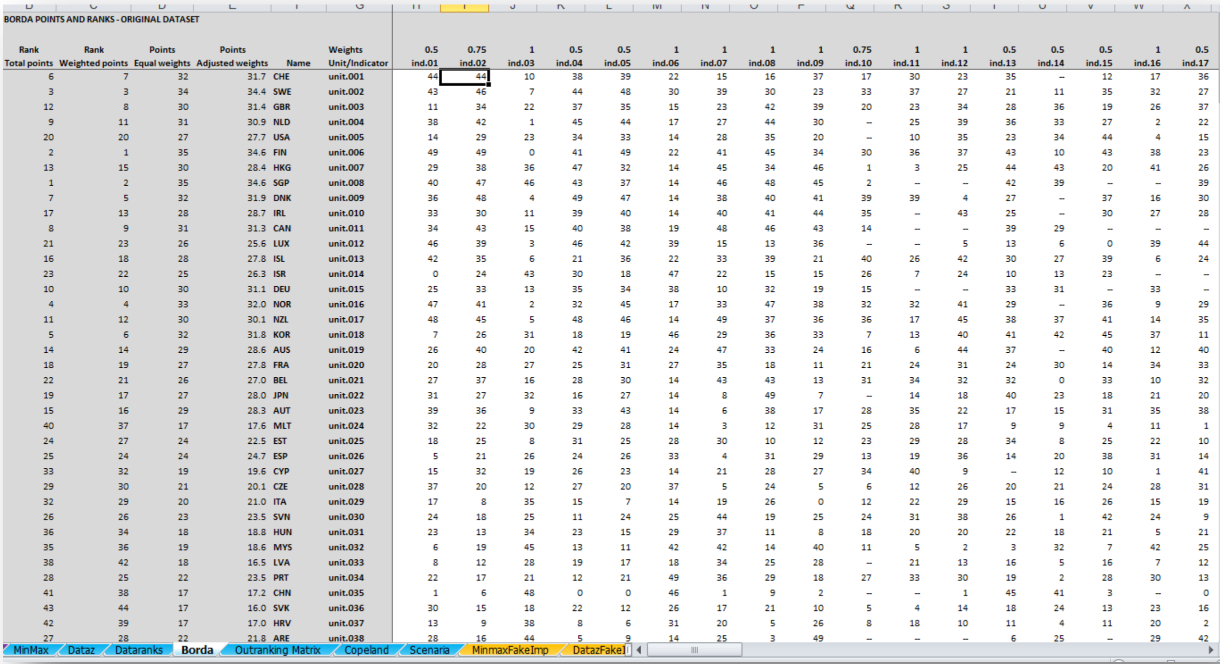
In the 'Borda' tab, for *Ni* units in indicator *i*, the top-ranked unit in that indicator gets *Ni – 1* points; the second ranked unit gets *Ni – 2* points and so on; the last ranked unit gets 0 points.

- Borda points (unit/indicator): Borda points = *Ni* – rank (rank computed in "Datarank")
- Borda points (equal weights): average Borda points = SUM (points) / COUNT (points)
- Weighted Borda points: weighted Borda points = SUMPRODUCT (weights scaled to unity sum * points]

A ranking is then computed for each aggregate (average and weighted Borda points), included in the tab "Scenaria".

Note: Missing data distort results, because for indicators with low unit-coverage, Borda points will be lower (thus worse).

Figure 15. 'Borda' tab



BORDA POINTS AND RANKS - ORIGINAL DATASET

Rank	Rank	Points	Points		Weights	0.5	0.75	1	0.5	0.5	1	1	1	1	0.75	1	1	0.5	0.5	0.5	1	0.5
Total points	Weighted points	Equal weights	Adjusted weights	Name	Unit/Indicator	ind.01	ind.02	ind.03	ind.04	ind.05	ind.06	ind.07	ind.08	ind.09	ind.10	ind.11	ind.12	ind.13	ind.14	ind.15	ind.16	ind.17
6	7	32	31.7	CHE	unit.001	44	44	10	38	39	22	15	16	37	17	30	23	35	–	12	17	36
3	3	34	34.4	SWE	unit.002	43	46	7	44	48	30	39	30	23	33	37	27	21	11	35	32	27
12	8	30	31.4	GBR	unit.003	11	34	22	37	35	15	23	42	39	20	23	34	28	36	19	26	37
9	11	31	30.9	NLD	unit.004	38	42	1	45	44	17	27	44	30	–	25	39	36	33	27	2	22
20	20	27	27.7	USA	unit.005	14	29	23	34	33	14	28	35	20	–	10	35	23	34	44	4	15
2	1	35	34.6	FIN	unit.006	49	49	0	41	49	22	41	45	34	30	36	37	43	10	43	38	23
13	15	30	28.4	HKG	unit.007	29	38	36	47	32	14	45	34	46	1	3	25	44	43	20	41	26
1	2	35	34.6	SGP	unit.008	40	47	46	43	37	14	46	48	45	2	–	–	42	39	–	–	39
7	5	32	31.9	DNK	unit.009	36	48	4	49	47	14	38	40	41	39	39	4	27	–	37	16	30
17	13	28	28.7	IRL	unit.010	33	30	11	39	40	14	40	41	44	35	–	43	25	–	30	27	28
8	9	31	31.3	CAN	unit.011	34	43	15	40	38	19	48	46	43	14	–	–	39	29	–	–	–
21	23	26	25.6	LUX	unit.012	46	39	3	46	42	39	15	13	36	–	–	5	13	6	0	39	44
16	18	28	27.8	ISL	unit.013	42	35	6	21	36	22	33	39	21	40	26	42	30	27	39	6	24
23	22	25	26.3	ISR	unit.014	0	24	43	30	18	47	22	15	15	26	7	24	10	13	23	–	–
10	10	30	31.1	DEU	unit.015	25	33	13	35	34	38	10	32	19	15	–	–	33	31	–	33	–
4	4	33	32.0	NOR	unit.016	47	41	2	32	45	17	33	47	38	32	32	41	29	–	36	9	29
11	12	30	30.1	NZL	unit.017	48	45	5	48	46	14	49	37	36	36	17	45	38	37	41	14	35
5	6	32	31.8	KOR	unit.018	7	26	31	18	19	46	29	36	33	7	13	40	41	42	45	37	11
14	14	29	28.6	AUS	unit.019	26	40	20	42	41	24	47	33	24	16	6	44	37	–	40	12	40
18	19	27	27.8	FRA	unit.020	20	28	27	25	31	27	35	18	11	21	24	31	24	30	14	34	33
22	21	26	27.0	BEL	unit.021	27	37	16	28	30	14	43	43	13	31	34	32	32	0	33	10	32
19	17	27	28.0	JPN	unit.022	31	27	32	16	27	14	8	49	7	–	14	18	40	23	18	21	20
15	16	29	28.3	AUT	unit.023	39	36	9	33	43	14	6	38	17	28	35	22	17	15	31	35	38
40	37	17	17.6	MLT	unit.024	32	22	30	29	28	14	3	12	31	25	28	17	9	9	4	11	1
24	27	24	22.5	EST	unit.025	18	25	8	31	25	28	30	10	12	23	29	28	34	8	25	22	10
25	24	24	24.7	ESP	unit.026	5	21	26	24	26	33	4	31	29	13	19	36	14	20	38	31	14
33	32	19	19.6	CYP	unit.027	15	32	19	26	23	14	21	28	27	34	40	9	–	12	10	1	41
29	30	21	20.1	CZE	unit.028	37	20	12	27	20	37	5	24	5	6	12	26	20	21	24	28	31
32	29	20	21.0	ITA	unit.029	17	8	35	15	7	14	19	26	0	12	22	29	15	16	26	15	19
26	26	23	23.5	SVN	unit.030	24	18	25	11	24	25	44	19	25	24	31	38	26	1	42	24	9
36	34	18	18.8	HUN	unit.031	23	13	34	23	15	29	37	11	8	18	20	20	22	18	21	5	21
35	36	19	18.6	MYS	unit.032	6	19	45	13	11	42	42	14	40	11	5	2	3	32	7	42	25
38	42	18	16.5	LVA	unit.033	8	12	28	19	17	18	34	25	28	–	21	13	16	5	16	7	12
28	25	22	23.5	PRT	unit.034	22	17	21	12	21	49	36	29	18	27	33	30	19	2	28	30	13
41	38	17	17.2	CHN	unit.035	1	6	48	0	0	46	1	9	2	–	–	1	45	41	3	–	0
43	44	17	16.0	SVK	unit.036	30	15	18	22	12	26	17	21	10	5	4	14	18	24	13	23	16
42	39	17	17.0	HRV	unit.037	13	9	38	8	6	31	20	5	26	8	18	10	11	4	11	20	2
27	28	22	21.8	ARE	unit.038	28	16	44	5	9	14	25	3	49	–	–	–	6	25	–	29	42

