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Investigation of multi-criteria method for the assessment of sustainable development: The case of Lithuania

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Abstract

The process of implementing **s**ustainable development started at the end of the 20th century with the aim to balance economic, social and environmental development and minimize damage to humans and the environment. Nowadays, when new economic problems emerge social interest groups lobby, environmental standards are raised, sustainable development becomes an integral part of democratic society and is a particularly relevant object of scientific investigations. Taking into consideration the aspect of sustainable development complex assessment, the research problem can be formulated as follows: how to assess sustainable development comprehensively? This research, according to statistical data analysis (Lithuania's case), identifies multi-criteria method (SAW) as the best method of analyzing sustainable development from the approach of different dimensions (economic, social and environmental).

According to the results of SAW method, it can be noted that when a country is improving economic indicators, environmental indicators usually decrease, which in turn determines the characteristics of the social dimension slight decrease.

Keywords*:* multi-criteria method, sustainable development, complex assessment, SAW method.

Introduction

In the scientific literature (Du Pisani, 2006; Kates, Parris, & Leiserowitz, 2005; Estes, 1993; Pearce, & Atkinson, 1998) authors often use the United Nations Environment and Development Commission's presented definition of sustainable development: sustainable development as development that meets the needs of the current period, without risk to future generations to meet them. That means that economic development meets the environmental requirements. J. R. Engel, and J. G. Engel (1990) gives a broader approach to sustainable development. They argue that sustainable development is a human activity that contributes to the development of the community on Earth. P. Dasgupta (2007) says that sustainable development is a kind of economic program in which the welfare of current and future generations is becoming more important and relevant.

P. Hjorth, and A. Bagheri (2006) argue that R. Solow describes sustainability as production capacity in the long term and D. W. Pearce, E. Barbier, and A. Markandya (1990) notes that the development is as social goals, which society is trying to maximize by using general indicators: increase of real income per capita; improvement of hygiene and dietary conditions, education, access to resources, equitable distribution of wealth and freedom.

H. T. Odum (1994) provides another approach to sustainable development. He argues that the real world is always changing. If the difference is positive, then the sustainability can be as natural capital (environment) management. Therefore, sustainability can only be understood as the process of adaptation to change, a lot of emphasis on the management and standards setting. I emphasize, however, that although sustainable development really is a dynamic process, to "insert" sustainable development in certain "frames" (or standards) is more or less impossible. It is also impossible to predict what will happen in the future, because any negative changes can unbalance all calculations or forecasts. Therefore, the process of normalization of sustainable development is unlikely to help because the situation both domestically and around the world is constantly changing, and it cannot be predicted precisely. That is why the aim of my research is to find out how we can identify the sustainable development and how we can measure and evaluate this process. In the article I used SAW method as one of the most frequently used methods in the social sciences. This method will help me to make an analysis and to evaluate the situation of sustainable development in Lithuania.

Literature review

Sustainable development in Lithuania mostly analyzes R. Čiegis (2004a, 2004b, 2004c; 2009a, 2009b) and with co-authors (Čiegis, & Gavenauskas, 2005a; Čiegis, Ramanauskienė, & Martinkus, 2009; Čiegis, Tamošiūnas, Ramanauskienė, & Navickas, 2010; and et al.). Various aspects of sustainable development emphasizes D. Štreimikienė (Štreimikienė, & Kovaliov, 2007; Štreimikienė, Čiegis, & Jankauskas, 2007), J. Staniškis (Staniškis, Arbačiauskas, & Stasiškienė, 2008) and other scientists. Although Lithuanian scientists and scientists of the world (Fanelli, 2007; Hacking, & Guthrie, 2008; Lee, 2001; Nader, Salloum, & Karam, 2008; Wilson, Tyedmers, & Pelot, 2007) analyze sustainable development issues and focus on sustainable development assessment, but there is no fully formulated unified methodology that would allow the country to assess the sustainability.

United Nations Commission on Sustainable Development notes 61 sustainable development indicators: 14 indicators attributed to the economic dimension, 20 indicators - the environmental dimension, 21 indicators - the social dimension. Meanwhile, the Eurostat database indicates 138 sustainable development indicators, divided into four levels: Level 1, Level 2, Level 3 and Contextual indicators. Level 1 comprises 11 indicators, level 2 - 31 indicators, level 3 - 84 indicators and there are 12 contextual indicators. Also, all of these indicators are divided into ten groups: Socio-economic development, Sustainable consumption and produc-

tion, Social Inclusion, Demographic changes, Public health, Climate change and energy, Sustainable transport, Natural Resources, Global partnership and Good governance.

