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Rebuilding the Pillars of Sustainable Society Index: a Multivariate Post Hoc I-distance Approach

Kształtowanie wskaźnika Zrównoważonego Społeczeństwa: analiza wielowariantowa I-distance

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Abstract
Sustainable Society Index (SSI) is a composite indicator constructed to measure and describe societal progress along all three dimensions of sustainable development: human, environmental and economic. In this paper, we explore possibilities to evaluate and enhance SSI ranking calculation methodology based on the use of an iterative multivariate post hoc I-distance approach. Based on the assessment on how each indicator contributes to the final position of different countries and identification of the most influential indicators, we examine possibilities of reduction of a number of indicators. The goal is to improve the stability of the ranking results and overall quality of the model, focusing on the analysis of the relative contribution of the indicators in an iterative assessment process. By this, we provide in-depth analysis and more comprehensive understanding of specific factors that determines one country ranking position. Thus proposed approach can support policymakers to identify key indicators and focus the priority areas where investment in improvement measures and programs would have the most efficient impact on the overall positioning of the country.

Key words: sustainable development; Sustainable Society Index; composite indicators; I-distance; relative contributions

Streszczenie
Indeks Zrównoważonego Społeczeństwa (Sustainable Society Index, SSI) jest zagregowanym wskaźnikiem stworzonym w celu pomiaru i opisu postępu społecznego w trzech wymiarach rozwoju zrównoważonego: publicznym, środowiskowym i ekonomicznym. W artykule przeanalizowano możliwości oszacowania i rozszerzenia metodologii SSI w oparciu o wielokrotną analizę wielowariantową I-distance. W oparciu o ocenę, jak każdy wskaźnik przyczynia się do ostatecznego wyniku osiąganego przez różne kraje i identyfikację wskaźników o największym znaczeniu, zbadamy możliwość zmniejszenia ilości branych pod uwagę wskaźników. Celem jest poprawa wiarygodności otrzymywanych wyników i ogólnej jakości modelu, z podkreśleniem znaczenia analizy względnych udziałów wskaźników w wielokrotnym procesie oceny. Umożliwi to przeprowadzenie szczegółowych badań i bardziej wszechstronne podejście do poszczególnych czynników które wpływają na miejsce, które dany kraj zajmuje w rankingu. Proponowane narzędzie może pomóc decydentom w zidentyfikowaniu kluczowych wskaźników i wskazać obszary priorytetowe, w ramach których inwestycje i programy modernizacyjne będą miały największy wpływ na pozycjonowanie danego kraju.

Słowa kluczowe: rozwój zrównoważony wskaźnik Społeczeństwa Zrównoważonego, wskaźniki zagregowane, analiza wielowariantowa, względny udział

1. Introduction

The roots of sustainability concept could be found in different sources from the sciences of religion, philosophy and economics from many centuries ago (Mebratu, 1998). However, the most common definition of sustainable development was published in The Brundtland Report (WCED, 1987), where sustainable development was defined as development that satisfies the needs of the existing, without jeopardizing possibilities of the future generations to satisfy their needs. Sustainable development includes various environmental, economic and social factors, which are stated as the three pillars of the sustainability which do not exclude each other, but even can accent each other (UN, 2005). Rising interest for sustainable development is a result of the perception of current worrying conditions of the global human environment. It calls and demands urgent reaction of all members of society, focused on long-term environment protection and overall sustainable development of the humanity (Petrovic, 2012).

