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A Novel Approach to Evaluating Sustainable Development

Nowe podejście do waloryzacji rozwoju zrównoważonego

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Abstract
Sustainable development is a difficult issue to measure and there is no one method agreed upon. In this article a statistical method, which synthesizes many indicators into one quantitative indicator is proposed. 27 member states of the European Union has been analyzed. The results have demonstrated that Sweden and Denmark are the two top EU countries concerning sustainable development. On the other hand, the newest EU members, such as Latvia, Hungary, Estonia, Lithuania and Slovakia, remain at the bottom of the ranking. It is a challenge for the EU, since it has the ambition to take a lead on sustainable development on the global level.
It should be emphasized, that the proposed statistical method can be applied to all other regions of the world and can provide useful information as to whether the world is actually moving towards the goals of sustainable development.

Key words: sustainable development, I-distance method, ranking of countries

Streszczenie
Rozwój zrównoważony jest zagadnieniem trudnym do zmierzenia, tym bardziej, że nie ma jednej uniwersalnej metody takiego pomiaru. W tym artykule proponujemy metodę statystyczną, która sprowadza wiele wskaźników w jeden wskaźnik ilościowy. Przeanalizowano uwarunkowania rozwoju zrównoważonego w 27 krajach Unii Europejskiej. Rezultaty pokazują, że najbardziej zaawansowanymi we wdrażaniu tego rozwoju są Szwecja i Dania. Na drugim końcu skali znajdują się nowi członkowie UE, kraje takie jak Łotwa, Węgry, Estonia, Litwa i Słowacja. To wyzwanie dla Unii, jeśli chce ona odgrywać wiodącą rolę we wdrażaniu rozwoju zrównoważonego w perspektywie globalnej.
Należy podkreślić, że proponowaną metodę można zastosować w stosunku do wszystkich innych regionów, a poprzez to uzyskać informacje pozwalającej określić, czy świat zmierza w kierunku realizacji celów zrównoważonego rozwoju.

Słowa kluczowe: rozwój zrównoważony, metoda I-distance, ranking krajów

Introduction

The most often quoted definition of sustainability comes from the 1987 report published by the World Commission on Environment and Development (WCED), also known as the Brundtland Commission (WCED, 1987; Petrovic et al., 2010; Petrovic et al., 2011a,b, Redclift, 2009). Environmental sustainability and development are defined as a single, indivisible issue, which, consequently, led to the following definition: *Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs* (WCED, 1987, p. 43). Based on this widely accepted definition, the philosophy of welfare can be studied in the same manner as a country's social, economic and environmental development (Kras, 2011; Durbin, 2010).
In addition, the *Earth Charter* shows the evolution of the sustainability concept, particularly in respect to the inclusion of social and economic justice components (The Earth Charter, 2008). It possesses

the power to challenge the dominant paradigm of economic development as being the yardstick for individual, community, national, and global progress, since it *is founded on the principle that caring for the earth and caring for people are two dimensions of the same task* (Greenwood, 2004, p. 96).

Since sustainability is a multidimensional concept, economic, social and environmental aspects must be considered and integrated (Pope et al., 2004; Pawłowski, 2009; Tuziak, 2010). The appropriate instrument for multidimensional representation is a suitable set of indicators that must be an integral part of an assessment methodology to be used for the purposes of measuring sustainability (Bruni et al., 2011; Mihci & Mollaveligiu, 2011; Moffat et al., 2001; Ness et al., 2007; Zhong et al., 2011). Improvements in the way the indicators are constructed and used are very important research issues (Munda and Nardo, 2009). Precisely, this paper shall evaluate sustainability by implementing many variables and create one synthesized indicator. The methodology used here is very similar to propositions made by Ivanovic in his work (Ivanovic, 1973); according to whom, the choice of social and economic development indicators is certainly one of the most important problems when evaluating countries. There is a certain number of indicators, which are always thought to provide the most reliable information on national social and economic development (Ivanovic, 1977). They are most frequently used in evaluating country's development level; for example, its *per capita* GDP, its literacy rate or the percentage of its population not employed in agriculture. However, the lists of development indicators used in various national or international research institutions are not always identical, and there is constant controversy concerning the value and importance of one or another of these well-established indicators (Ivanovic, 1973). In accordance with these ideas, sustainable development shall be evaluated though the headline indicators of *European Union Sustainable Development Indicators.*

I-distance Method

Quite often, the ranking of specific marks is done in a way that can seriously affect the process of taking exams, sport competitions, UN participation, Universities ranking, medicine selection and many others (Al-Lagilli et al., 2011; Ivanovic, 1973; Ivanovic and Fanchette, 1973; Jeremic and Radojicic, 2010; Jeremic et al., 2011a).