The National Strategy for Sustainable Development in Lithuania was approved in 2003. In 2006 the EU Council adopted a renewed EU Sustainable Development Strategy and obliged Member States to carry out the relevant national sustainable development strategy, so Lithuanian National Sustainable Development Strategy was updated in 2009. This new national sustainable development strategy contains 84 indicators of sustainable development. Sustainable development indicators are divided into three main sustainable development sectors: environmental (17 indicators), economic development (figure 31) and social development (27 indicators) (National strategy for sustainable development, 2011).

After the evaluation of literature review, I can state that there is no unified methodology for the establishment of indicators, because in the world there are more than 500 indicators of sustainable development (if we count both less and more developed countries). So to set the sufficient number of indicators is very important if we want to analyze a country's sustainable development situation.

Multi-criteria assessment methodology

For the evaluation of sustainable development multi-criteria methods are very important, because then the assessment is performed by various economic, social, environmental and other aspects. Multi-criteria methods can solve problems arising from the different priorities of the people in a decision-making processes.

According to V. Belton, and T. J. Steward (2002), multiple analysis can still choose the optimal solution even if there are conflicting criteria. Therefore, multi-criteria methods are suitable for sustainable development assessment because of different conflicting criteria (Čiegis, Tamošiūnas, Ramanauskienė, & Navickas, 2010).

In the scientific literature (Sage, 1977; Chankong, & Haimes, 1983; French, Simpson et al, 1998; Hwang, & Lin, 1987; Triantaphyllou, 2000; Zimmermann, 2000) multi-criteria decision-making methods are usually divided into two categories: Multi-attribute decision-making (MADM), which solves tasks in a discrete space, and Multi-objective decision-making (MODM), which deals with vectorial crest problems on a continuous decision space. Z. Turskis, E. K. Zavadskas, and F. Peldschus (2009) emphasize, that alternatives of multi-criteria assessment can be described by quantitative (measurable) indicators, qualitative (identified by expert survey or other form of scale). Some methods can be described by verbal (lexicographical) indicators.

Scientific literature (Zavadskas, Turskis, Tamošaitienė, & Marina, 2008a, 2008b) indicates very wide variety of multi-criteria analysis: SAW - *Simple Additive Weighting* method (Ginevičius, Podvezko, & Bruzgė, 2008; Sivilevičius, Zavadskas, & Turskis, 2008), MOORA -. *Multi-Objective Optimization on the Basis of Ratio Analysis* method (Brauers, & Zavadskas, 2006; Brauers, Zavadskas, Peldschus, & Turskis, 2008; Kalibatas, & Turskis, 2008); TOPSIS -. *Technique for Order Preference*

by Similarity to Ideal Solution method (Hwang, & Yoon, 1981; Zavadskas, Zakarevičius, & Antuchevičienė, 2006); VIKOR - *Compromise ranking* method (Zavadskas, & Antuchevičienė, 2007); COPRAS - *Complex Proportional Assessment* method (Zavadskas, Kaklauskas, Peldschus, & Turskis, 2007); *Game theory* (Peldschus, & Zavadskas, 2005; Antuchevičienė, Turskis, & Zavadskas, 2006) and other multi--criteria evaluation methods.

For the assessment of sustainable development there is one mostly used multi--criteria method SAW (Ginevičius, & Podvezko, 2004a, 2004b, 2005, 2007a, 2007b, 2008a, 2008b; Ustinovičius, & Zavadskas, 2004). The main criteria (or index) S_j is the sum of the weighted normalized values and shows the best alternative:

$$S_j = \sum_{i=1}^{m} w_i \tilde{r}_j \; ; \qquad (1)$$

where: w_i – the weight of i-th criterion; $\tilde{r}_{ij}$ – normalized i-th criterion's value for j-th object.

SAW method applies the „classical" normalization using this formula (Ginevičius, & Podvezko, 2007a, b):

$$\tilde{r}_{ij} = \frac{r_j}{\sum_{j=1}^{n} r_j}, \text{ when: } \sum_{j=1}^{n} \tilde{r}_{ij} = 1. \qquad (2)$$

The largest value of the criterion S_j corresponds to the best alternative.