Sustainable development is a critical and popular concept that is open to different approaches and interpretations. Naturally a large number of researchers, organizations, institutions and international agencies developed and offered many various methodologies and concepts for measuring sustainability. Conceptual approaches to measuring sustainable development could be grouped into two general categories: (1) set of indicators and (2) composite indicators. Unlike the sets of indicators, composite indicators have the ability to summarize complex and sometimes elusive processes into a single figure to benchmark a country's performance in policy consumption (Giovannini et al., 2008). Numerous sustainability composite indicators were developed and proposed in recent decades. The following approaches are mostly present and discussed: Index for Sustainable Economic Welfare ISEW (Daly and Cobb, 1989), Genuine Progress Indicator GPI (Cobb et al., 1995), Genuine Savings/Adjusted Net Savings GS/ANS (Hamilton et al., 1997), Environmental Sustainability Index ESI (Esty et al, 2005), Environmental Performance Index EPI (Esty et al, 2006), Ecological Footprint EF (Ewing et al., 2010), Human Development Index HDI (UNDP, 2014) and Sustainable Society Index SSI (van de Kerk and Manuel, 2014). Among all of them, only SSI approach is tending to consider all three dimensions of sustainable development integrally.

The Sustainable Society Index (SSI) has been developed since 2006 with the aim to be a comprehensive quantitative method for measurement of the health of coupled human-environmental systems and to describe societal progress across human, environmental and economic dimensions (Saisana and Philippas, 2012). SSI tends to overcome the main noted shortcomings of previously developed metrics: a limited definition of sustainability, a deficit of transparency and an absence of regular updates (van de Kerk and Manuel, 2008). SSI is calculated for 151 countries accounting for 99% of the world population, with regular two-year updates that demonstrate developments over time and available underlying data that allow in-depth analysis of the differences between countries. SSI methodology has been refined several times to improve conceptual coherence and statistical soundness, with the support of Joint Research Centre (JRC) (Saisana and Philippas, 2012). In latest fifth edition, the new SSI-2014 framework has been presented, consisting of 21 indicators, grouped into seven categories and three dimensions (Table 1).

Table 1. The SSI-2014 conceptual framework

Category	Dimension	Indicator	Code
Human Wellbeing	Basic Needs	1. Sufficient Food	var1
		2. Sufficient to Drink	var2
		3. Safe Sanitation	var3
	Health	4. Education	var4
		5. Healthy Life	var5
		6. Gender Equality	var6
	Personal & Social Development	7. Income Distribution	var7
		8. Population Growth	var8
		9. Good Governance	var9
Environmental Wellbeing	Natural Resources	10. Biodiversity	var10
		11. Renewable Water Resources	var11
		12. Consumption	var12
	Climate & Energy	13. Energy Use	var13
		14. Energy Savings	var14
		15. Greenhouse Gases	var15
		16. Renewable Energy	var16
Economic Wellbeing	Economy	17. Organic Farming	var17
		18. Genuine Savings	var18
	Transition	19. Gross Domestic Product	var19
		20. Employment	var20
		21. Public Debt	var21

Because of *lack of a scientific basis for the attribution of different weights to the indicators, every indicator has received the same weight for the aggregation into dimensions* (SSI, 2014). In the last edition, dimensions are not aggregated into a single value for the overall composite, in view of the negative correlation between Human and Environmental Wellbeing (SSI, 2014). Composite indicators like SSI are designed to measure a multi-criteria performance, where is important to avoid composite indicators to represent unstable assessments, as their stability ensures the amount of validity of the observed system (Dobrota et al., 2015b). The usefulness of multivariate analysis for the aggregation of individual indicators to a composite indicator is often emphasized (Saltelli et al., 2008). As weights are essentially value judgments (Giovannini et al., 2008), results and values of composite indicators are significantly influenced by the indicator weights and often are the subject of controversy and debate (Saltelli, 2007). Equal weighting of indicators implies that all variables are *worth* the same in the composite indicator. However, the decision to apply equal weighting could be the consequence of the absence of a statistical or an empirical basis or a lack of consensus on the alternative (Giovannini et al., 2008). Paruolo et al. (2013) noted that *in many cases the declared importance of single indicators and their main effect are very different, and that the data correlation structure often prevents developers from obtaining the stated importance*.