I-distance is a metric distance in an n-dimensional space. It was proposed and defined by B. Ivanovic in various publications that have appeared since 1963 (Ivanovic, 1973). Ivanovic devised this method to rank countries according to their level of development based on several indicators. Many socio-economic development indicators were considered and the problem was how to use all of them in order to calculate a single synthetic indicator, which will thereafter represent the rank.

For a selected set of variables $X^T = (X_1, X_2, \ldots X_k)$ chosen to characterize the entities, the I-distance between the two entities $e_r = (x_{1r}, x_{2r}, \ldots, x_{kr})$ and $e_s = (x_{1s}, x_{2s}, \ldots, x_{ks})$ is defined as

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

where $d_i(r,s)$ is the distance between the values of variable X_i for e_r and e_s, e.g. the discriminate effect,

$$d_i(r,s) = x_{ir} - x_{is}, \qquad i \in \{1, \ldots, k\} \qquad (2)$$

σ_i the standard deviation of X_i, and $r_{ji.12..j-1}$ is a partial coefficient of the correlation between X_i and X_j, ($j<i$), (Ivanovic, 1973; Jeremic et al., 2011d).

The construction of the I-distance is iterative; it is calculated through the following steps:

- Calculate the value of the discriminate effect of the variable X_1 (the most significant variable, which provides the largest amount of information on the phenomena that are to be ranked – the variable which has greatest correlation coefficient with I-distance value (Ivanovic, 1977).
- Add the value of the discriminate effect of X_2 which is not covered by X_1.
- Add the value of the discriminate effect of X_3 which is not covered by X_1 and X_2.
- Repeat the procedure for all variables (Mihailovic et al., 2009; Jeremic et al., 2012).

Sometimes, it is not possible to achieve the same sign mark for all variables in all sets, and, as a result, a negative correlation coefficient and a negative coefficient of partial correlation may occur (Jeremic et al., 2011b,c). This makes the use of the square I-distance even more desirable. The square I-distance is given as:

$$D^2(r,s) = \sum_{i=1}^{k} \frac{d_i^2(r,s)}{\sigma_i^2} \prod_{j=1}^{i-1} \left(1 - r_{ji.12\ldots j-1}^2\right) \quad (3)$$

In order to rank the entities (in this case, countries), it is necessary to have one entity fixed as a referent in the observing set using the I-distance methodology. The entity with the minimal value for each indicator, or a fictive maximal, or average values entity can be set up as the referent entity. The ranking of entities in the set is based on the calculated distance from the referent entity.

The Results

In this paper, the sustainable development of the 27 member states of the European Union has been analyzed. As input variables, the Sustainable Development Indicators of *EU Sustainable Development Strategy* have been used (Eurostat, 2010). In order to rank the countries of the European Union, the following 11 variables have been used.

Table 1. Sustainable Indicators for Determining a Country's Wellbeing (Authors' own work).

Theme	Headline Indicators
Socio-economic development	Growth rate of real GDP *per capita*
Sustainable consumption and production	Resource productivity
Social inclusion	Population at-risk-of-poverty or exclusion
Public health	Healthy life years: male
	Healthy life years: female
Climate change and energy	Greenhouse gas emissions
	Share of renewable energy in gross final energy consumption
Demographic changes	Employment rate of older workers: male
	Employment rate of older workers: female
Sustainable transport	Energy consumption of transport relative to GDP
Global partnership	Official development assistance as a share of the gross national income

Table 2. The Results of the Square I-distance Method, I-distance Value and Rank (Authors' own work).

