European Innovation Scoreboard: new theoretical advances and visualization tools.

By Stefano Tarantola (JRC) June 12, 2008

DRAFT for comments

Introduction

Recently, the JRC has been working on theoretical advances for composite indicators building [1]. These advances concern the weighting procedure, probably one of the most delicate and controversial phases of the process. In the ambit of the FP6 project 'Knowledge Economy Indicators', with the Katholieke University of Leuven, the *endogenous weighting procedure* has been implemented and tested. We review the approach in Section 1 and we give an example using the 2007 EIS dataset.

Another methodological advance in indicators' aggregation is the *multi-criteria procedure* [1], which tries to resolve the conflict arising in country comparisons as some indicators are in favour of one country while other indicators are in favour of another. This conflict can be treated in the light of a non-compensatory logic and taking into account the absence of preference independence within a discrete multi-criteria approach [2]. In Section 2 we review the approach and we give an example using the 2007 EIS dataset.

A number of visualization tools are available in [1]. A proper visualization of the results is indispensable to communicate the information appropriately and transparently and affects both relevance and interpretability of the results. In section 3 we provide presentational material from [1] and from additional sources that can help improving the way the SII results are presented.

The report is an overview of approaches and tools that are in principle applicable to any given dataset. The report is not a feasibility study of a specific technique to the EIS dataset, for which more detailed analyses would be required given the constraints dictated by the quality of the dataset, including the presence of missing values.

1 *Endogenous weighting*

The *endogenous weighting* procedure identifies, for a given country, the set of weights that maximizes the composite indicator with respect to the best performing country under the same set of weights. The same procedure is followed for each country. Weights are therefore country-dependent. In general, even using the best combination of weights for a given country, other countries may show better performance. Without any further constraint the optimization would lead to just one non-zero weight. Further bounding restrictions are therefore imposed on the weights to make the approach of practical use; for example all weights can be constrained so as to have values between 75% and 125% their nominal values in a equal weighting approach.

This approach rewards country's revealed preference (benefit of the doubt), thus making more difficult for the given country to complain for a poor score.

This procedure is available at the JRC with a user-friendly software. Table 1 provides the country scores obtained by running the endogenous weighting approach on 2007 data to a restricted number of countries (18) and indicators (23, excluding indicators 2.3, 2.5 and 3.4). Due to the presence of missing values some indicators and countries have been eliminated in order to have a full dataset on which to apply the approach. The frontier is represented by Denmark, which has a score of 1. Germany is almost on the frontier, having a score of 0.9996.

EU	0.7957
BE	0.8099
CZ	0.2444
DK	1
DE	0.9996
EE	0
IE	0.7599
EL	0.0844
ES	0.3875
FR	0.8078
IT	0.6086
LT	0.0356
LU	0.752
HU	0.232
NL	0.8721
PL	0.0603
PT	0.1103
SK	0.012

Table 1: Country scores resulting from applying the endogenous weighting approach on 2007 data to a restricted set of countries and indicators.

These scores can not be directly compared to the standard SII scores as they are, by definition, pushed up towards the frontier by the optimisation procedure. Of course, it is possible to compare the country rankings.

2 *Multi-criteria aggregation*

The multi-criteria aggregation approach employs a mathematical formulation (Condorcet ranking procedure) to rank in a complete pre-order (i.e. without any incomparability relation) all the countries from the best to the worst, after a pair-wise comparison of countries across the whole set of the available indicators [3].
We offer here a 'hand waiving' description of the method. Imagine we have just three countries, A, B and C, and we want to compare them with one another. We build to this effect an 'outscoring matrix' whose entries e_{ij} tell us how much country *i* does better than country *j*. The entry e_{ij} is in fact the sum of all weights of all indicators for which country *i* does better than country *j*. Likewise, e_{ji} will be the sum of all weights for which the reverse is true. If the two countries do equally well on one variable, its weight is split between e_{ij} and e_{ji}. As a result, $e_{ij} + e_{ji} = 1$, if weights have been correctly normalised. We now write down all permutations of county order (ABC,ACB,BAC,BCA,CAB,CBA) and compute for each of them the ordered sum of the scores, e.g. for ABC we compute $Y = e_{AB} + e_{AC} + e_{BC}$. We do this for all permutations and take as the multi-criteria country ranking the one with the highest total score *Y*. Note that this ordering is only based on the weights, and on the sign of the difference between countries values for a given indicator, the magnitude of the difference being ignored. Hence, to exemplify, a country that does marginally better on many indicators comes out better than a country that does much better on a few ones. In principle, the opposite is true for the endogenous approach. Note that the multi-criteria method is scale-free. Thus, in order to apply the *endogenous* and *equal weighting* methods, the component indicators are normalised across countries. For the *multi-criteria* approach no normalisation is required.

As an example, we calculated the composite indicator using the 2007 data and we compare these results with those of the standard SII published on the EIS. The output rankings are provided in Table 2. The *multi-criteria* approach provides, by definition, only the rankings of the countries. We can note quite large differences in some countries. For example, Canada gains eight positions and Croatia gains ten positions with the *multi-criteria* method, while Iceland loses six places and Luxembourg ten places.

Multi-criteria		Standard SII	
1	SE	SE	0.73
2	IL	CH	0.67
3	JP	FI	0.64
4	CH	IL	0.62
5	FI	DK	0.61
6	DK	JP	0.60
7	US	DE	0.59
8	DE	UK	0.57
9	AT	US	0.55
10	CA	LU	0.53
11	UK	IS	0.50
12	BE	IE	0.49
13	FR	AT	0.48
14	EU	NL	0.48
15	AU	FR	0.47
16	IE	BE	0.47
17	IS	EU	0.45
18	LU	CA	0.44
19	NL	EE	0.37
20	NO	AU	0.36
21	IT	NO	0.36
22	CZ	CZ	0.36
23	ES	SI	0.35
24	HR	IT	0.33
25	EE	CY	0.33
26	SI	ES	0.31
27	PT	MT	0.29
28	MT	LT	0.27
29	LT	HU	0.26
30	HU	EL	0.26
31	PL	PT	0.25
32	SK	SK	0.25
33	LV	PL	0.24
34	CY	HR	0.23
35	TR	BG	0.23
36	EL	LV	0.19
37	BG	RO	0.18
38	RO	TR	0.08

Table 2: Comparison between the *multi-criteria* approach and the standard approach used in the EIS to compute the SII using 2007 data. Many differences in country ranking can be appreciated.