In order to reduce subjectivity, improve stability and overall quality of the SSI ranking model, we apply I-distance methodology on the SSI-2014 values (SSI, 2014). One task is to provide clear understanding of how each indicator contributes to the final position of different countries, as well as to identify the most influential indicators and assess their relative influence on the overall results. The second goal is to use analysis of the relative contribution of the indicators as a tool to examine possibilities for reduction of a number of indicators in iterative assessment process focused on gradual improvement of the statistical quality of the model. By this, we provide in-depth analysis and more comprehensive understanding of specific factors that determines one country ranking position. It could represent useful signals for policymakers in which priority areas they should focus relevant measures and programs to have the most efficient impact on the overall positioning of the country.

The paper is structured as follows. Section 2 focuses on the post hoc I-distance methodology. The results of the analysis are discussed in Section 3. The last section provides a summary of the conclusions, including policy implications.

2. Methodology

The often problem with a different composite indicator based ranking and rating methods is that normative and subjective model assumptions significantly affect the results of measurements. This problem can be overcome by the use of the statistical I-distance method, which was originally developed by Ivanovic (1973, 1977) and which has been recently significantly advanced (Jeremic et al., 2012; Maricic et al, 2014; Dobrota et al., 2015a,b; Isljamovic et al., 2015). The I-distance measurement is based on calculating the mutual distances between the entities, where I-distance is a metric distance in an n-dimensional space. Any entity with real or fictive minimal, maximal or average values of all its variables' values can be considered as the referent entity. The ranking of assessed entities in the set is based on the calculated distance from the referent entity. For a designated set of variables $XT = (X1, X2, \dots Xk)$ that characterize the entities under assessment, the I-distance between the two entities $er = (x1r, x2r, \dots xkr)$ and $es = (x1s, x2s, \dots xks)$ is given as

$$D(r,s) = \sum_{i=1}^{k} \frac{|d_i(r,s)|}{\sigma_i} \prod_{j=1}^{i-1} \left(1 - r_{ji.12\ldots j-1}\right)$$

where *di(r,s)* represent the distance between the values of variable *Xi* for *er* and *es*, e.g. the discriminate effect,

$$di(r,s) = xir - xis,\ i \in \{1, \dots, k\}$$

σi the standard deviation of *Xia* and *rji.12...j-1* is a partial coefficient of the correlation between *Xi* and *Xj, (j<i)*.

The measure of the square I-distance represents a solution to the problem of the negative coefficient of partial correlation, which can occur in cases where is not possible to achieve the same direction of all variables in all sets. The square I-distance is defined as:

$$D^2(r,s) = \sum_{i=1}^{k} \frac{d_i^2(r,s)}{\sigma_i^2} \prod_{j=1}^{i-1} \left(1 - r^2_{ji.12\ldots j-1}\right)$$

Based on CIDI approach (Dobrota et al., 2015a), I-distance could be used to determine indicator weights based on the empirical Pearson correlations, where values of correlations are divided by the sum of correlations:

$$w_i = \frac{r_i}{\sum_{r=1}^{j} r_j}$$

where *ri* (*i* = *1*, . . . *k*) is a Pearson correlation between *i*-th input variable and I-distance value and the final sum of all weights equals 1 (same applies using coefficient of determination, as used in our case study).

3. Results

Our analysis has been performed in several consecutive I-distance iterations, starting with the first I-distance iteration that includes all of the indicators listed in Table 1, together with calculated coefficients of determination. For the following I-distance iterations, a variable with the smallest coefficient of determination in the previous iteration has been excluded from the further analysis. The analysis of the relative contribution of the indicators to the score of some country has been used to determine the final number of iterations. This statistical method could provide information if some indicators dominate over the total scores and what is the level of that influence (Saisana and d'Hombres, 2008). The relative contributions have been calculated as a proportion of an indicator score multiplied by the appropriate weight (calculated by the CIDI approach) with regard to the overall score for each indicator and country. Average relative contributions and standard deviations have been calculated in next step, where is important to note that higher standard deviation leads to higher level of rank oscillation. Focus is to

Table 2. Average relative contributions (Me) and related standard deviations (SD) for all variables (Var) comprehended in 14th and 15th iterations