For the using SAW method, first, we have to make normalized matrix $\tilde{R}$ of decision (or indicators). Each indicator has a different rate, units, so normalized matrix will include these elements:

$$\tilde{R} = \begin{bmatrix} \tilde{r}_1 & \tilde{r}_2 & \dots & \tilde{r}_{1m} \\ \tilde{r}_2 & \tilde{r}_2 & \dots & \tilde{r}_{2m} \\ \dots & \dots & \dots & \dots \\ \tilde{r}_{n1} & \tilde{r}_{n2} & \dots & \tilde{r}_m \end{bmatrix}; \qquad (3)$$

where: i=1, 2, …, m; j=1, 2, …, n; n – the number of alternatives; m – the number of indicators.

Indicator values are normalized using the formula (2). Normalization of indicators need to take into account the fact that some indicators show the increasing

significance of an improving situation (eg., The gross domestic product, investment, level of education), and other indicators (eg., The unemployment rate, the energy intensity of deaths) increase indicate a worse situation. Therefore, in SAW method minimizing indicators should be reorganized to maximizing. C. L. Hwang, and K. S. Yoon (1981); R. Ginevičius, and V. Podvezko (2007a) propose to do this using the following formula.

$$\hat{r}_{ij} = \frac{\min_j r_j}{r_j}; \qquad (4)$$

where: $\hat{r}_{ij}$ – maximized i-th criterion's value; $\min_j r_j$ – minimum i-th criterion's value ($\min_j r_j > 0$).

In most cases, minimum i-th criterion's value cannot be equal to 0 or a negative. If there is negative value of the indicator (eg., perhaps in the country was deflation or household savings rate in a given period is negative), so the value of this indicator should be recalculated according to the following formula:

$$r_{ij}' = r_j + \left|\min_j r_j\right| + 1; \qquad (5)$$

where: r_{ij} – i-th criterion's value; r_{ij}' –shifted i-th criterion's value for j-th object.

A review of SAW methodology helps to evaluate a country's situation and to identify what kind of indicators we need (i.e. in Lithuania's case). It can be noted that for the assessment of sustainable development various indicators were selected: from *economic dimension* - real GDP per capita; investment rate; real labour productivity growth per hour worked; total unemployment rate; electricity consumption of households; energy dependence; from *social dimension* - persons at--risk-of-poverty after social transfers; inequality of income distribution; lower secondary educational attainment; total fertility rate; death rate due to chronic diseases; and from *environmental dimension* - greenhouse gas emissions; share of renewable resources in gross final energy consumption; average CO_2 emissions per km from new passenger cars; waste generation and treatment; water exploitation index. An analysis was for the period of 2004-2013.

Analysis of sustainable development in Lithuania

Based on the set of sustainable development indicators, sustainable development assessment in Lithuania was done for the period of 2004-2013. The results of multi-criteria assessment (the final index and ranks) presented in Table 1.

Tab.1. The results of SAW method

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Sj (SAW)	0,07639	0,07944	0,08424	0,09357	0,12032	0,08652	0,09103	0,11074	0,12473	0,13302
Rank	10	9	8	5	3	7	6	4	2	1
GDP, mln. EUR	18237,7	21002,4	24079,2	29040,7	32696,3	26934,8	28001,3	31247,3	33314	34955,6
GDP growth rate, %	-	15,16	14,65	20,61	12,59	-17,62	3,96	11,59	6,43	4,93

Source: own research

According to the results of SAW method, the worst position was for the period 2004-2006 (the highest ranks), and the best position was in 2013 (with lowest ranks). In order to compare the rank with GDP growth rates, it was necessary to recalculate the positions of ranks, i.e. in a good position to create the maximum rank and a bad position - lowest rank.