3 *Visualization tools*

The way composite indicators should be presented is not a trivial issue. Composite indicators must be able to communicate the picture to decision-makers and users quickly and accurately. Visual models of these composites must provide signals, in particular, warning signals that flag for decision-makers those areas requiring policy intervention.

Hereafter, we give some interesting ways to display and visualize composite indicators. We accompany each type of visualization by a brief commentary of the pros and cons. We start from the simplest tools and we explore their modifications. We also give reference to the sources that employ these tools.

Tabular format

This is the simplest format whereby, for each country, the composite indicator and its underlying indicators are presented as a table of values. Usually countries are displayed in decreasing ranking order. An example is the Human Development Index of the UNDP (see Figure 1). This is a comprehensive approach to display results, yet not particularly visually appealing. The approach could be adapted to show targeted information for sets of countries grouped, for example, by location, GDP, etc.

1 Human development index

MONITORING HUMAN DEVELOPMENT: ENLARGING PEOPLE'S CHOICES . . .

HDI rank [a]	Life expectancy at birth (years) 2002	Adult literacy rate (% ages 15 and above) 2002 [b]	Combined gross enrolment ratio for primary, secondary and tertiary schools (%) 2001/02 [c]	GDP per capita (PPP US$) 2002	Life expectancy index	Education index	GDP index	Human development index (HDI) value 2002	GDP per capita (PPP US$) rank minus HDI rank [d]
High human development									
1 Norway	78.9	.. [e]	98 [f]	36,600	0.90	0.99	0.99	0.956	1
2 Sweden	80.0	.. [e]	114 [g,h]	26,050	0.92	0.99	0.93	0.946	19
3 Australia	79.1	.. [e]	113 [g,h]	28,260	0.90	0.99	0.94	0.946	9
4 Canada	79.3	.. [e]	95 [f]	29,480	0.90	0.98	0.95	0.943	5
5 Netherlands	78.3	.. [e]	99 [f]	29,100	0.89	0.99	0.95	0.942	6
6 Belgium	78.7	.. [e]	111 [f,g]	27,570	0.90	0.99	0.94	0.942	7
7 Iceland	79.7	.. [e]	90 [f]	29,750	0.91	0.96	0.95	0.941	1
8 United States	77.0	.. [e]	92 [h]	35,750	0.87	0.97	0.98	0.939	-4
9 Japan	81.5	.. [e]	84 [h]	26,940	0.94	0.94	0.93	0.938	6
10 Ireland	76.9	.. [e]	90 [f]	36,360	0.86	0.96	0.98	0.936	-7
11 Switzerland	79.1	.. [e]	88 [f]	30,010	0.90	0.95	0.95	0.936	-4
12 United Kingdom	78.1	.. [e]	113 [f,g]	26,150	0.88	0.99	0.93	0.936	8
13 Finland	77.9	.. [e]	106 [f,g]	26,190	0.88	0.99	0.93	0.935	6
14 Austria	78.5	.. [e]	91 [f]	29,220	0.89	0.96	0.95	0.934	-4
15 Luxembourg	78.3	.. [e]	75 [f,i]	61,190 [j]	0.89	0.91	1.00	0.933	-14
16 France	78.9	.. [e]	91 [f]	26,920	0.90	0.96	0.93	0.932	0
17 Denmark	76.6	.. [e]	96 [f]	30,940	0.86	0.98	0.96	0.932	-12
18 New Zealand	78.2	.. [e]	101 [g,h]	21,740	0.89	0.99	0.90	0.926	6
19 Germany	78.2	.. [e]	88 [h]	27,100	0.89	0.95	0.94	0.925	-5
20 Spain	79.2	97.7 [e,f,k]	92 [h]	21,460	0.90	0.97	0.90	0.922	5
21 Italy	78.7	98.5 [e,f,k]	82 [f]	26,430	0.89	0.93	0.93	0.920	-3
22 Israel	79.1	95.3	92	19,530	0.90	0.94	0.88	0.908	5
23 Hong Kong, China (SAR)	79.9	93.5 [f,k]	72	26,910	0.91	0.86	0.93	0.903	-6
24 Greece	78.2	97.3 [e,f,k]	86 [f]	18,720	0.89	0.95	0.87	0.902	5
25 Singapore	78.0	92.5 [i]	87 [m]	24,040	0.88	0.91	0.92	0.902	-3

Figure 1: Human Development Index as from the Human Development Report 2004 of the UNDP. The top 25 countries, with high human development, are reported here.

Bar charts.

The composite indicator is expressed via a bar chart (see Figure 2). The countries are on the vertical axis, the values of the composite on the horizontal axis. The top bar indicates the average performance of all countries in the world, and enables the reader to identify how a country is performing with regards to the average.

This figure was used in "Sustainable development indicators in your pocket 2004", a publication of the UK government,
(see http://www.sustainable-development.gov.uk/progress/documents/sdiyp04a4.pdf p. 16).