14th iteration	Var	var19	var5	var9	var4	var13	var15	var3	var2	Total
	Me	0.1432	0.1201	0.1428	0.1481	0.0949	0.1212	0.1162	0.1135	1.0
	SD	0.0158	0.0442	0.0189	0.0186	0.0269	0.0664	0.0701	0.0619	0.3228
15th iteration	Var	var19	var9	var5	var4	var13	var15	var3		Total
	Me	0.1295	0.1674	0.1715	0.1156	0.1457	0.1358	0.1344		1.0
	SD	0.0487	0.0232	0.0226	0.0329	0.0787	0.0808	0.0741		0.3609

Table 3. List of comprehended variables with their coefficient of determination (r^2) and average r^2 for initial and final iterations

1st iteration	r^2	2nd iteration	r^2	…	13th iteration	r^2	14th iteration	r^2
var9	0.7310	var9	0.7396	…	var19	0.8911	var19	0.9025
var19	0.6115	var19	0.6448	…	var5	0.8082	var5	0.8154
var5	0.5700	var5	0.5929	…	var4	0.7039	var9	0.7709
var4	0.5155	var4	0.5655	…	var9	0.7022	var4	0.7174
var13	0.4942	var13	0.5027	…	var3	0.6889	var13	0.6708
var6	0.4638	var17	0.4998	…	var15	0.6773	var15	0.6529
var17	0.4597	var6	0.4651	…	var13	0.6773	var3	0.6480
var2	0.4290	var2	0.4529	…	var2	0.6529	var2	0.6209
var15	0.4134	var15	0.4316	…	var1	0.6384		
…	…	…	…	…				
var11	0.0317	var11	0.0259					
var20	0.0066							
Average r^2	0.3316		0.3665			0.7156		0.7248

Table 4. Changes in rank, median rank and IQR for selected countries

Country	Iterations														Delta	Me	IQR
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th			
Norway	1	1	1	1	1	2	2	2	2	3	2	6	1	1	0	2	1
Australia	21	24	24	29	27	24	12	13	13	13	12	8	2	2	-19	13	19
Netherlands	12	15	15	11	11	9	10	10	10	10	9	10	3	3	-9	10	7
Denmark	10	10	9	9	10	11	5	5	5	5	5	5	4	4	-6	5	4
Finland	4	4	4	3	4	4	1	1	1	1	1	3	5	5	1	4	3
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Lebanon	137	132	129	123	116	115	100	82	82	76	77	52	51	53	-84	91	57
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Sudan	151	151	151	151	151	151	150	150	150	149	149	149	149	147	-4	150	6
Congo DR	147	148	149	149	149	148	149	149	149	151	151	151	151	148	1	149	3
Niger	100	103	110	114	112	121	131	144	145	136	135	131	130	149	49	131	26
Sierra Leone	126	136	137	138	140	143	136	145	146	145	145	143	143	150	24	143	11
Chad	148	147	148	150	150	150	151	151	151	150	150	150	150	151	3	150	0

identify the iteration with the lowest cumulative standard deviation of the average relative contributions of each variable. This iteration should be the final one because following iterations would increase fluctuations of the countries ranks, which would decrease the quality of the model.

In our case, calculated values of cumulative standard deviation have been continuously lower compared to the previous one for all iterations until the 15th iteration, which have had higher value then in 14th iteration (Table 2). Therefore, the 14th iteration, which comprehends eight statistically most important indicators, has been defined as the final one. The in-depth analysis focused on the consistency in the rank and general structure of the performance can reveal the sensitivity of the rank of countries in relation to each indicator included in the analysis. Table 3 provides a review of comprehended variables, their coefficient of determination and appropriate average coefficient of determination calculated for initial and final iterations. The table with full results for all iterations is available with authors on request.