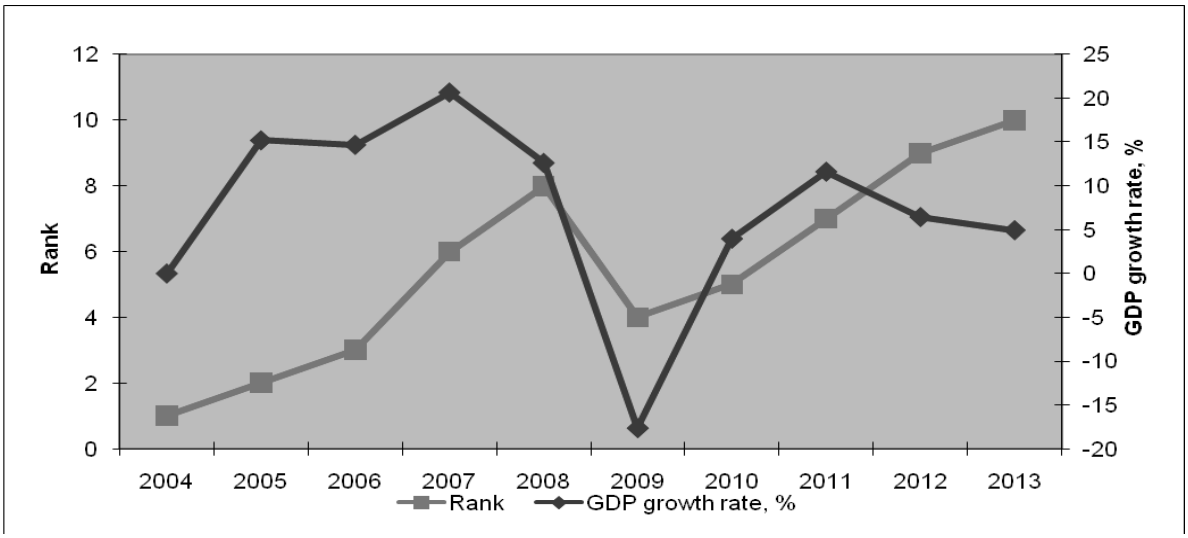

Fig. 1. Recalculated ranks of SAW method and GDP growth rates dynamics
Source: own research

According to recalculated ranks of SAW method and GDP growth rates, the period of 2004-2005 associated with Lithuania's accession to the European Union and NATO. Ranks of SAW method increased, which reflects positively all the events that occurred during this period. However, it is noted that government expenditures on social issues in 2006 were lower than in 2005. That shows that the improvement in the social field is not the main direction of government appropriations (Lithuanian Macroeconomic Review, 2005).

In the period of 2006-2007 Lithuania tried to become a full member of the euro area, it improved macroeconomic indicators, but in 2007 Lithuania was not able to adopt the euro because of inflation, which did not meet the specified level. During this period citizens took loans from the banking sector, which led to extremely

rapid growth of real estate prices. Therefore, such fluctuations also reflected in the ranks of multi-criteria method.

The period of 2008 was related with the US financial crisis, which led to further deterioration of economic indicators and declines not only in Lithuania, but also in other parts of the world. In 2009 GDP growth was negative, which means a decrease in GDP. All indicators (economic, social and environmental) decreased and showed especially bad positions in the labour market. However, in 2010 the Lithuanian economy has started to recover, sustainable development indicators changed for the better. Although since 2012 GDP growth slowed down, but it shows that from the developing country Lithuania becomes more developed (as we know, more developed countries' GDP growth rate usually slow down, and that is a normal process).

Multi-criteria evaluation also showed that ranks fluctuated in the same direction as GDP. It can be concluded that the economic downturn has affected the sustainable development (negatively), but only because of this attention was drawn to environmental problems, the public welfare, and the most important instrument became institutions and regulation.

Conclusions

Summing up the results of sustainable development, it should be mentioned that the assessment of sustainable development is appropriate for the SAW method. The reliability of this method shows two main aspects. First of all, on the basis of mathematical logic, SAW method result (factor) ranking from 0 (worst situation of the country) to 1 (the best situation of the country). Second, in the world SAW method is popular, there are a lot of researches and foreign practices of the use of SAW method, so the frequency shows that the method is the best and most appropriate in sustainable development assessment.

Analyzing the situation in Lithuania it was noted that the bad situation in the field of sustainable development was in 2004-2006 and the economic crisis in 2009. However, in spite of all the difficulties, Lithuanian economy since 2010 began to grow. The paradox, but in most cases (especially in the analysis of sustainable development indicators) has been observed that economic growth leads to a deterioration of environmental indicators, holistic sustainable development principle stops to exist (holistic principle gives equal attention to all sustainable development dimensions). When a country is improving economic indicators, environmental indicators usually decrease, which in turn determines the characteristics of the social dimension slight decrease. Sustainable development analysis in Lithuania showed that when the economy is growing, so citizens and government should pay more attention for environmental improvement.

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