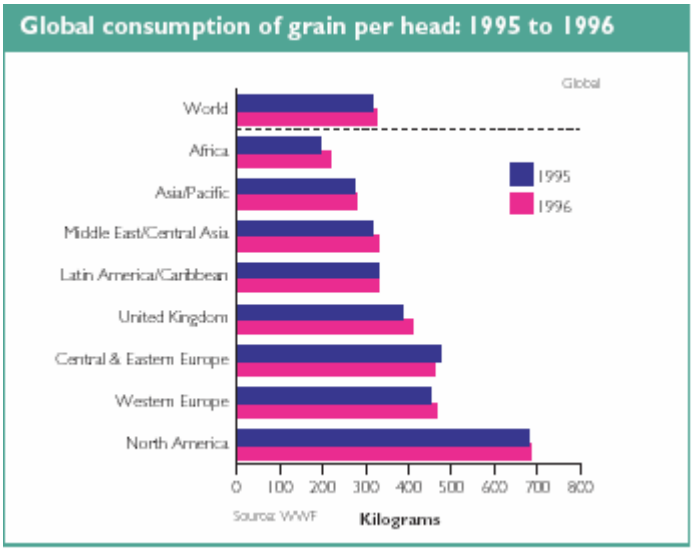


Figure 2: Global consumption of grain per head in two consecutive years.

The tool is clear, easy to understand. Country comparisons can be made with the average performance. Each underlying indicator can also be displayed with a bar chart. The use of colors can make the graph more visually appealing and highlight countries performing well or bad, or showing either growth or slow down, or, finally, to highlight countries having reached an average or mandatory standard. The top bar could alternatively be thought as a target to be reached by countries instead of the current world average. This bar chart shows values at two given points in time.

Line charts

Line charts are used to show performance across time. Performance can be displayed using a) absolute levels; b) absolute growths (in percentage points with respect to the previous year or a number of past years); c) indexed levels and d) indexed growths.

The term 'indexed' means that the values of the indicator are linearly transformed so that their indexed value at a given year is 100. For instance, the indicator called 'Price level index' shows values such that EU15=100 at each year; more expensive countries have values larger than 100, countries cheaper than EU15 have values smaller than 100 (see Figure 3).

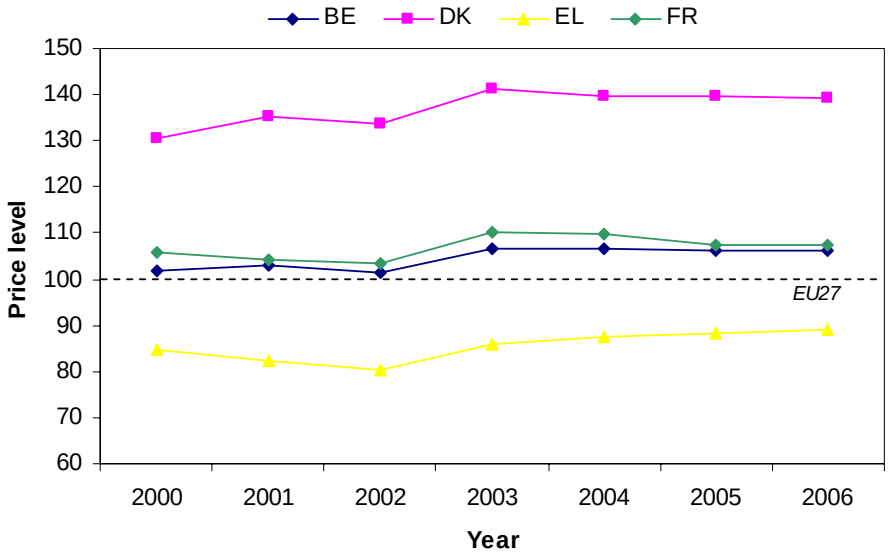


Figure 3: EU price level index. Comparative price levels of final consumption by private households including indirect taxes (EU-27=100). JRC elaboration, data source: Eurostat, 2007. http://ec.europa.eu/eurostat

A number of lines are usually superimposed in the same chart to allow comparisons between countries. Another example is given by the Internal Market Index 2004, published on the Internal Market Scoreboard N. 13 [4]. Here, groups of countries with similar performance (better, similar or worse than the EU) have been displayed in the same chart. All the countries have been indexed to 100 in the starting year (1994). See an example in Figure 4.

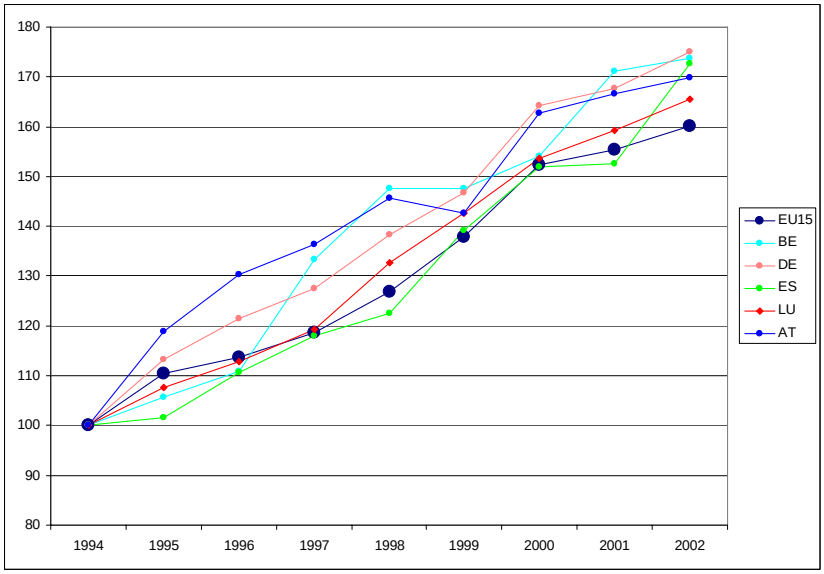


Figure 4: The Internal Market Index for Belgium, Germany, Spain, Luxembourg and Austria improved significantly more than the European average since 1994.