The average coefficient of determination continuously rises through all iterations, confirming the increase of the quality of the model (Markovic et al., 2015). The results of the final 14th iteration are pointing out the significant importance of eight indicators out of initially considered 21 indicators, which represent essential elements for utilization of the I-distance framework in an evaluation of SSI results and methodology. These most important variables are: Gro*ss Domestic Product* (var19), *Healthy Life* (var5), *Good Governance* (var9), *Education* (var4), *Energy Use* (var13), *Greenhouse Gases* (var15), *Safe Sanitation* (var3) and *Sufficient to Drink* (var2). It can be noted that indicators from all three dimensions are present in the final set, with the highest share of indicators of human wellbeing (5 indicators) compared to environmental (2 indicators) and economic wellbeing (1 indicator).

First ranked *Gross Domestic Product* is calculated on GDP *per capita* PPP basis. GDP has been qualified as a poor indicator of economic well-being (Pissourios, 2013) which cannot be used alone to describe the broader quality of life (Caminada et al., 2010). However, the results of our analysis confirm that GDP *remains a very important indicator for measuring the economic performance of countries, which is a fundamental driver of well-being* (Borini, 2012).

Health-adjusted life expectancy (HALE) at birth represent a basis for the calculation of *Healthy Life* variable. It represents a number of years that a newborn is expected to live, reduced by the number of years spent in poor health. WHO introduced this metric with the goal to take into account not only the average life expectancy of people but also their health (Mathers et al., 2010).

Good Governance variable represents the average of values of the six World Bank's Governance Indicators: Voice and Accountability, Political Stability, Government Effectiveness, Regulatory Quality, Rule of Law and Control of Corruption (WGI, 2015). It is founded on the rationale that good governance represents *condition for the development of all people in freedom and harmony, within the framework of rules and laws* (van de Kerk and Manuel, 2014).

Education indicator is calculated based on the UNESCO metric of combined gross enrollment ratio (UNESCO, 2015). This ratio expresses the count of students enrolled in primary, secondary and tertiary levels of education, irrespective of their age and expressed as a percentage of the population of official school age for the all three levels. Outputs of our study are in alignment with the opinions that education plays *crucial role in adaptation towards sustainable development* (Svanstrom et al., 2008) and that it is essential for *the change in social attitudes that will be needed to protect the welfare of future generations* (Chalkley et al., 2013).

"*Energy Use* is calculated based on IEA measure of energy consumption in tons oil equivalents (toe) per person, where energy use higher than 5 toe per capita is penalized with a zero value of the *Energy Use* indicator (SSI, 2014). Energy is not only a key requirement for economic progress, but also it causes significant pressures on the environment, both by depletion of the resources and by the creation of the pollution. Results of our analysis confirm relevance and importance of the ability of this variable to reflect the energy-use patterns and aggregate energy intensity of a society (IAEA, 2005).

Calculation formula for *Greenhouse Gases* as a measure of main human contribution to climate change is based on IEA metric of CO_2 emissions per capita per year, with zero-score penalization of the emissions higher than 10 (SSI, 2014). As the latest carbon dioxide emissions continue to track the top end of emission scenarios (Piters et al., 2013), the main focus in climate change battle is moving towards economy-wide emission reduction targets (Olivier et al., 2013).

Safe Sanitation variable is related to WHO estimation of the share of total population with sustainable access to improved sanitation, considering connection to facilities like public sewer, septic tank, pour-flush latrine, etc. (WHO, 2015). Accessibility to adequate sanitation facilities is fundamental to decrease the risk and the frequency of associated diseases.

Sufficient to Drink variable is based on another WHO measure of the number of people as share of the total population with sustainable access to an improved water source like household connections, public standpipes, protected wells, springs, rainwater collection, etc. (WHO, 2015). The ability of the latest two variables to describe general hygiene and quality of life and their easy association with other socioeconomic characteristics (like education and income) make them useful indicators of human development (UNDESA, 2007).