Source: JRC, 2017.

3.2.4 Copeland rule

The Copeland rule requires the computation of the outranking matrix.

3.2.4.1 Outranking matrix

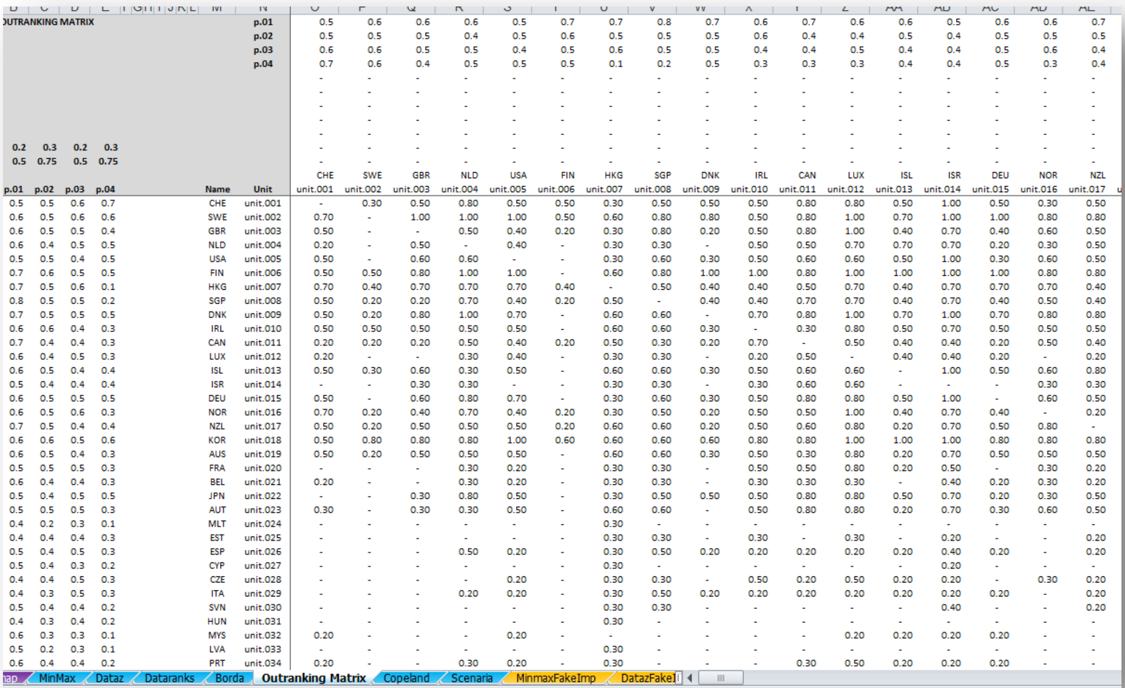
In the 'Outranking Matrix' tab, units are compared pairwise. For each comparison, all the weights corresponding to the indicators in which unit A has a better score than unit B are added up as evidence in favour of "A better than B" (abbreviated as AB). For N units, there are N*(N-1) comparisons to be made. The diagonal elements are set at 0 by definition. In practical terms, for each pairwise unit comparison the following formula is used:

<u>Formulas</u>

- <u>With raw values</u>: SUM across all indicators [(weight for indicator *i*) * (1 + direction of indicator *i*) * SIGN(raw value of unit A on indicator *i* – raw value of unit B on indicator *i*)] / 2
- <u>With normalized values</u>: SUM across all indicators [(weight for indicator *i*) * SIGN(normalized value of unit A on indicator *i* – normalized value of unit B on indicator *i*)]

Pairwise comparison values are entered in the so-called outranking matrix. Since the sum of weights is one, above/below diagonal entries add up to one.

Figure 16. 'Outranking Matrix' tab



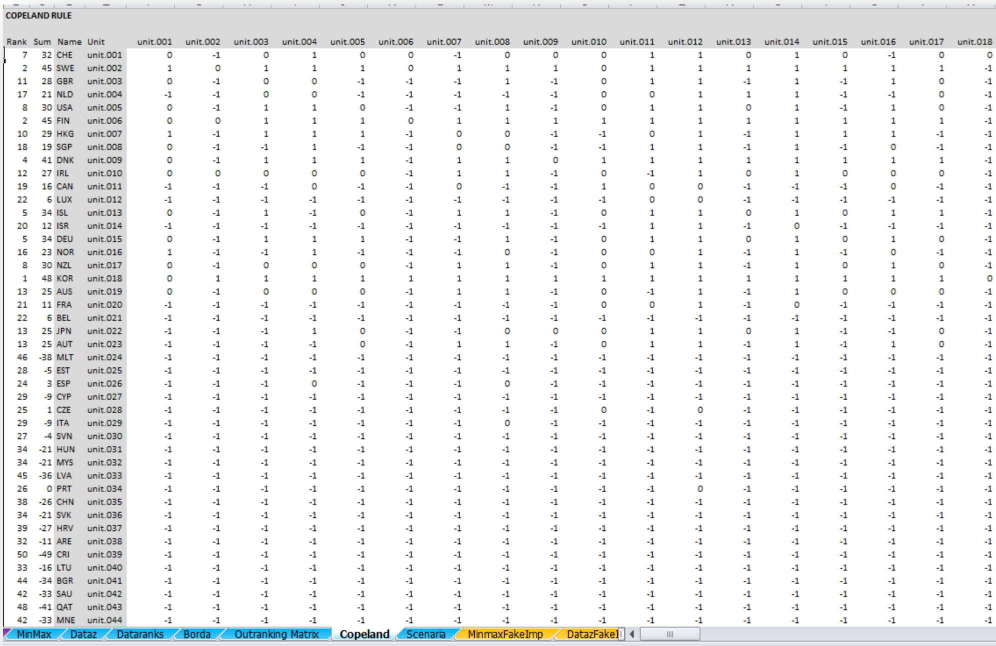
Source: JRC, 2017.

