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COMPOSITE INDEX OF SUSTAINABLE DEVELOPMENT IN THE FUNCTION OF EXAMINATION OF BALANCED ENVIRONMENTAL AND ECONOMIC DEVELOPMENT IN EU COUNTRIES

Vesna Janković Milić [*]

Sonja Jovanović [*]

Abstract: *Realization of the concept of sustainable development through the maintenance and improvement of the competitiveness of the national economy stands for the challenge that every country is faced with under modern conditions of development. The subject of this paper is the issue of achieved level of sustainable development of European Union (EU) countries. The paper aims at calculating the composite index of sustainable development (CISD) and classifying EU countries into homogeneous groups on the basis of the achieved level of sustainable development and competitiveness of their national economies.*

Keywords*: composite index; European Union; sustainable development.*

1. Introduction

The issue of protection of natural resources has become globally topical during the 1970s. During that period, numerous analyses that dealt with limited possibilities of the environment to support further economic growth and development were published (Meadows et al. 1972). "That was, in the first place, influenced by unfavorable environmental situation caused by economic growth, as well as by the fears stemming from the lack of natural resources on which modern production rests." (Jovanović-Gavrilović, 2006, 53). Pointing to the so-called "limits to growth" implied warnings that were related to the prospects of producing sufficient food in the face of rapid increase of population. The solution for this situation lay in balancing economic growth and the degree of exploitation of natural resources. The approach on the basis of which it was possible to achieve this

[*] University of Niš, Faculty of Economics, Serbia;
✉ vesna.jankovic@eknfak.ni.ac.rs, sonja.jovanovic@eknfak.ni.ac.rs
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balance implied the application of the concept of sustainable development. The concept of sustainable development was originally defined in the Report[1] of the United Nations World Commission on Environment and Development in 1987. "Sustainable development offers new theoretical paradigm that differs from the standard economic approach. Consideration of the new paradigm is justified due to the fact that global reality has significantly changed in relation to the previous period when economic policy could be formulated without considering its impact on the environment" (Harris 2009, 32).

"Today, resource demand is so high that biocapacity – the services and resources that nature makes available – is being overexploited, not just locally but at the planetary scale. If these trends continue resource constraints will become a leading factor determining economic success – or crisis – in the 21st century" (Global Footprint Network). Because of that, maintenance of competitive advantage within national economies and high level of sustainable development stand for the challenge that all countries are faced with.

Sustainable development is seen as the primary priority of almost all contemporary strategies and models of development. What is more, elements of the concept of sustainability are involved into the highest legislative acts of certain countries as well as the entire EU.

2. Composite Index of Sustainable Development

With the purpose of showing the situation or performances in a specific area, data can be displayed in several different ways. That means that the indicators of conditions in the analyzed area can be categorized into one of these categories:

1) "*Individual indicator* sets represent a menu of separate indicators or statistics. This can be seen as a first step in stockpiling of the existing quantitative information.
2) *Thematic indicators* are individual indicators which are grouped together around a specific area or theme. This approach requires identification of a core set of indicators that are linked or related in some way. They are generally presented individually rather than synthesized in a composite (e.g. OECD's Measuring the Information Economy).
3) *Composite indicators* are formed when thematic indicators are compiled into a synthetic index and presented as a single composite measure" (Freudenberg 2003).

The need to define a composite index occurs in situations when the individual indicators cannot present complex/multidimensional concept in an adequate way. The situation is such in the case of sustainable development. With the help of one such index, it is possible to compare countries by taking into account great number of different dimensions or performances (natural environment, economic development, social development) simultaneously. In other words "the composite indicator should ideally measure multi-dimensional concepts which cannot be captured by a single indicator, e.g. competitiveness, industrialization, sustainability, single market integration, knowledge-based society, etc." (Handbook on Constructing Composite Indicators – Methodology and User Guide 2012, 13). In order to avoid large amounts of data and indicators during the

[1] Report entitled *Our Common Future* defined sustainable development as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

process of designing the development strategies and policies, decision makers, who stand for the users of these information, replace the data by a composite index and obtain considerable benefit in doing so. "Composite indicators (CIs) that compare country performance are increasingly recognized as a useful tool in policy analysis and public communication" (Handbook on Constructing Composite Indicators – Methodology and User Guide 2012, 13).