Table 4 provides changes in ranks of countries between the first and the final iteration (Delta), together with related median ranking position (Me) and interquartile range (IQR) values, for the selected countries. The full list of values for all countries is available with authors on request. The interquartile range is a robust measure of statistical dispersion that represents the middle 50 percent of the distribution of an ordered range of data. Being equal to the difference between the upper and lower quartiles, IQR is not affected by extreme values. Median presents the average value that falls in a middle of the set of an ordered range of data.

In total, there are nine countries with a change of rank for 50 or more places, which implies that these countries are the most sensitive to excluding variables through iterations. The largest change in rank occurs with Lebanon for 84 places. On the other hand, small changes of the rank (max. 5 places) are noted for 40 countries, including four of them (Norway, New Zealand, Kenya, Guinea) without any change.

Figure 1 shows the oscillation in the ranks of the five top-ranked countries. Obviously, all of them are democracies with the highly developed economies. Interestingly, Norway does not change its first position between initial and last iteration, which can be explained with very good scores in terms of the elaborated most significant indicators: *Safe Sanitation*, *Sufficient to Drink* (all 10/10), *GDP* (9.89/10), *Education* (9.81/10), *Healthy life* (8.99/10) and *Good Governance* (8.56/10).

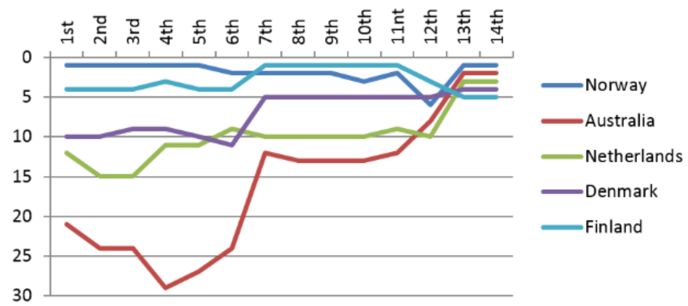

Figure 1. Overview of the fluctuations in the ranks of the five top-ranked countries

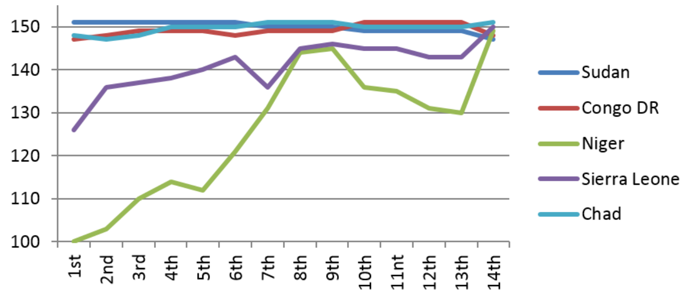

Figure 2. Overview of the fluctuations in the ranks of the five bottom-ranked countries

Indeed, being one of the most developed countries with very stable and prosperous mixed economy, with both large state sector and a vibrant private sector (NEP, 2014), Norway has very high value of GDP *per capita* PPP of $65.640 (WB, 2015). In addition to the best performance in area of sanitation and drinking water, Norway have impressive combined gross enrolment ratio of 98.1% and life expectancy at birth equal to 74 years of healthy life years (SSI, 2014). Although health care expenditure participates in GDP with 9.4%, due to Norway's very high value of GDP *per capita*, its average health expenditure is among the highest on a global level (Ringard et al., 2013). Finally, the traditions and institutions by which authority in a Norway is exercised are perceived as among the best on global level, which is illustrated by very high values of the six Worldwide Governance Indicators (WGI, 2015). At the same time, Norway has good performances in many other variables that have been gradually excluded, which explains the low level of rank oscillations through iterations indicated by IQR value equal to 1.