One can also consider a target for the underlying indicators and add it to the plot. The corresponding target for the composite indicator can be computed and displayed in the plot. See an example in Figure 5 taken from [5]. See also:

http://www.icsu-scope.org/downloadpubs/scope58/box4b.html

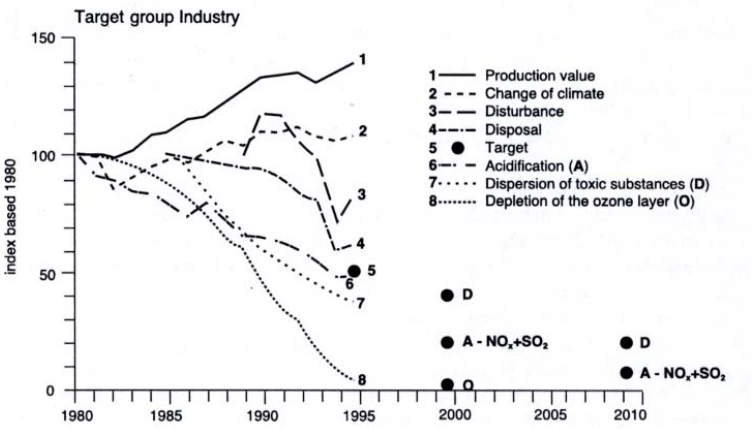


Figure 5: Indicator for the target group industry

Traffic lights to monitor progress

For each indicator, where possible, an assessment of progress can be made by comparing the latest data with the position at a number of baselines. Table 1 illustrates the approach used by the UK government[1] in sustainable development for three baselines: since 1970, since 1990, and since late 1990s. The 'Traffic light' assessments are used as in Table 2

Assessment for indicator against objective				
		Change since 1970	**Change since 1990**	**Change since Strategy**[1]
H1 Economic output				
H2 Investment				
H3 Employment				
H15 Waste	All arisings and management			
	Household waste			

Table 1: Assessment of each sustainability indicator for three different baselines, as used by UK government.

[1] http://www.sustainable-development.gov.uk/progress/data-resources/documents/sdiyp2007_a6.pdf

Key	
	Significant change, in direction of meeting objective
	No significant change
	Significant change, in direction away from meeting objective
	Insufficient or no comparable data

Table 2: Traffic-light assessments used by UK government in sustainable development

Rankings.

A quick and easy way to display country performance is to use rankings. It consists in a simple tabular representation such as that supplied by the *Growth Competitiveness Index*, in the Global Competitiveness Report 2003-2004 published by the World Economic Forum (see Figure 6). The table shows the rankings of countries for two consecutive years. Thus, it can be used to track changes of country performance over time. The limitation of ranks is that one loses the information on the difference between countries performances.

GROWTH COMPETITIVENESS INDEX RANKINGS

Country	Growth Competitiveness ranking 2003	Growth Competitiveness ranking 2003 among GCR 2002 countries	Growth Competitiveness ranking 2002*
Finland	1	1	1
United States	2	2	2
Sweden	3	3	3
Denmark	4	4	4
Taiwan	5	5	6
Singapore	6	6	7
Switzerland	7	7	5
Iceland	8	8	12
Norway	9	9	8
Australia	10	10	10
Japan	11	11	16
Netherlands	12	12	13
Germany	13	13	14
New Zealand	14	14	15
United Kingdom	15	15	11
Canada	16	16	9
Austria	17	17	18
Korea	18	18	25
Malta	19	—	—
Israel	20	19	17
Luxembourg	21	—	—
Estonia	22	20	27

Figure 6: Growth competitiveness index rankings from the competitiveness Report 2003-2004.

Scores and rankings.

In several cases one provides both levels and country rankings, for both the component indicators and the composite one. The British Office of National Statistics has produced indices of economic deprivation in six domains (income, employment, health deprivation and disability; education; skills and training; housing; and access to services) for the all the districts in 2000. The composite is the average of scores out of a 100 for each sub-indicator (see Table 3). The rank is the average of ranks for each component indicator; ranks go from 1 to approximately 8,000 (the total number of districts).

Variable	Index of multiple deprivation					
Units	Score					
Area			Income domain		Employment domain	
Ascot	5.20	Rank	Score	Rank	Score	Rank
Binfield	5.13					
Bullbrook	18.72	7,991	7.38	7,640	2.26	8,330
Central Sandhurst	6.55	8,014	5.36	8,205	1.80	8,388
College Town	4.18	3,811	19.23	3,198	8.46	4,087
Cranbourne	12.70	7,614	11.62	5,746	3.36	7,923
Crowthorne	10.32	8,188	4.64	8,300	2.53	8,284
Garth	15.14	5,460	12.29	5,443	4.56	7,100
Great Hollands North	12.55	6,256	5.04	8,257	8.32	4,177
Great Hollands South	12.28	4,690	15.68	4,200	7.54	4,669
Hanworth	10.75	5,517	17.81	3,574	5.69	6,156

Table 3: index of multiple deprivation by district in England, Office of National Statistics

Scores and moving average.

Sometimes we want to monitor not only the performance at a given point in time but also the trend over the last period. Very often this is done via the calculation of percentage growth, yet moving average can be a useful tool.

An example is given by First Great Western Link railways, which use this tool to inform the public about the punctuality of the Thames trains service. One can read the most recent figure on punctuality and the corresponding moving average over the last 52 weeks. If the moving annual average over the last 12 months for punctuality is less than the most recent figure, a discount of up to 5% will be given on qualifying season ticket renewals!

Four-quadrant model for sustainability

Arup (a professional consultancy group) developed a tool to demonstrate the sustainability of a project, process or product to be used either as a management information tool or as part of a design process. The Sustainable Project Appraisal Routine (SPeAR®) is based on a four-quadrant model that structures the issues of sustainability into a robust framework, from which an appraisal of performance can be undertaken (see Figure 7). The outcome of the SPeAR® assessment reflects the utilisation of an unweighted indicator set. SPeAR® contains a set of core sectors and indicators that have been derived from the literature on sustainability. The appraisal is based on the performance of each indicator against a scale of best and worst cases. Each indicator scenario is aggregated into the relevant sector and the average performance of each sector is then transferred onto the SPeAR® diagram. The transparent methodology behind the SPeAR® diagram ensures that all scoring decisions are fully audit traceable. The only limitation is that the diagram gives snapshot of performance at a particular time.