3.2.4.2 Copeland rule

In the 'Copeland' tab, the outranking matrix is transformed as follows: all values greater than 0.5 are replaced with +1, all values lower than 0.5 with -1 and all ties (values of exactly 0.5) with 0. The diagonal elements are set at 0 by definition. The Copeland score for each unit is the sum of the values in a given row. A final ranking in then calculated.

Note: In general, some compensability/substitutability is desired at lower aggregation levels (sub-pillars), aggregation methods listed in the previous section are thus appropriate. However, at higher aggregation levels (pillars, sub-indices, overall index), compensability is less desirable; the Copeland rule can then be used to aggregate dimensions.

Figure 17. 'Copeland' tab



COPELAND RULE

Rank	Sum	Name	Unit	unit.001	unit.002	unit.003	unit.004	unit.005	unit.006	unit.007	unit.008	unit.009	unit.010	unit.011	unit.012	unit.013	unit.014	unit.015	unit.016	unit.017	unit.018
7	32	CHE	unit.001	0	-1	0	1	0	0	-1	0	0	0	1	1	0	1	0	-1	0	0
2	45	SWE	unit.002	1	0	1	1	1	0	1	1	1	0	1	1	1	1	1	1	1	-1
11	28	GBR	unit.003	0	-1	0	0	-1	-1	-1	1	-1	0	1	1	-1	1	-1	1	0	-1
17	21	NLD	unit.004	-1	-1	0	0	-1	-1	-1	-1	-1	0	0	1	1	1	-1	-1	0	-1
8	30	USA	unit.005	0	-1	1	1	0	-1	-1	1	-1	0	1	1	0	1	-1	1	0	-1
2	45	FIN	unit.006	0	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	-1
10	29	HKG	unit.007	1	-1	1	1	1	-1	0	0	-1	-1	0	1	-1	1	1	1	-1	-1
18	19	SGP	unit.008	0	-1	-1	1	-1	-1	0	0	-1	-1	1	1	-1	1	-1	0	-1	-1
4	41	DNK	unit.009	0	-1	1	1	1	-1	1	1	0	1	1	1	1	1	1	1	1	-1
12	27	IRL	unit.010	0	0	0	0	0	-1	1	1	-1	0	-1	1	0	1	0	0	0	-1
19	16	CAN	unit.011	-1	-1	-1	0	-1	-1	0	-1	-1	1	0	0	-1	-1	-1	0	-1	-1
22	6	LUX	unit.012	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	0	-1	-1	-1	-1	-1	-1
5	34	ISL	unit.013	0	-1	1	-1	0	-1	1	1	-1	0	1	1	0	1	0	1	1	-1
20	12	ISR	unit.014	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1	1	-1	0	-1	-1	-1	-1
5	34	DEU	unit.015	0	-1	1	1	1	-1	-1	1	-1	0	1	1	0	1	0	1	0	-1
16	23	NOR	unit.016	1	-1	-1	1	-1	-1	-1	0	-1	0	0	1	-1	1	-1	0	-1	-1
8	30	NZL	unit.017	0	-1	0	0	0	-1	1	1	-1	0	1	1	-1	1	0	1	0	-1
1	48	KOR	unit.018	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
13	25	AUS	unit.019	0	-1	0	0	0	-1	1	1	-1	0	-1	1	-1	1	0	0	0	-1
21	11	FRA	unit.020	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	0	1	-1	0	-1	-1	-1	-1
22	6	BEL	unit.021	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
13	25	JPN	unit.022	-1	-1	-1	1	0	-1	-1	0	0	0	1	1	0	1	-1	-1	0	-1
13	25	AUT	unit.023	-1	-1	-1	-1	0	-1	1	1	-1	0	1	1	-1	1	-1	1	0	-1
46	-38	MLT	unit.024	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
28	-5	EST	unit.025	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
24	3	ESP	unit.026	-1	-1	-1	0	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
29	-9	CYP	unit.027	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
25	1	CZE	unit.028	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	0	-1	-1	-1	-1	-1	-1
29	-9	ITA	unit.029	-1	-1	-1	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
27	-4	SVN	unit.030	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
34	-21	HUN	unit.031	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
34	-21	MYS	unit.032	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
45	-36	LVA	unit.033	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
26	0	PRT	unit.034	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1
38	-26	CHN	unit.035	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
34	-21	SVK	unit.036	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
39	-27	HRV	unit.037	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
32	-11	ARE	unit.038	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
50	-49	CRI	unit.039	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
33	-16	LTU	unit.040	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
44	-34	BGR	unit.041	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
42	-33	SAU	unit.042	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
48	-41	QAT	unit.043	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
42	-33	MNE	unit.044	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1

MinMax | Dataz | Dataranks | Borda | Outranking Matrix | Copeland | Scenaria | MinmaxFakeImp | DatazFake

Source: JRC, 2017.

3.3 Scenaria

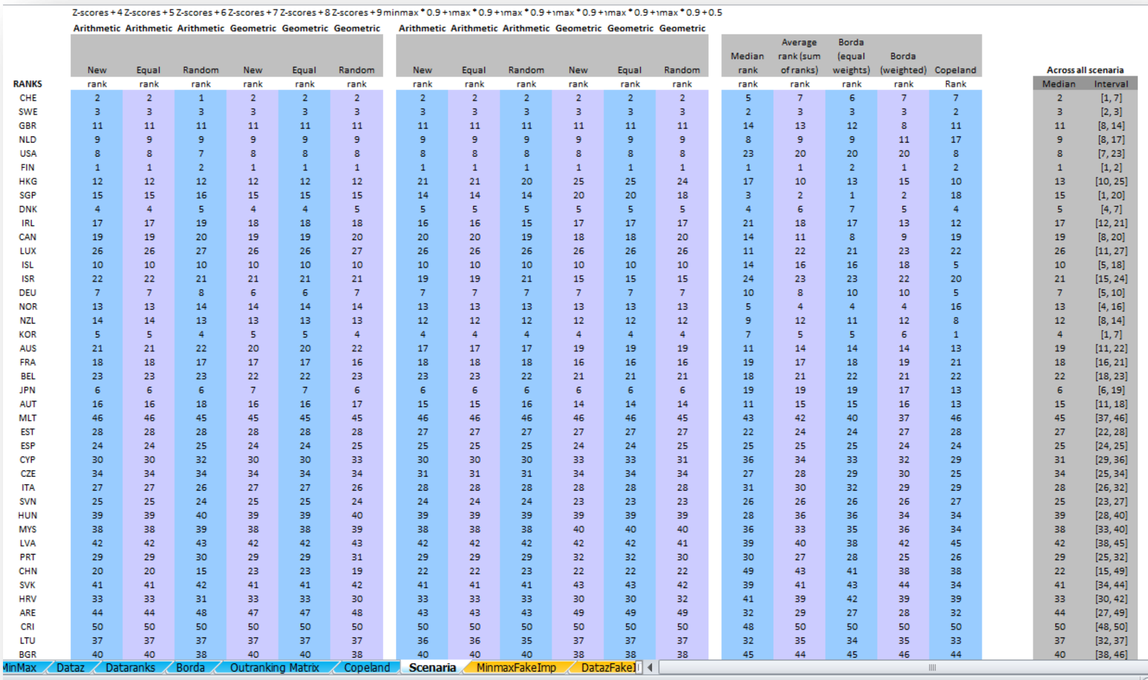
In the 'Scenaria' tab, unit scores associated with composite indicators are generally not calculated under conditions of certainty. For each composite indicator, modelling choices are based on different criteria, such as expert opinion in the field (e.g. selection of indicators), common practice (e.g. min-max normalization), statistical analysis (e.g. treatment of outliers); simplicity (e.g. no imputation of missing data), etc.