Country	***I-distance***	***Rank I-distance***
Sweden	44.645	1
Denmark	30.500	2
Luxembourg	29.453	3
The Netherlands	26.512	4
United Kingdom	24.629	5
Cyprus	24.422	6
Spain	19.084	7
Malta	18.726	8
Ireland	17.693	9
Germany	17.676	10
Poland	17.097	11
Bulgaria	16.103	12
Austria	15.724	13
Greece	15.581	14
Italy	15.411	15
Czech Republic	13.935	16
France	13.739	17
Portugal	13.281	18
Finland	13.152	19
Belgium	11.383	20
Romania	9.426	21
Slovenia	7.685	22
Latvia	6.708	23
Hungary	6.694	24
Estonia	5.736	25
Lithuania	5.66	26
Slovakia	3.838	27

The results achieved through the use of the I-distance ranking method are presented in Table 2. Sweden and Denmark topped the list according to the I-distance method, while the newest EU members such as Latvia, Hungary, Estonia, Lithuania and Slovakia, came in at the bottom of the ranking. This data set was further examined and a correlation coefficient of each indicator with its I-distance value was determined, the results of which are presented in Table 3 (the Pearson correlation test has been used here).

Table 3. The Correlation between I-distance and Input Indicators (Authors' own work).

Indicators	r
Official development assistance as share of gross national income	.803**
Healthy life years: male	.706**
Growth rate of real GDP *per capita*	.670**
Resource productivity	.600**
Healthy life years: female	.628**
Employment rate of older workers: male	.535**
Employment rate of older workers: female	.429*
Greenhouse gas emissions	.341
Share of renewable energy in gross final energy consumption	.112
Energy consumption of transport relative to GDP	.024
Population at-risk-of-poverty or exclusion	.022

** p<.01, *p<.05.

As the results show, official development assistance as share of gross national income is the most significant variable, with r=.803, p<.01. Additionally, a very interesting finding is that resource productivity has a significant correlation with I-distance ranking, with r=.600 (p<.01). This result is far from unexpected. Many papers regarded development assistance and resource productivity as very important sustainable development indicators (Hu et al., 2011; Pitt et al., 2011; Polimeni 2011; Steinberger et al., 2010). In addition, it is worth to mention that renewable energy in gross final energy consumption is of great concern for the EU (EU Energy Policy, 2010) but countries are far from achieving 2020 predicted goals. On the other hand, the growth rate of real GDP *per capita* was ranked as being the third most significant indicator. Although GDP has very often been used as the most significant indicator in the past (Davidson, 2000), it must be now acknowledged that it is essential to implement components of sustainable development into research.

Conclusion

The environment provides numerous goods and services to humanity. Keeping with this, the integration of ecology into general development, according to the principle of sustainable development, is an obvious necessity (Mitchell, 2006; Ropke, 2005). Therein, the approach presented in this paper has demonstrated that EU countries have to dramatically improve their policies concerning sustainable development. This paper contributes to this issue by implementing entirely new approach that integrates many sustainable indicators into one indicator. Real benefit from this approach is that large number of variables can be included into analysis, many of them with different type of measurement. I-distance method proved to be quite useful and applicable. On the other hand, one can argue that different choice of sustainable indicators could potentially lead to different ranking. Either way, it is essential to further elaborate on this issue and potentially create a framework for evaluating sustainable development.

As a final synthesis regarding which goals and topics are most relevant in the context of sustainable development (UNEP, 2007; UNDSD, 2008), six main policy pillars can be proposed to encompass a variety of sustainability issues:

- sustaining natural capital – biodiversity, water, air;
- sustaining life support systems – ecosystems, ecosystem services, resources;
- minimizing human impact – climate change, pollution, waste, desertification, population growth;
- developing human capital – human rights, political liberties, learning, equity, health, wealth;
- developing social capital – solidarity, community, culture;
- developing economies – economy, agriculture, consumption, employment, technology;
- developing institutions – proper governance, democracy, transparency, public participation, international cooperation (Quental et al., 2011).

Only by implementing these six policy pillars, a country can improve its level of sustainable development and fulfill *Millennium Development Goals.*

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