Figure 7: The four-quadrant model of the Sustainable Project Appraisal Routine (SPeAR®).

The **Dashboard of Sustainability** (see http://esl.jrc.it/envind/) is a free, non-commercial software which allows to present complex relationships between economic, social and environmental issues in a highly communicative format aimed at decision-makers and citizens interested in Sustainable Development. Besides indicator experts, it is also particularly recommended to students, university lecturers and researchers.

The Dashboard includes maps of all continents and can be developed using one's own dataset. A vast collection of dashboards already exist. To make some examples, on the internet site one can find the "ecological footprint", a pure environmental composite, the "environment sustainability index", presented at World Economic Forum annual meetings, the "European Environmental Agency's EEA Environmental Signals". The "From Rio to Johannesburg" and the "Millennium Development Goals" versions are recommended for introductory courses on Sustainable Development.

The Dashboard can help answering some typical questions as:

1. What is the situation of my country compared to others (see Figure 8)?
2. What are specific strengths and weaknesses of my continent/my country (Figure 9)?
3. How are certain indicators linked to each other (Figure 10)?

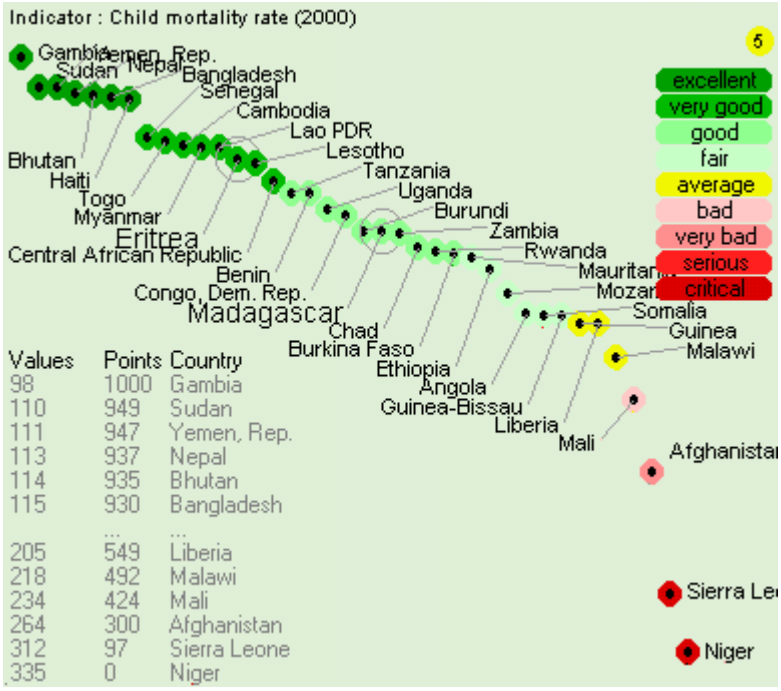


Figure 8: What is the situation of my country compared to others? Source: Dashboard of Sustainability

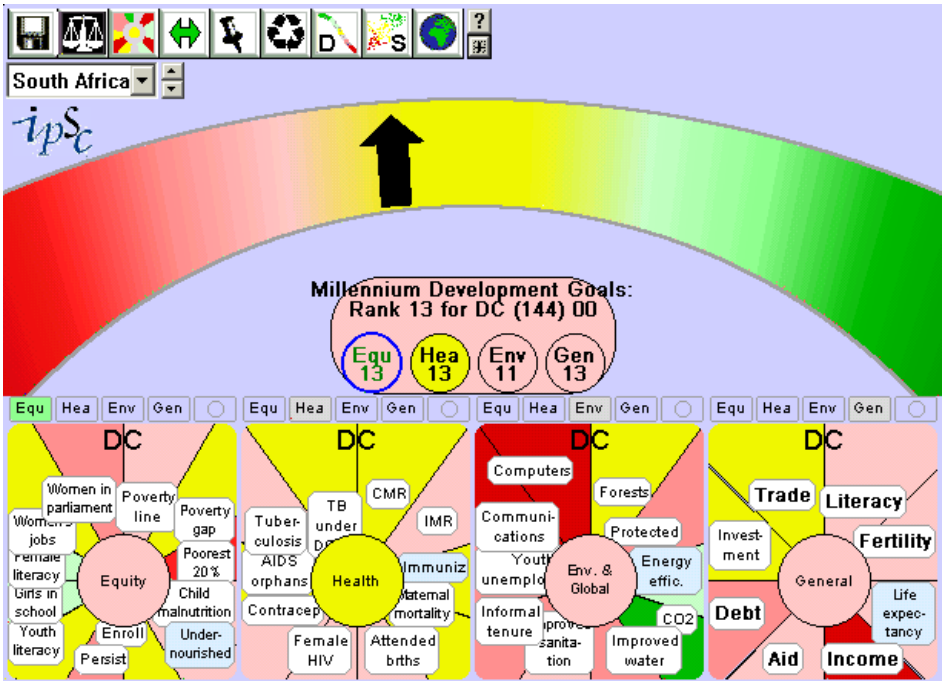


Figure 9: What are specific strengths and weaknesses of my continent/country? Source: Dashboard of Sustainability