The robustness of results to modelling choices can be assessed by computing rankings with a combination of Monte Carlo simulations (uncertainty analysis) and a multi-modelling approach (sensitivity analysis) involving, for instance, weights, the imputation of missing data, and the aggregation formula.

This tab simply gathers all the rankings calculated in the previous tabs, combining different normalisation and aggregation methods.

A median rank across all scenaria together with the rank interval (minimum and maximum rank) is also reported for each unit.

Figure 18. 'Scenaria' tab



Z-scores + 4 Z-scores + 5 Z-scores + 6 Z-scores + 7 Z-scores + 8 Z-scores + 9 minmax * 0.9 + ımax * 0.9 + ımax * 0.9 + ımax * 0.9 + ımax * 0.9 + ımax * 0.9 + 0.5

RANKS	Arithmetic New rank	Arithmetic Equal rank	Arithmetic Random rank	Geometric New rank	Geometric Equal rank	Geometric Random rank	Arithmetic New rank	Arithmetic Equal rank	Arithmetic Random rank	Geometric New rank	Geometric Equal rank	Geometric Random rank	Median rank	Average rank (sum of ranks) rank	Borda (equal weights) rank	Borda (weighted) rank	Copeland Rank	Across all scenaria Median	Across all scenaria Interval
CHE	2	2	1	2	2	2	2	2	2	2	2	2	5	7	6	7	7	2	[1, 7]
SWE	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	2	3	[2, 3]
GBR	11	11	11	11	11	11	11	11	11	11	11	11	14	13	12	8	11	11	[8, 14]
NLD	9	9	9	9	9	9	9	9	9	9	9	9	8	9	9	11	17	9	[8, 17]
USA	8	8	7	8	8	8	8	8	8	8	8	8	23	20	20	20	8	8	[7, 23]
FIN	1	1	2	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	[1, 2]
HKG	12	12	12	12	12	12	21	21	20	25	25	24	17	10	13	15	10	13	[10, 25]
SGP	15	15	16	15	15	15	14	14	14	20	20	18	3	2	1	2	18	15	[1, 20]
DNK	4	4	5	4	4	5	5	5	5	5	5	5	4	6	7	5	4	5	[4, 7]
IRL	17	17	19	18	18	18	16	16	15	17	17	17	21	18	17	13	12	17	[12, 21]
CAN	19	19	20	19	19	20	20	20	19	18	18	20	14	11	8	9	19	19	[8, 20]
LUX	26	26	27	26	26	27	26	26	26	26	26	26	11	22	21	23	22	26	[11, 27]
ISL	10	10	10	10	10	10	10	10	10	10	10	10	14	16	16	18	5	10	[5, 18]
ISR	22	22	21	21	21	21	19	19	21	15	15	15	24	23	23	22	20	21	[15, 24]
DEU	7	7	8	6	6	7	7	7	7	7	7	7	10	8	10	10	5	7	[5, 10]
NOR	13	13	14	14	14	14	13	13	13	13	13	13	5	4	4	4	16	13	[4, 16]
NZL	14	14	13	13	13	13	12	12	12	12	12	12	9	12	11	12	8	12	[8, 14]
KOR	5	5	4	5	5	4	4	4	4	4	4	4	7	5	5	6	1	4	[1, 7]
AUS	21	21	22	20	20	22	17	17	17	19	19	19	11	14	14	14	13	19	[11, 22]
FRA	18	18	17	17	17	16	18	18	18	16	16	16	19	17	18	19	21	18	[16, 21]
BEL	23	23	23	22	22	23	23	23	22	21	21	21	18	21	22	21	22	22	[18, 23]
JPN	6	6	6	7	7	6	6	6	6	6	6	6	19	19	19	17	13	6	[6, 19]
AUT	16	16	18	16	16	17	15	15	16	14	14	14	11	15	15	16	13	15	[11, 18]
MLT	46	46	45	45	45	45	46	46	46	46	46	45	43	42	40	37	46	45	[37, 46]
EST	28	28	28	28	28	28	27	27	27	27	27	27	22	24	24	27	28	27	[22, 28]
ESP	24	24	25	24	24	25	25	25	25	24	24	25	25	25	25	24	24	25	[24, 25]
CYP	30	30	32	30	30	33	30	30	30	33	33	31	36	34	33	32	29	31	[29, 36]
CZE	34	34	34	34	34	34	31	31	31	34	34	34	27	28	29	30	25	34	[25, 34]
ITA	27	27	26	27	27	26	28	28	28	28	28	28	31	30	32	29	29	28	[26, 32]
SVN	25	25	24	25	25	24	24	24	24	23	23	23	26	26	26	26	27	25	[23, 27]
HUN	39	39	40	39	39	40	39	39	39	39	39	39	28	36	36	34	34	39	[28, 40]
MYS	38	38	39	38	38	39	38	38	38	40	40	40	36	33	35	36	34	38	[33, 40]
LVA	42	42	43	42	42	43	42	42	42	42	42	41	39	40	38	42	45	42	[38, 45]
PRT	29	29	30	29	29	31	29	29	29	32	32	30	30	27	28	25	26	29	[25, 32]
CHN	20	20	15	23	23	19	22	22	23	22	22	22	49	43	41	38	38	22	[15, 49]
SVK	41	41	42	41	41	42	41	41	41	43	43	42	39	41	43	44	34	41	[34, 44]
HRV	33	33	31	33	33	30	33	33	33	30	30	32	41	39	42	39	39	33	[30, 42]
ARE	44	44	48	47	47	48	43	43	43	49	49	49	32	29	27	28	32	44	[27, 49]
CRI	50	50	50	50	50	50	50	50	50	50	50	50	48	50	50	50	50	50	[48, 50]
LTU	37	37	37	37	37	37	36	36	35	37	37	37	32	35	34	35	33	37	[32, 37]
BGR	40	40	38	40	40	38	40	40	40	38	38	38	45	44	45	46	44	40	[38, 46]

Source: JRC, 2017.

4 Advanced features

4.1 Imputation of missing data

A composite indicator might be computed with no imputation of missing data; however the imputation of missing data is highly recommended to undertake a statistical audit of the composite indicator, in particular to assess the robustness of results and their sensitivity of results to modelling choices. Usually the latest available data point within a specified period is used for the imputation of missing data. The period used should be relatively short, ideally less than 5 years.

4.2 Shadow imputation

The non-imputation of missing data is equivalent to assigning the sub-pillar score value to the particular indicator (or the pillar score if the sub-pillar score is not available either). In order to work with a complete dataset for the assessment of robustness of rankings, this tab performs a fake imputation of missing data by replacing missing values by the score of the unit on the respective sub-pillar or, if not available, in the respective pillar (these come from the scores computed with the adjusted weights). The values that differ from the values in the original dataset are detected in green (concerns missing data and outliers).