The quality of the composite index does not only depend on the methodology used for its construction, but on the quality of data used in the analysis as well. In this regard, it is possible to identify both good and bad sides of the composite index.

Strengths of the composite index can be identified as follows:

- The same amount of information or more information than needed can be obtained with a smaller number of indicators;
- They enable easier interpretation of a specific problem;
- These indicators are useful for comparing performances among countries;
- They are useful for policy makers when designing strategies and development plans on the basis of simultaneous processes of decision making regarding the goals from different areas (e.g. the goal of sustainable development).

Disadvantages of the composite index:

- With this method, the conclusions can be simplified and this method does not present a true picture of the situation in a particular area;
- Using inappropriate statistical methods, inadequate information can be obtained.

3. Research Methodology

The subject of this analysis is the examination of the achieved level of sustainable development of EU countries and their classification into homogeneous groups according to the indicators of sustainability and competitiveness of their national economies. The aim of this study is to create the composite index of sustainable development, based on several indicators of different sustainability dimensions.

Information base for this analysis consists of: World Economic Forum Reports on the level of competitiveness of national economies (Global Competitiveness Index – GCI), Yale University Reports (Yale Center for Environmental Law and Policy – YCELP), Columbia University (Center for International Earth Science Information Network – CIESIN) in collaboration with World Economic Forum on Environmental Performance Index (EPI), International Monetary Fund data on GDP, and Transparency International data on Corruption Perceptions Index (CPI)[2].

[2] *GCI* is used for measuring and monitoring the country's competitiveness level. The base of this Index is composed of the three subindices: *Basic requirements, Efficiency enhancers, and Innovation factors*. Each subindex is composed of a number of pillars, which help to perform the estimation of national competitiveness.
EPI provides framework which allows greater detail in the analysis of environmental performances. *EPI* consists of two components: *Environmental health* (shows the influence of environmental

For this research the following statistical methods were used: correlation analysis, cluster analysis, and weighting and aggregation methods. On the basis of what has been mentioned so far, it is necessary to:

- Calculate the composite index of sustainable development;
- Explore the correlation between the obtained composite index of sustainable development and the Global Competitiveness Index;
- Classify the EU countries into homogenous groups according to the calculated composite index of sustainable development and the Global Competitiveness Index.

4. Research Results and Discussion

Methodological procedure for calculating the composite index of sustainable development consists of five steps.

1) Selection of indicators – The adequate selection of indicators and variables is very important for increasing the reliability of the obtained composite index. This stage of the composite index calculation may result in the problems related to data collection, or problems related to the fact that data are not comparable among countries. With the purpose of overcoming possible problems, the following criteria for the selection of indicators can be recommended: *relevance* of indicators for the research; *redundancy* – if there are several indicators that provide the same information, it is necessary to make their selection and if there is a high correlation between two indicators it is desirable to include both in the analysis; *data availability*– the use of indicators with available data in databases or statistical reports (Tarantola 2010).

This step involves the selection of the components of the *composite index of sustainable development* on the basis of indicators that reflect the dimensions of sustainable development (ecological dimension of sustainability – EPI, the economic dimension of sustainability – GDP, the social dimension of sustainability – CPI). In this way, the selected indicators reflect the basic aspects of the concept of sustainable development. The values of selected indicators, chosen for the calculation of the *composite index of sustainable development*, are presented in Table 1.

Table 1. Scores of selected indicators of sustainable development for 2013

Country/ Indicator	*EPI**	*CPI*	*GDP***	Country /Indicator	*EPI**	*CPI*	*GDP***
Austria	78,32	69	48,956.923	Italy	74,36	43	34,714.703
Belgium	66,61	75	45,383.999	Latvia	64,05	53	15,205.424
Bulgaria	64,01	41	7,328.488	Lithuania	61,26	57	16,003.195
Croatia	62,23	48	13,561.708	Luxembourg	83,29	80	110,423.839
Cyprus	66,23	63	24,761.306	Malta	67,42	56	22,872.480
Czech Republic	81,47	48	18,857.914	Netherlands	77,75	83	47,633.622

conditions on human health) and *Ecosystem vitality*, which shows "health of ecosystem" and natural resource management.