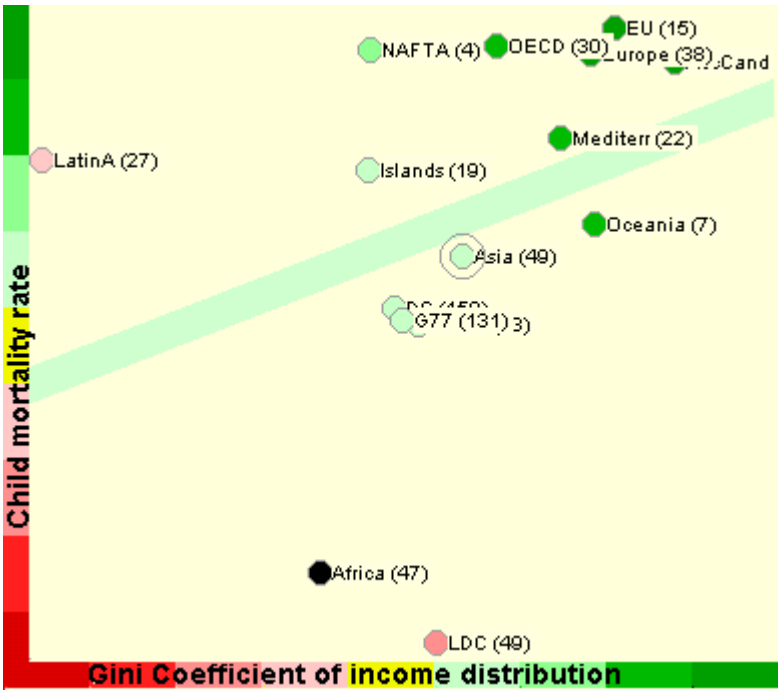


Figure 10: How are certain indicators linked to each other? Source: Dashboard of Sustainability

Nation Master

The following internet site is not strictly for composite indicators. However its graphical features can be helpful for presentational purposes.

www.nationmaster.com is a massive central data source on the internet with a handy way to graphically compare nations. Nation Master is a vast compilation of data from such sources as the CIA World Factbook, United Nations, World Health Organization, World Bank, World Resources Institute, UNESCO, UNICEF and OECD.

It is possible to generate maps and graphs on all kinds of statistics with ease.

On June 2008, it includes 8,294 stats, and new features and new statistics are constantly added. This internet site is considered the web's one-stop resource for country statistics on anything and everything.

Correlation reports and scatterplots can be used to find relationships between variables. See Figure 11 for a snapshot.

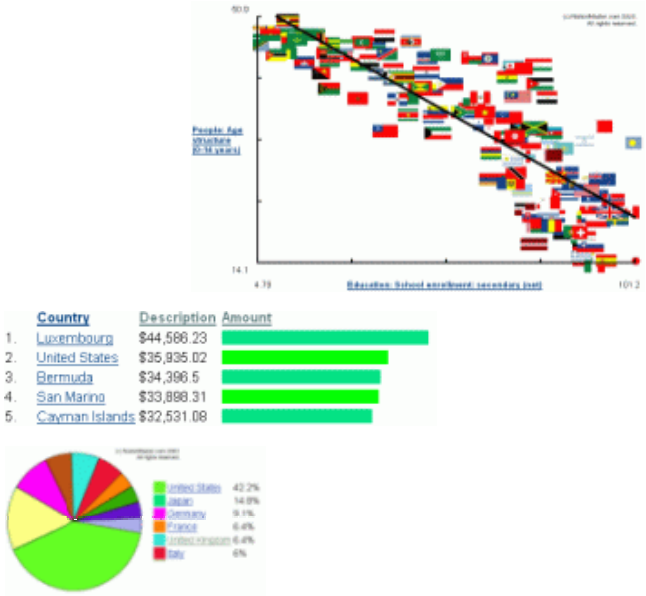
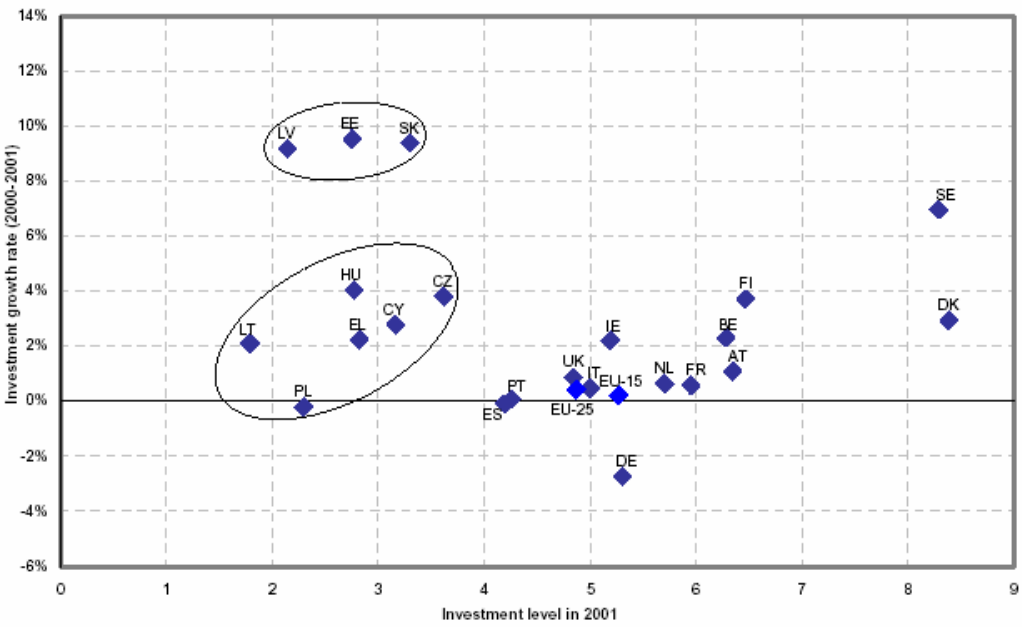


Figure 11: A snapshot from the Nation Master

Another example of this presentational tool is given by the composite indicators of investment and performance in the knowledge-based economy, developed by the European Commission in the framework of the Lisbon agenda. In the publication *Key Figures 2003/2004* of the Directorate General RTD one can find pictures like that given in Figure 14, where levels are given along the X-axis, and short term trends on the Y-axis.



Source: DG Research/JRC Key Figures 2003-2004
Note: Only 5 sub-indicators were included: R&D expenditure (GERD per capita), PhDs (number of new S&T PhDs per capita), Researchers (number of researchers per capita), gross fixed capital formation (GFCF (excluding building) per capita), and e-government. The other two sub-indicators (educational spending and life-long-learning) are not available for all countries. L, MT, SL are not included (no data for most of indicators).

Figure 14: Composite indicator of investment in the knowledge-based economy for comparison between EU-27 Countries.