Figure 19. 'MinmaxfakeImp' tab

FAKE IMPUTATION OF DATA - MIN-MAX NORMALIZATION - WEIGHTED ARITHMETIC AVERAGES - ADJUSTED WEIGHTS - OUTLIER FREE DATASET
(with sub-pillar or pillar score)

		p.01	p.01	p.01	p.01	p.01	p.01	p.01	p.01	p.01	p.02	p.02	p.02	p.02	p.02	p.02	p.02	p.02	p.02	p.02	p.02	p.02	p.03	p.03	p.03	p.03	p.03	p.03	p.03
		sp.01	sp.01	sp.01	sp.02	sp.02	sp.02	sp.03	sp.03	sp.03	sp.04	sp.04	sp.04	sp.04	sp.04	sp.05	sp.05	sp.05	sp.05	sp.06	sp.06	sp.06	sp.07	sp.07	sp.07	sp.07	sp.08	sp.08	sp.08
		ind.01	ind.02	ind.03	ind.04	ind.05	ind.06	ind.07	ind.08	ind.09	ind.10	ind.11	ind.12	ind.13	ind.14	ind.15	ind.16	ind.17	ind.18	ind.19	ind.20	ind.21	ind.22	ind.23	ind.24	ind.25	ind.26	ind.27	ind.28
CHE	unit.001	0.97	0.87	0.05	0.86	0.92	0.08	0.58	0.36	0.72	0.42	0.40	0.49	0.71	0.50	0.48	0.33	0.37	0.19	0.46	0.65	0.84	0.94	0.95	0.48	0.32	0.29	0.31	0.82
SWE	unit.002	0.96	0.90	0.04	0.96	0.99	0.25	0.78	0.74	0.52	0.70	0.53	0.53	0.60	0.21	0.68	0.55	0.16	0.19	0.59	0.76	0.67	0.86	0.86	0.75	0.68	0.62	0.59	0.84
GBR	unit.003	0.62	0.75	0.16	0.85	0.88	0.01	0.65	0.94	0.73	0.46	0.34	0.62	0.62	0.51	0.53	0.43	0.38	0.03	0.48	0.39	1.00	0.86	0.83	0.96	0.92	0.20	0.20	0.87
NLD	unit.004	0.90	0.84	0.00	0.96	0.94	0.03	0.67	0.94	0.63	0.55	0.35	0.66	0.72	0.47	0.59	0.10	0.10	0.09	0.30	0.45	0.71	0.83	0.76	0.94	1.00	0.23	0.27	0.94
USA	unit.005	0.68	0.70	0.18	0.79	0.85	-	0.70	0.84	0.46	0.48	0.20	0.63	0.61	0.47	0.91	0.16	0.08	-	0.81	0.62	1.00	0.66	0.57	1.00	0.92	0.52	0.54	0.89
FIN	unit.006	1.00	1.00	-	0.93	1.00	0.08	0.80	0.96	0.68	0.63	0.47	0.65	0.84	0.20	0.90	0.81	0.11	0.17	0.81	0.86	0.56	0.71	0.63	0.81	0.73	0.52	0.66	0.96
HKG	unit.007	0.84	0.81	0.30	0.97	0.83	-	0.87	0.84	0.94	0.14	0.11	0.50	0.85	0.73	0.54	0.92	0.16	0.59	0.25	0.16	0.85	1.00	1.00	1.00	1.00	0.18	0.22	0.99
SGP	unit.008	0.94	0.97	0.56	0.95	0.89	-	0.88	0.98	0.91	0.16	0.51	0.51	0.83	0.55	0.49	0.49	0.49	0.49	0.55	0.47	0.56	0.84	0.83	1.00	0.95	0.32	0.32	1.00
DNK	unit.009	0.90	0.97	0.01	1.00	0.98	-	0.77	0.92	0.79	0.89	0.65	0.18	0.62	0.58	0.69	0.31	0.18	0.12	0.75	0.70	0.69	0.84	0.80	0.77	0.54	0.21	0.22	0.94
IRL	unit.010	0.86	0.71	0.06	0.87	0.92	-	0.78	0.93	0.87	0.74	0.74	0.87	0.61	0.74	0.60	0.47	0.16	0.54	0.36	0.39	0.61	0.69	0.60	0.26	0.11	0.20	0.21	0.66
CAN	unit.011	0.87	0.86	0.09	0.88	0.92	0.08	0.97	0.97	0.81	0.40	0.52	0.52	0.75	0.39	0.15	0.15	0.15	0.15	0.63	0.39	0.87	0.67	0.57	0.82	0.68	0.71	0.64	0.84
LUX	unit.012	0.98	0.82	0.00	0.97	0.94	0.53	0.58	0.30	0.71	0.29	0.29	0.21	0.53	0.13	-	0.84	1.00	1.00	0.45	0.31	-	0.93	0.94	0.52	0.38	0.17	0.65	0.83
ISL	unit.013	0.94	0.76	0.03	0.57	0.89	0.08	0.73	0.89	0.46	1.00	0.36	0.86	0.63	0.37	0.73	0.17	0.11	1.00	1.00	0.59	-	0.92	0.90	0.27	0.14	1.00	1.00	0.59
ISR	unit.014	-	0.63	0.40	0.73	0.60	0.75	0.65	0.33	0.34	0.54	0.12	0.49	0.42	0.21	0.56	0.37	0.37	0.18	0.76	1.00	0.52	0.63	0.52	0.76	0.89	0.27	0.26	0.60
DEU	unit.015	0.81	0.75	0.06	0.80	0.86	0.52	0.47	0.79	0.45	0.42	0.50	0.50	0.67	0.42	0.36	0.56	0.36	0.15	0.45	0.64	0.76	0.89	0.86	0.60	0.76	0.26	0.27	0.94
NOR	unit.016	0.99	0.83	0.00	0.76	0.97	0.03	0.73	0.97	0.72	0.67	0.42	0.72	0.62	0.61	0.69	0.18	0.16	0.36	0.70	0.37	0.54	0.82	0.72	0.77	0.68	1.00	1.00	0.75
NZL	unit.017	0.99	0.89	0.03	0.99	0.98	-	1.00	0.86	0.71	0.75	0.28	1.00	0.74	0.52	0.78	0.30	0.34	0.10	0.48	0.28	0.59	0.69	0.58	0.66	0.57	0.37	0.37	0.61
KOR	unit.018	0.57	0.64	0.27	0.54	0.61	0.75	0.70	0.84	0.67	0.34	0.22	0.68	0.82	0.72	1.00	0.77	0.04	0.32	0.80	0.85	0.74	0.82	0.76	1.00	1.00	0.39	0.41	0.76
AUS	unit.019	0.81	0.82	0.13	0.93	0.93	0.13	0.94	0.83	0.52	0.42	0.12	0.99	0.72	0.56	0.75	0.21	0.51	0.03	0.69	0.53	0.85	0.70	0.61	0.78	0.76	0.38	0.39	0.78