CPI ranks countries around the world according to their perceived levels of corruption in public sector. This Index is calculated based on different sources of information about corruption.

Denmark	76,92	91	59,190.745	Poland	69,53	60	13,394.339
Estonia	74,66	68	19,031.941	Portugal	75,80	62	20,727.588
Finland	75,72	89	47,129.297	Romania	50,52	43	8,910.469
France	71,05	71	42,999.968	Slovakia	74,45	47	17,706.196
Germany	80,47	78	44,999.496	Slovenia	76,43	57	22,756.016
Greece	73,28	40	21,857.280	Spain	79,79	59	29,150.345
Hungary	70,28	54	13,404.834	Sweden	78,09	89	57,909.292
Ireland	74,67	72	45,620.711	United Kingdom	77,35	76	39,567.410

Source: 2014 Environmental Performance Index (2014) Yale University (Yale Center for Environmental Law and Policy – YCELP), Columbia University (Center for International Earth Science Information Network – CIESIN) in collaboration with World Economic Forum, http://www.epi2014.yale.edu/; International Monetary Fund, http://www.imf.org/external/pubs/ft/weo/2014/01/weodata/index.aspx; Corruption Perceptions Index, http://www.transparency.org/research/cpi/cpi_2013

**closest available data for the purposes of analysis given in the Report for 2014*

***per capita in US dollars*

2) Judgment of indicators' impact – This step in the process of calculation of the composite index can be based on several statistical techniques and methods: correlation method, factor analysis, data nvelopment analysis, analytic hierarchy process. According to the aim of the research, the causality between indicators of sustainable development (EPI, GDP, CPI) and the competitiveness (GCI) will be determined on the basis of correlation analysis. Values of GCI in EU countries are presented in Table 2.

Table 2. Global Competitiveness Index of EU countries in 2013

Country/Indicator	*GCI*	Country/Indicator	*GCI*
Austria	5,15	Italy	4,41
Belgium	5,13	Latvia	4,40
Bulgaria	4,31	Lithuania	4,41
Croatia	4,13	Luxembourg	5,09
Cyprus	4,30	Malta	4,50
Czech Republic	4,43	Netherlands	5,42
Denmark	5,18	Poland	4,46
Estonia	4,65	Portugal	4,40
Finland	5,54	Romania	4,13
France	5,05	Slovakia	4,10
Germany	5,51	Slovenia	4,25
Greece	3,93	Spain	4,57
Hungary	4,25	Sweden	5,48
Ireland	4,92	United Kingdom	5,37

Source: The Global Competitiveness Report 2013-2014(2013) World Economic Forum, Geneva, Switzerland, www.weforum.org

Estimated values of Spearman Correlation Coefficients between sustainability indicators and GCI will serve as the basis for calculating the weights. Thus, in the second

step of the required calculation of the *composite index of sustainable development*, it is necessary to identify the indicator's impact and to determine the weights.

Table 3. Coefficients and weights

	EPI	*CPI*	*GDP*
Spearman Correlation	0,584	0,880	0,781
Weight (w_i)	0,260	0,392	0,348

Table 3 shows values of correlation coefficients obtained by the ordinary least squares method. These values were the basis for the calculation of EPI, CPI and GDP weights. The sum of weights equals to one, i.e. $\sum_1^3 w_j = 1$.

3) Transformation of indicators – Since the selected indicators are expressed in different units, there is a need for their reduction to the same scale, i.e. for their transformation. There are several ways to transform or normalize the data which are expressed in different units:

- *Ranking* – the simplest technique of transformation, i.e. normalization;
- *Standardization* – data normalization by using the mean and standard deviation of data;
- *Min-max method* – reducing the data to a single scale based on the minimum and maximum observed values in the sample.