Composite scores with uncertainty

The practice to investigate the effects of uncertainty in data sources and weights on the ultimate country scores is not yet established. Without uncertainty propagation, there may be the evidence that a country performs better than another. It is important to assess whether the uncertainties arising in the development of a composite indicator can corroborate this evidence or not. The example given in Figure 15 provides the country scores with their empirical uncertainty bounds (represented by the colored clouds) for the case of the e-business readiness composite indicator [6,7], which is composed of two domains (each domain is also a composite): the ICT adoption (in the x-axis) and the ICT use (in the y-axis). The countries represented here are those who perform better than the EU average (represented by the red cloud). Here it is easy to show that some countries overlap along one or both domains (and therefore nothing can be said about their relative performance), and others can be clearly distinguished despite the uncertainties.

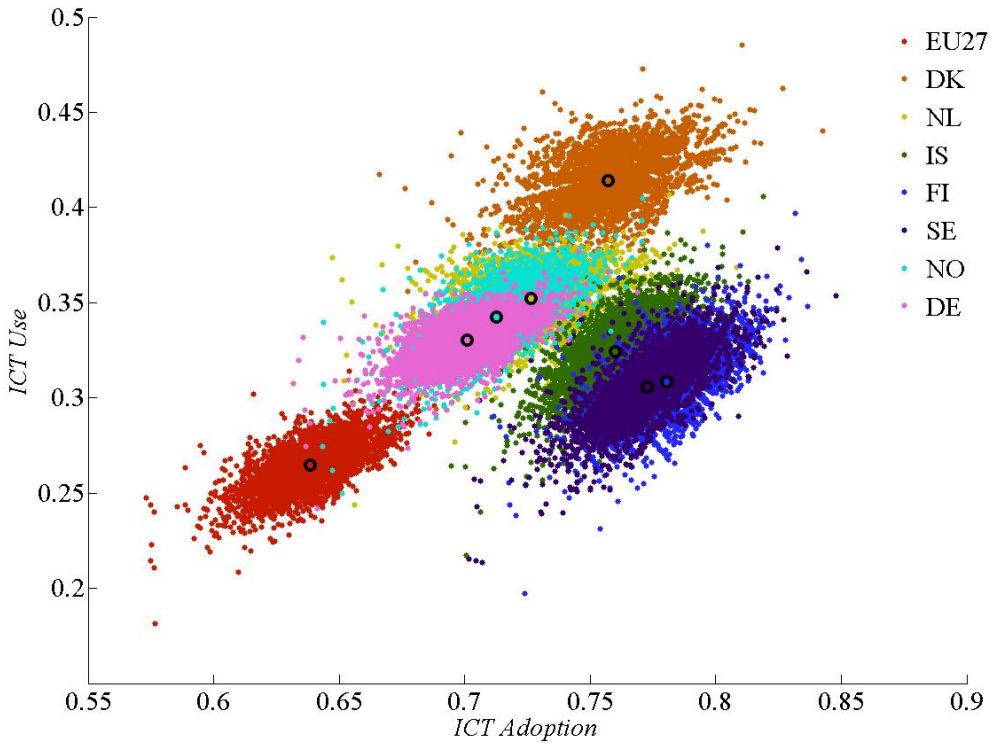


Figure 15: Composite indicator of e-business readiness: representation of country scores with uncertainty bounds.

Comparing indicators using clusters of countries

In the United Nations Industrial Development Organization (UNIDO) publication *Industrial Development Report 2002/2003: Competing through Innovation and Learning*, (see http://www.unido.org/userfiles/hartmany/12IDR_full_report.pdf), at page 50, the technological evolution of industry in industrialized and transition economies in years 1985 and 1998 is based on clusters of countries with similar performance (see Figure 16). This format can be used to plot levels vs. growths for a given composite indicator.

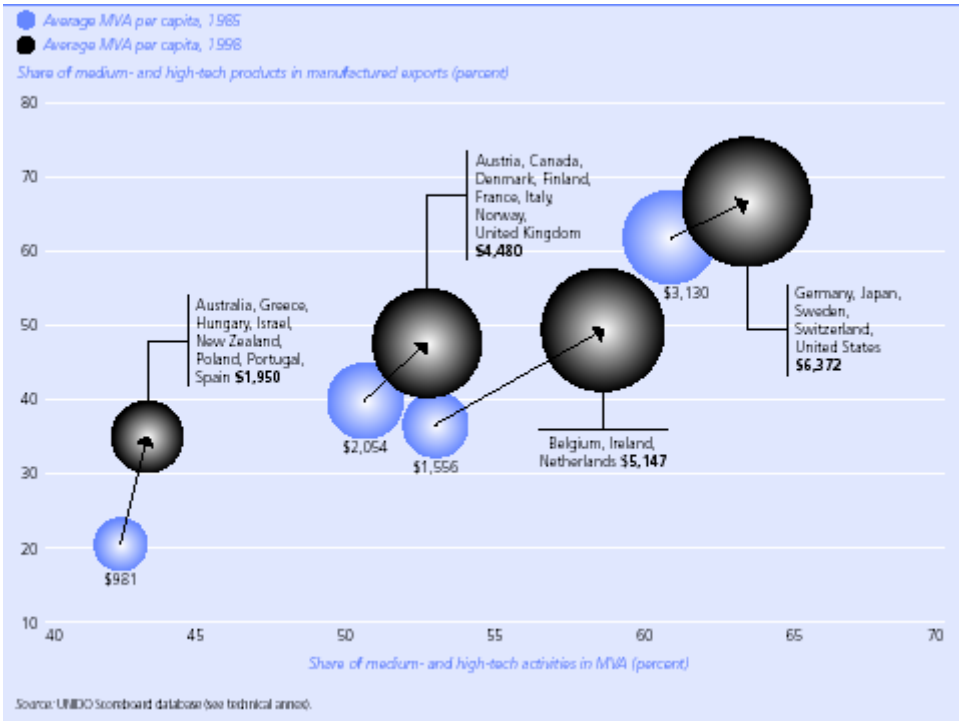


Figure 16: technological evolution in industry both in industrialized and transition economies in years 1985 (blue cluster) and 1998 (black cluster). Source: UNIDO.