FRA	unit.020	0.71	0.69	0.23	0.62	0.81	0.15	0.75	0.37	0.30	0.48	0.34	0.56	0.61	0.40	0.50	0.58	0.28	0.10	0.39	0.50	0.75	0.75	0.68	0.80	0.57	0.31	0.28	0.84
BEL	unit.021	0.81	0.79	0.10	0.68	0.79	-	0.83	0.94	0.33	0.64	0.46	0.59	0.67	-	0.65	0.19	0.19	0.13	0.40	0.45	0.63	0.71	0.62	0.44	0.11	0.29	0.31	0.92
JPN	unit.022	0.85	0.68	0.28	0.52	0.72	-	0.46	1.00	0.20	0.45	0.24	0.44	0.77	0.35	0.53	0.36	0.08	0.03	0.54	0.74	0.83	0.72	0.66	0.78	0.73	0.30	0.31	0.89
AUT	unit.023	0.93	0.79	0.05	0.76	0.94	-	0.39	0.87	0.36	0.56	0.46	0.48	0.56	0.23	0.62	0.69	0.47	0.19	0.54	0.63	0.46	0.74	0.66	0.59	0.35	0.26	0.33	0.87
MLT	unit.024	0.86	0.62	0.25	0.71	0.75	-	0.19	0.24	0.63	0.54	0.39	0.41	0.40	0.18	0.27	0.19	0.00	0.31	0.17	0.13	-	0.74	0.68	0.39	0.24	0.17	0.14	0.46
EST	unit.025	0.70	0.63	0.04	0.75	0.68	0.19	0.71	0.23	0.31	0.50	0.39	0.53	0.69	0.15	0.58	0.36	0.04	0.29	0.42	0.53	0.08	0.61	0.52	0.72	0.76	0.35	0.23	0.29
ESP	unit.026	0.53	0.57	0.21	0.61	0.69	0.36	0.31	0.77	0.62	0.39	0.30	0.64	0.55	0.28	0.73	0.54	0.07	0.06	0.37	0.29	0.51	0.59	0.48	0.61	0.49	0.21	0.22	0.76
CYP	unit.027	0.69	0.75	0.11	0.67	0.63	-	0.64	0.69	0.54	0.71	0.72	0.27	0.48	0.21	0.41	0.07	0.77	1.00	0.12	0.10	-	0.46	0.30	0.30	0.05	0.23	0.24	0.51
CZE	unit.028	0.90	0.57	0.06	0.68	0.61	0.47	0.38	0.48	0.19	0.32	0.22	0.51	0.58	0.29	0.57	0.47	0.19	0.12	0.33	0.41	0.29	0.47	0.31	0.27	0.24	0.29	0.23	0.45
ITA	unit.029	0.70	0.36	0.30	0.45	0.36	-	0.63	0.58	-	0.37	0.33	0.55	0.55	0.23	0.59	0.30	0.08	0.10	0.19	0.27	0.47	0.59	0.47	0.32	0.24	0.16	0.19	0.74
SVN	unit.030	0.80	0.55	0.21	0.39	0.63	0.13	0.85	0.39	0.53	0.50	0.42	0.66	0.62	0.04	0.85	0.38	0.03	0.14	0.41	0.56	0.07	0.62	0.52	0.47	0.19	0.27	0.25	0.53
HUN	unit.031	0.76	0.46	0.30	0.59	0.51	0.21	0.77	0.23	0.28	0.44	0.30	0.46	0.60	0.24	0.54	0.17	0.09	0.09	0.27	0.26	0.22	0.46	0.31	0.50	0.43	0.11	0.13	0.47
MYS	unit.032	0.54	0.56	0.55	0.40	0.40	0.61	0.81	0.32	0.75	0.36	0.12	0.10	0.20	0.47	0.34	1.00	0.14	0.16	0.05	0.13	0.45	0.34	0.20	0.67	0.49	0.14	0.14	0.64
LVA	unit.033	0.59	0.45	0.25	0.54	0.52	0.06	0.74	0.53	0.55	0.34	0.32	0.34	0.56	0.12	0.51	0.17	0.04	0.21	0.21	0.12	-	0.40	0.24	0.34	0.19	0.08	0.09	0.25
PRT	unit.034	0.75	0.55	0.16	0.40	0.61	1.00	0.75	0.74	0.44	0.55	0.46	0.55	0.57	0.05	0.59	0.53	0.06	0.16	0.69	0.33	0.32	0.55	0.45	0.45	0.35	0.16	0.17	0.65
CHN	unit.035	0.22	0.25	1.00	-	-	0.75	0.03	0.19	0.09	0.52	0.52	0.00	1.00	0.56	0.18	0.07	-	0.02	0.10	0.39	0.76	-	-	0.25	0.19	0.09	0.08	0.66
SVK	unit.036	0.84	0.51	0.10	0.58	0.46	0.14	0.60	0.44	0.29	0.31	0.11	0.37	0.56	0.36	0.48	0.37	0.08	0.58	0.34	0.14	-	0.43	0.24	0.21	0.11	0.15	0.17	0.39
HRV	unit.037	0.68	0.40	0.30	0.36	0.26	0.28	0.64	0.11	0.54	0.34	0.30	0.29	0.50	0.11	0.47	0.34	0.01	0.19	0.21	0.15	0.07	0.50	0.35	0.43	0.27	0.09	0.12	0.46
ARE	unit.038	0.84	0.54	0.41	0.28	0.38	-	0.67	0.10	1.00	0.32	0.32	0.32	0.28	0.36	0.52	0.52	0.92	0.14	0.29	0.29	0.29	0.54	0.36	0.78	0.73	0.49	0.45	0.81
CRI	unit.039	0.71	0.33	0.09	0.31	0.38	0.41	-	-	0.14	0.61	0.10	0.21	0.27	0.55	0.35	-	0.03	0.02	0.05	0.11	-	0.23	0.08	0.20	0.30	0.04	0.04	0.23
LTU	unit.040	0.72	0.45	0.18	0.54	0.51	0.64	0.51	0.41	0.50	0.49	0.27	0.46	0.52	0.13	0.64	0.40	0.03	0.25	0.31	0.17	0.16	0.49	0.32	0.52	0.51	0.02	0.10	0.34
BGR	unit.041	0.60	0.21	0.33	0.36	0.15	-	0.73	0.13	0.34	0.36	0.37	0.27	0.29	0.36	0.50	0.33	0.08	0.38	0.15	0.12	-	0.36	0.21	0.19	-	0.21	0.15	0.49
SAU	unit.042	0.37	0.05	0.76	0.10	0.22	0.44	0.43	0.08	0.95	0.24	0.18	0.23	0.24	0.31	0.33	0.91	0.08	0.12	-	-	0.45	0.49	0.34	0.68	0.62	0.31	0.31	0.47