Dispersion of the rank measured by IQR for the most of these top-ranked countries is reasonably low, except for Australia (IQR=19). Australia is the only one with a significant change of the rank by improving its position for 19 places, mainly in the 7th iteration, where variable *Biodiversity* has been excluded. There are almost 3000 threatened ecosystems and ecological communities in Australia while 94% of the bioregions have at least one or more threatened ecosystems (Randall, 2008). At the same time, the imposingly negative trend in forest area noticed for an extended period (Bradshaw, 2012). All together it could explain Australia's poor SSI score (4.9) and a very low 112th ranking position for *Biodiversity* variable. On the other hand, Australia has quite good scores in terms of *Education, Safe Sanitation, Sufficient to Drink* (all 10), *GDP* (9.61), *Healthy Life* (9.12) and *Good Governance* (8.21). It implies that good performances of Australia in previously elaborated most significant indicators have been shadowed by the influence of less significant indicators where Australia do not have impressing results. Thus, reduction of the number of indicators provided more transparent insight and enabled Australia to improve its rank significantly through proposed iterative procedure to the remarkable second overall position.

The fluctuations in the ranks of the five bottom-ranked countries are illustrated in Figure 2. Chad is a country in the last 151st position with a very small change in rank (3 places) compared to the initial iteration, mainly due to its quite poor scores for the majority of the most significant indicators: *Safe Sanitation* (1.19), *GDP* (1.73), *Good Governance* (2.44) and *Healthy Life* (3.65).

Indeed, Chad is a poor country with weak institutional and policy capacity, limited progress in poverty reduction, fragile economy facing a trend decline in oil revenues and vulnerable to oil price and regional security shocks (IMF, 2014). Chad was ranked in 184th place out of 187 countries on the UN's 2014 HDI list (UNDP, 2014). Being one of the poorest and most corrupted countries, it is noted that

Chad failed to utilize recently emerged oil export revenues to boost development and reduce poverty due to three major factors: institutional capacity constraints, socio-political incompatibilities and subversive interactions with external factors (Kojucharov, 2007).

On the other hand closely positioned Niger has noticed one of the biggest increases in rank, which has significantly worsened its position through iterations for 49 places. With the negative shift of 19 places and high level of dispersion of the ranking results confirmed by IQR value equal to 26, the last iteration appeared to be the most influential one, in which variable *Sufficient Food* has been excluded from the analysis. Obviously, Niger has good results in this variable (9.36), and when its effect has been neutralized, the final rank has been swiftly adjusted in accordance with generally poor achievement in the most of remaining variables. Niger is least-developed, low-income country with desert counting for two-thirds of its land and dominantly agricultural population that is doubling every 18 years, which all together represent a real challenge for food security, healthcare, family planning, social protection, education and employment growth (AEO, 2015).

The biggest change of rank for 84 places occurs with Lebanon, causing improvement of its rank from 137th to 53rd position, and with the highest level of dispersion of the result (IQR=57) measured in our research. Its economy was hard-hit by the 15-years civil war (1975–1990) and still occasionally suffers from economic downturns caused by local and regional political instabilities. At the same time, the Lebanese real GDP has grown at a faster pace than the regional real GDP since 2007 (Dagher and Yacoubian, 2012). It can be noted that effects of generally solid performances in the final set of significant variables, which all have been better or close to average values, have been extenuated with relatively lower results in many of the other variables. Among them following ones have had the biggest negative impact: *Biodiversity* (score 3.85 compared to average per country 6.18; excluded in 7th iteration), *Genuine Savings* (score 3.66 compared to average per country 6.57; excluded in 8th iteration) and *Gender Equality* score 6.03 compared to average per country 6.8; excluded in 12th iteration).

4. Conclusion

The rising popularity and importance of the sustainable development concept induced development of numerous measurement approach and methodologies in the related area. Among them, the Sustainable Society Index is currently the only one that attempts to comprehend all three dimensions of sustainable development integrally. This composite indicator is constructed to be able to measure progress along all three dimensions of sustainable development: human, environmental and economic.