Graphical profile indicators.

Graphical representation of composite indicators should provide a clear and identifiable message, but without obscuring the individual indicators on which they built. Booz Allen Hamilton consulting developed a technique of graphical 'profile' indicators to achieve this. The 2003 International Benchmarking Study (IBS) includes a newly devised 'Sophistication Index' designed to provide a deeper insight into the true level of sophistication of a nation's businesses' use of ICT than simple measures of connectivity or adoption.

The chart given in Figure 17 lays out all elements of the sophistication index, arranged vertically down the left hand axis. The horizontal scale represents the index score achieved by the UK for each component indicator, normalized between 0 and 1. To score a perfect 1.0, a nation must emphatically lead across all the indicators. For this reason the best performer in the group is generally less than 1. The segmented line represents the composite outcome for the UK across the set of indicators. The scores of the other nations are reported without labels. Only the best performer in each single indicator is given. The approach permits the focus to remain on sharing successful policies.

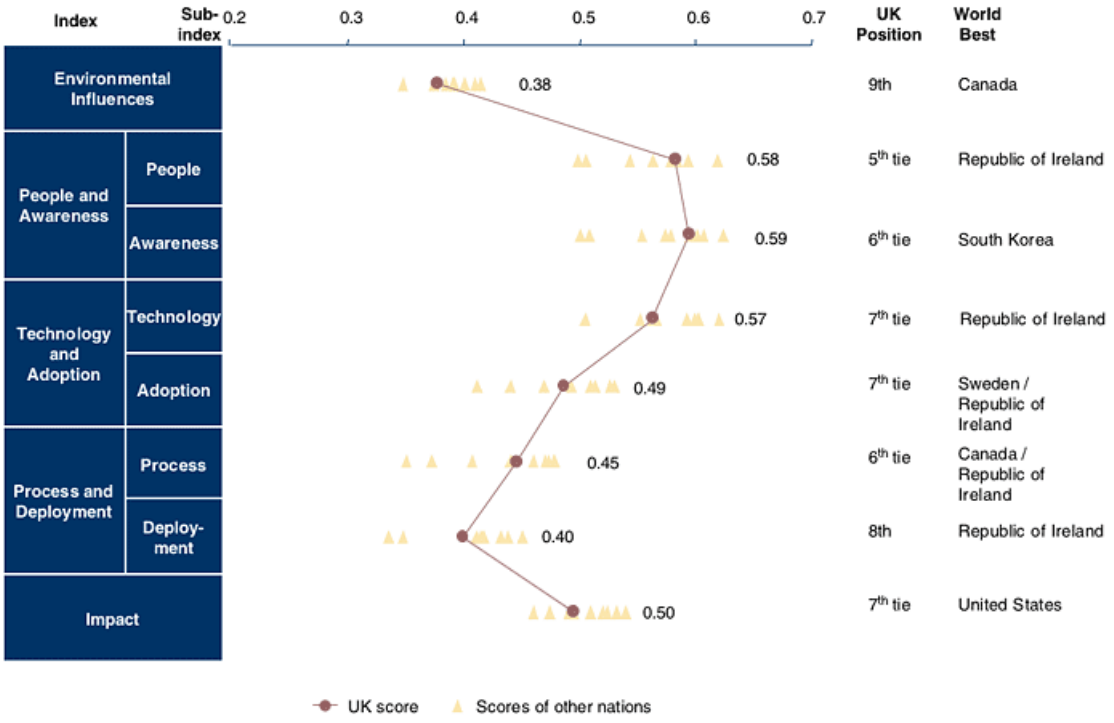


Figure 17: Sophistication Index' proposed by Booz Allen Hamilton to measure a nation's businesses' use of ICT.

Conclusions

This report gives an overview of recent theoretical advances for composite indicators building. In particular, the *endogenous weighting procedure* and the *multi-criteria* aggregation procedure. Both approaches are briefly reviewed in Sections 1 and 2 and we give two examples using the 2007 EIS dataset. In Section 3, we provide some presentational tools that can help improving the way the SII results are presented.

The focus of the report is to raise discussion among the participants to the workshop of June 16, 2008 upon the relative merits and limitations of these approaches, with the idea to identify potential candidates for further improvements of the SII.

As said, the report is an overview of approaches and tools that are in principle applicable to any given dataset. The report is not a feasibility study of a specific technique to the EIS dataset, for which more detailed analyses would be required given the constraints dictated by the quality of the dataset, including the presence of missing values.

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References

[1] Nardo, M. M. Saisana, A. Saltelli and S. Tarantola (EC/JRC), A. Hoffman and E. Giovannini (OECD), *Handbook On Constructing Composite Indicators: Methodology And User Guide,* OECD Statistics Working Paper JT00188147, STD/DOC(2005)3.
[2] Munda G. (1995) - Multicriteria evaluation in a fuzzy environment, *Physica-Verlag, Contributions to Economics Series,* Heidelberg.
[3] Munda G. and Nardo M. (2003) – Mathematical modelling of composite indicators for ranking countries, *Proceedings of the First OECD/JRC Workshop on Composite Indicators of Country Performance,* JRC, Ispra
[4] Tarantola S., Liska R., Saltelli A., Leapman N., Grant C. (2004) *The Internal Market Index*, EUR 21274 EN
[5] Adriaanse A. (1993), *Environmental policy performance. A study on the development of indicators for environmental policy in the Netherlands*. SDV Publishers, The Hague.
[6] Tarantola S. and W. Castaings *Monitoring e-Business Readiness of European enterprises using composite indicators,* IST-Africa Conference, May 7-9, 2008
[7] Castaings, W. and S. Tarantola (2008), *The 2007 European e-Business Readiness Index,* EUR 23254 EN