MinMax | Dataz | Dataranks | Borda | Outranking Matrix | Copeland | Scenaria | MinmaxFakeImp | DatazFake

Source: JRC, 2017.

Figure 20. 'DatazfakeImp' tab

FAKE IMPUTATION OF DATA - Z-SCORE NORMALIZATION - WEIGHTED ARITHMETIC AVERAGES - ADJUSTED WEIGHTS - OUTLIER FREE DATASET
(with sub-pillar or pillar score)

		p.01	p.01	p.01	p.01	p.01	p.01	p.01	p.01	p.01	p.02	p.02	p.02	p.02	p.02
		sp.01	sp.01	sp.01	sp.02	sp.02	sp.02	sp.03	sp.03	sp.03	sp.04	sp.04	sp.04	sp.04	sp.04
		ind.01	ind.02	ind.03	ind.04	ind.05	ind.06	ind.07	ind.08	ind.09	ind.10	ind.11	ind.12	ind.13	ind.14
CHE	unit.001	6.06	6.10	4.18	5.92	6.00	4.39	4.81	4.40	5.76	4.70	5.42	5.07	5.70	5.22
SWE	unit.002	6.01	6.20	4.12	6.26	6.28	4.98	5.70	5.60	5.01	6.01	6.08	5.25	5.20	4.37
GBR	unit.003	4.38	5.61	4.70	5.89	5.86	4.16	5.13	6.21	5.80	4.89	5.07	5.66	5.30	5.84
NLD	unit.004	5.75	5.96	3.92	6.28	6.09	4.20	5.23	6.22	5.43	5.59	5.13	5.84	5.74	5.67
USA	unit.005	4.68	5.41	4.80	5.67	5.75	4.11	5.32	5.90	4.77	5.24	4.38	5.68	5.22	5.68
FIN	unit.006	6.23	6.62	3.91	6.15	6.30	4.39	5.78	6.26	5.60	5.68	5.77	5.78	6.32	4.35
HKG	unit.007	5.45	5.83	5.39	6.33	5.66	4.11	6.13	5.89	6.61	3.33	3.88	5.13	6.37	6.97
SGP	unit.008	5.91	6.49	6.68	6.24	5.90	4.11	6.14	6.33	6.49	3.43	5.26	5.26	6.31	6.05
DNK	unit.009	5.73	6.51	3.96	6.42	6.23	4.11	5.67	6.15	6.03	6.93	6.69	3.73	5.28	5.66
IRL	unit.010	5.52	5.43	4.19	5.94	6.02	4.11	5.71	6.17	6.35	6.23	6.07	6.75	5.23	6.07
CAN	unit.011	5.60	6.04	4.38	6.00	5.99	4.38	6.58	6.31	6.13	4.60	5.27	5.27	5.92	5.29
LUX	unit.012	6.13	5.88	3.93	6.31	6.07	5.96	4.81	4.23	5.72	4.24	4.24	3.86	4.87	3.98
ISL	unit.013	5.94	5.64	4.07	4.87	5.89	4.39	5.50	6.05	4.79	7.48	5.18	6.67	5.32	5.15
ISR	unit.014	1.33	5.12	5.90	5.43	4.83	6.75	5.11	4.34	4.32	5.26	3.95	5.09	4.33	4.39
DEU	unit.015	5.28	5.59	4.20	5.71	5.78	5.95	4.30	5.75	4.73	4.67	5.21	5.21	5.54	5.40
NOR	unit.016	6.17	5.92	3.92	5.55	6.19	4.20	5.50	6.31	5.77	5.87	5.53	6.08	5.31	5.70
NZL	unit.017	6.17	6.16	4.06	6.39	6.22	4.11	6.70	5.97	5.72	6.27	4.80	7.30	5.86	5.92
KOR	unit.018	4.13	5.16	5.27	4.77	4.87	6.74	5.33	5.91	5.58	4.28	4.45	5.90	6.26	6.92
AUS	unit.019	5.29	5.89	4.57	6.18	6.03	4.56	6.41	5.87	5.02	4.69	3.93	7.27	5.74	5.41
FRA	unit.020	4.82	5.35	5.05	5.03	5.60	4.63	5.55	4.44	4.14	4.98	5.10	5.41	5.23	5.33
BEL	unit.021	5.31	5.78	4.40	5.27	5.53	4.11	5.93	6.22	4.26	5.76	5.71	5.53	5.52	3.35
JPN	unit.022	5.48	5.32	5.32	4.67	5.27	4.11	4.27	6.40	3.78	5.12	4.57	4.87	5.99	5.08
AUT	unit.023	5.87	5.77	4.14	5.55	6.07	4.11	3.93	5.98	4.40	5.35	5.73	5.04	4.99	4.46
MLT	unit.024	5.52	5.06	5.18	5.37	5.38	4.11	3.03	4.04	5.44	5.25	5.33	4.76	4.26	4.21
EST	unit.025	4.78	5.12	4.13	5.52	5.12	4.77	5.40	4.01	4.22	5.05	5.35	5.27	5.62	4.07
ESP	unit.026	3.94	4.86	4.97	5.00	5.16	5.38	3.59	5.68	5.38	4.52	4.90	5.73	4.93	4.73
CYP	unit.027	4.69	5.59	4.47	5.22	4.95	4.11	5.09	5.43	5.09	6.06	7.07	4.15	5.42	4.39
CZE	unit.028	5.74	4.85	4.20	5.27	4.88	5.77	3.90	4.79	3.74	4.22	4.44	5.17	5.08	4.78
ITA	unit.029	4.77	4.03	5.39	4.43	3.98	4.11	5.02	5.10	3.01	4.44	5.04	5.34	4.97	4.50
SVN	unit.030	5.24	4.80	4.97	4.22	4.97	4.57	6.04	4.50	5.04	5.07	5.53	5.83	5.27	3.56
HUN	unit.031	5.07	4.40	5.39	4.92	4.52	4.84	5.66	4.02	4.09	4.76	4.91	4.96	5.20	4.53
MYS	unit.032	3.98	4.82	6.63	4.27	4.14	6.27	5.83	4.28	5.88	4.41	3.92	3.37	3.28	5.67
LVA	unit.033	4.24	4.37	5.15	4.77	4.56	4.33	5.51	4.94	5.11	4.59	5.00	4.45	4.99	3.93
PRT	unit.034	4.98	4.79	4.69	4.26	4.88	7.62	5.58	5.60	4.70	5.29	5.70	5.36	5.06	3.61
CHN	unit.035	2.42	3.56	8.90	2.81	2.67	6.74	2.31	3.89	3.34	5.40	5.40	2.97	7.10	6.13
SVK	unit.036	5.46	4.62	4.43	4.90	4.33	4.59	4.90	4.67	4.13	4.17	3.90	4.55	5.02	5.12
HRV	unit.037	4.68	4.18	5.42	4.10	3.63	5.07	5.06	3.64	5.08	4.28	4.86	4.21	4.69	3.87
ARE	unit.038	5.45	4.76	5.94	3.83	4.06	4.11	5.20	3.61	6.85	4.40	4.40	4.40	3.67	5.13
CRI	unit.039	4.80	3.89	4.34	3.91	4.05	5.56	2.18	3.30	3.53	5.62	3.84	3.88	3.61	6.05
LTU	unit.040	4.85	4.37	4.80	4.75	4.51	6.36	4.48	4.56	4.93	5.04	4.73	4.96	4.81	4.00
BGR	unit.041	4.26	3.40	5.57	4.10	3.22	4.11	5.47	3.71	4.32	4.38	5.23	4.14	3.72	5.14
SAU	unit.042	3.15	2.77	7.69	3.16	3.46	5.66	4.12	3.55	6.64	4.37	4.24	3.98	4.37	4.89