In this paper, we explore possibilities to evaluate and enhance SSI ranking calculation methodology based on the use of an iterative multivariate post hoc I-distance approach. The I-distance method can synthesize many different indicators into a single numerical value that represents the basis for ranking observed entities. The proposed approach could provide not only more comprehensive and detailed understanding of differences between countries but also a deeper insight into the relative statistical importance of selected indicators. This post hoc approach can be a solid ground not only for gradual exclusion of the less significant existing indicators but also for inclusion of additional new variables in a process of evaluation and improvement of the considered measurement framework. The main idea behind proposed approach is to improve the stability of the ranking results and overall quality of the model, focusing on the analysis of the relative contribution of the indicators in an iterative assessment process. By this, we provide in-depth analysis and more comprehensive understanding of specific factors that determines one country ranking position.

As sustainability metrics are used as quantitative information base and foundation for creation of appropriate sustainable development policies, this proposal has important policy implications related to improvement of objectiveness of sustainability metrics used in processes of sustainable development policy making on all levels. Improved reliability and accuracy of the sustainability metrics combined with an analytical framework for exhaustive understanding of the most significant factors influencing one's country positioning is of the highest importance for sustainability policy making processes.

It is noted that statistical analysis of composite indicators is *essential to prevent media and stakeholders taking them at face value possibly leading to questionable policy choices* (Paruolo et al., 2013). More transparent and robust underpinning statistical framework of composite indicators would reduce perceived disproportion between strong communicative power and reliability of sustainability indexes (Luzzati and Gucciardi, 2015). It would simplify communication tasks of policymakers and make sustainable development policies more credible.

The proposed post hoc I-distance approach is able to reveal specific priority areas for each country so that policymakers could focus their attention on the areas where relevant policies, programs and action plans would have the most significant impact on the overall relative position of the country. It could be used to assess sustainable development in one country by the specific statistically-determined importance level. Clear identification and focus on those priority areas can represent a solid background in planning and regular monitoring of progress towards the strategic objectives of sustainable development. It can provide significant inputs for policy adjustment processes to identify and propose the most efficient programs and measures. Policymakers could use it to benchmark policies and to evaluate consequence and influence of the alternative scenarios on the country's position relative to others.

There are many factors that explain reasons for the current situation in one country, but obviously their importance and significance cannot be equal. In our approach, I-distance method is used to assess the relative contribution of the indicators in an iterative process, resulting in eight SSI indicators that are identified as the most significant. First ranked country is Norway, similar to its first position on the UN's 2014 HDI list (UNDP, 2014). It has superb performances in the most of variables and dimensions, coupled with the very low level of rank oscillations through iterations. Although Norway does not have the best scores noted for all variables, clearly it has a better balance of the performances over a set of those most crucial indicators compared to all other countries.

Obviously, it is important for policymakers to know and understand their country's relative position in terms of the achieved level of sustainable development per dimensions and overall. However, even more important for them is to know in which areas improvements are possible, how these improvements would impact their positioning and in which areas those improvements would provide the most efficient effects on the sustainability ranking. The proposed approach can improve capabilities of policymakers to understand the implications of selected sustainability-related policies and their impacts on the shaping and making development sustainable. As in reality trade-offs are inevitable, there is an imminent need for well-based and balanced choices to be made during policy creation and adjustment, where this approach could provide important insight of relative importance and contribution of alternative actions and measures in different areas.

Further potential study could be directed towards assessment of each SSI dimension separately based on CIDI approach, in order to better understand relative importance of variables within corresponding dimension and to exceed limitations of the originally applied equal weighting scheme. Moreover, our approach could be the foundation for the development of a more general framework for evaluation and improvement of some other composite indicators concepts and approaches, not necessarily in the area of sustainable development.

The main contribution of the paper is the application of the I-distance methodology in an iterative process focused on assessment of the relative contribution of individual indicators to the final position of the countries and appropriate stepwise reduction of number of indicators. By this, we not only improve stability and overall quality of the model but also provide in-depth analysis and more comprehensive understanding of specific factors that determines one country ranking position. This is of crucial importance policymakers to identify key indicators and focus the priority areas where appropriate policies, programs and measures would have the most efficient impact on the overall positioning of the country in terms of sustainable development.

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