		p.02	p.02	p.02	p.02	p.02	p.02	p.02	p.03	p.03	p.03	p.03	p.03	p.03	p.03
		sp.05	sp.05	sp.05	sp.05	sp.06	sp.06	sp.06	sp.07	sp.07	sp.07	sp.07	sp.08	sp.08	sp.08
		ind.15	ind.16	ind.17	ind.18	ind.19	ind.20	ind.21	ind.22	ind.23	ind.24	ind.25	ind.26	ind.27	ind.28
CHE	unit.001	4.71	4.69	5.60	4.75	5.50	6.08	6.33	6.50	6.69	4.76	4.54	4.96	5.02	5.73
SWE	unit.002	5.67	5.57	4.82	4.76	6.06	6.55	5.82	6.15	6.33	5.80	5.74	6.42	6.25	5.84
GBR	unit.003	4.96	5.09	5.63	4.11	5.60	5.07	6.83	6.12	6.23	6.61	6.58	4.55	4.53	5.95
NLD	unit.004	5.24	3.78	4.57	4.34	4.80	5.32	5.95	6.01	5.97	6.53	6.86	4.72	4.82	6.22
USA	unit.005	6.73	4.01	4.48	4.00	6.41	5.99	6.83	5.25	5.22	6.77	6.58	5.98	6.01	6.02
FIN	unit.006	6.67	6.58	4.60	4.68	6.98	6.93	5.48	5.46	5.45	6.04	5.93	5.97	6.52	6.28
HKG	unit.007	4.99	7.03	4.79	6.37	4.60	4.16	6.36	6.79	6.89	6.84	6.84	4.48	4.61	6.44
SGP	unit.008	6.05	6.05	6.05	6.05	5.86	5.36	5.48	6.04	6.23	6.77	6.67	5.11	5.07	6.46
DNK	unit.009	5.70	4.62	4.87	4.47	6.73	6.29	5.88	6.03	6.11	5.88	5.28	4.64	4.63	6.22
IRL	unit.010	5.28	5.23	4.82	6.17	5.07	5.05	5.64	5.38	5.33	3.92	3.80	4.59	4.55	5.11
CAN	unit.011	4.59	4.59	4.59	4.59	5.74	5.04	6.44	5.28	5.22	6.08	5.74	6.82	6.46	5.84
LUX	unit.012	2.47	6.70	8.02	7.99	5.46	4.75	3.78	6.48	6.66	4.92	4.72	4.43	6.50	5.77
ISL	unit.013	5.91	4.04	4.63	7.99	7.77	5.88	3.78	6.43	6.50	3.96	3.89	8.10	8.01	4.82
ISR	unit.014	5.10	4.91	4.91	4.73	6.42	7.49	5.36	5.11	5.03	5.84	6.48	4.89	4.78	4.86
DEU	unit.015	5.11	5.60	5.11	4.62	5.44	6.06	6.09	6.30	6.36	5.24	6.02	4.85	4.85	6.24
NOR	unit.016	5.70	4.09	4.82	5.44	6.50	4.97	5.43	5.96	5.81	5.88	5.74	8.10	8.01	5.46
NZL	unit.017	6.11	4.56	5.49	4.41	5.59	4.63	5.58	5.35	5.26	5.44	5.37	5.32	5.28	4.88
KOR	unit.018	7.15	6.43	4.34	5.26	6.47	6.88	6.05	5.97	5.96	6.77	6.86	5.40	5.44	5.51
AUS	unit.019	5.98	4.20	6.15	4.14	6.00	5.63	6.37	5.40	5.37	5.92	6.02	5.38	5.36	5.57
FRA	unit.020	4.80	5.68	5.25	4.39	5.18	5.51	6.06	5.63	5.66	6.00	5.37	5.05	4.86	5.84
BEL	unit.021	5.51	4.12	4.93	4.51	5.23	5.32	5.69	5.45	5.43	4.60	3.80	4.96	5.01	6.13
JPN	unit.022	4.96	4.80	4.51	4.13	5.82	6.44	6.30	5.53	5.56	5.92	5.93	4.99	5.00	6.02
AUT	unit.023	5.39	6.13	5.99	4.75	5.83	6.01	5.17	5.59	5.57	5.20	4.63	4.84	5.09	5.93
MLT	unit.024	3.72	4.12	4.20	5.25	4.28	4.01	3.78	5.61	5.63	4.40	4.26	4.44	4.27	4.31
EST	unit.025	5.19	4.81	4.34	5.16	5.34	5.63	4.04	4.98	5.00	5.68	6.02	5.24	4.66	3.64
ESP	unit.026	5.89	5.52	4.45	4.25	5.11	4.66	5.34	4.91	4.85	5.28	5.09	4.64	4.61	5.51
CYP	unit.027	4.38	3.67	7.14	7.99	4.04	3.89	3.78	4.31	4.17	4.08	3.61	4.72	4.70	4.48
CZE	unit.028	5.15	5.26	4.91	4.48	4.95	5.13	4.68	4.38	4.19	3.96	4.26	4.99	4.67	4.26
ITA	unit.029	5.22	4.58	4.50	4.40	4.34	4.59	5.22	4.90	4.84	4.16	4.26	4.40	4.50	5.44
SVN	unit.030	6.47	4.90	4.33	4.57	5.30	5.75	4.00	5.06	5.03	4.72	4.08	4.90	4.76	4.60
HUN	unit.031	5.00	4.04	4.54	4.34	4.70	4.53	4.47	4.33	4.19	4.84	4.91	4.17	4.22	4.33
MYS	unit.032	4.08	7.34	4.74	4.65	3.77	4.02	5.15	3.76	3.78	5.48	5.09	4.31	4.25	5.04
LVA	unit.033	4.84	4.05	4.35	4.84	4.44	3.99	3.78	4.02	3.91	4.24	4.08	4.05	4.04	3.46
PRT	unit.034	5.25	5.49	4.44	4.66	6.45	4.81	4.75	4.75	4.73	4.64	4.63	4.38	4.38	5.06
CHN	unit.035	3.29	3.86	4.20	4.08	3.96	5.06	6.09	2.21	2.99	3.88	4.08	4.07	4.03	5.11
SVK	unit.036	4.71	4.85	4.49	6.33	5.00	4.06	3.78	4.19	3.94	3.72	3.80	4.36	4.38	4.02
HRV	unit.037	4.68	4.74	4.22	4.76	4.43	4.10	4.00	4.50	4.34	4.56	4.35	4.08	4.19	4.31
ARE	unit.038	5.89	5.42	7.72	4.54	4.68	4.68	4.68	4.70	4.41	5.92	5.93	5.84	5.60	5.68
CRI	unit.039	4.11	3.38	4.31	4.07	3.79	3.93	3.78	3.25	3.29	3.68	4.45	3.88	3.81	3.40
LTU	unit.040	5.45	4.95	4.32	5.02	4.88	4.17	4.27	4.45	4.25	4.92	5.19	3.79	4.08	3.84
BGR	unit.041	4.81	4.70	4.50	5.53	4.17	3.98	3.78	3.88	3.82	3.64	3.43	4.61	4.32	4.42
SAU	unit.042	4.02	6.98	4.49	4.47	3.56	3.51	5.15	4.47	4.33	5.52	5.56	5.08	5.00	4.35

ataz | Dataranks | Borda | Outranking Matrix | Copeland | Scenaria | MinmaxFakeImp | DatazFakeImp

Source: JRC, 2017.

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