In this paper, the transformation of variables (indicators) will be performed by min-max method. The classic method of min-max transformation reduces the value on the scale from 0 to 1. However, in this research, guided by the normalization methodology used by the World Economic Forum for calculating the GCI, we used a modified min-max transformation by which the observed values of indicators are reduced to a scale from 1 to 7.

Values of variables (indicators) transform into normalized values according to the following equation (Eq. (1)) :

$$SIt_{ji} = 6 \times \frac{SI_{ji} - SI_j^{min}}{SI_j^{max} - SI_j^{min}} + 1 \qquad (1)$$

whereby:

SIt_{ji} – transformed value of *j*th indicator in *i*th country

SI_{ji} – observed value of *j*th indicator in *i*th country

SI_j^{min} – minimum value of *j*th indicator in the sample of observed countries

SI_j^{max} - maximum value of *j*th indicator in the sample of observed countries.

In Eq. (1) terms of minimum and maximum value of the indicators represent the lowest and the highest value of a given indicator. Transforming the data, i.e. their ranking on a scale from 1 to 7 increases the ability of comparative indicators.

Table 4. Transformed values of indicators

Country/Indicator	SI_{t1}	SI_{t2}	SI_{t3}	Country/Indicator	SI_{t1}	SI_{t2}	SI_{t3}
Austria	6.090	4.360	3.423	Italy	5.365	1.240	2.594
Belgium	3.946	5.080	3.215	Latvia	3.477	2.440	1.458
Bulgaria	3.470	1.000	1.000	Lithuania	2.966	2.920	1.505
Croatia	3.144	1.840	1.363	Luxembourg	7.000	5.680	7.000
Cyprus	3.876	3.640	2.015	Malta	4.094	2.800	1.905
Czech Republic	6.667	1.840	1.671	Netherlands	5.986	6.040	3.346
Denmark	5.834	7.000	4.018	Poland	4.481	3.280	1.353
Estonia	5.420	4.240	1.681	Portugal	5.629	3.520	1.780
Finland	5.614	6.760	3.316	Romania	1.000	1.240	1.092
France	4.759	4.600	3.076	Slovakia	5.381	1.720	1.604
Germany	6.484	5.440	3.192	Slovenia	5.744	2.920	1.898
Greece	5.167	0.880	1.846	Spain	6.359	3.160	2.270
Hungary	4.618	2.560	1.354	Sweden	6.048	6.760	3.944
Ireland	5.422	4.720	3.229	United Kingdom	5.912	5.200	2.876

In Table 4, SI_{t1} is the transformed value of the EPI, SI_{t2} refers to the transformed value of CPI, while SI_{t3} symbol represents the transformed value of GDP.

4) Weighting of indicators – In order to calculate the *composite index of sustainable development*, weighting of transformed values of indicators will be based on the weights calculated in the second step (Table 5). In that sense, "weights reflect the importance given to the economic, environmental, and social performance of the company, respectively" (Krajnc, Glavič 2005, 197).

The specific values are given to the variables which ultimately affect the value of composite indicators. "The weights given to different variables heavily influence the outcomes of the composite indicator. The rank of a country on a given scale can easily change with alternative weighting systems. In many composite indicators, all variables are given common weights largely for reasons of simplicity" (Freudenberg 2003).

Table 5. Weighted values of indicators

Country/Indicator	w_1SI_{t1}	w_2SI_{t2}	w_3SI_{t3}	Country/Indicator	w_1SI_{t1}	w_2SI_{t2}	w_3SI_{t3}
Austria	1.583	1.709	1.191	Italy	1.395	0.486	0.903
Belgium	1.026	1.991	1.119	Latvia	0.904	0.956	0.508
Bulgaria	0.902	0.392	0.348	Lithuania	0.771	1.145	0.524
Croatia	0.817	0.721	0.474	Luxembourg	1.820	2.227	2.436
Cyprus	1.008	1.427	0.701	Malta	1.065	1.098	0.663
Czech Republic	1.733	0.721	0.582	Netherlands	1.556	2.368	1.164
Denmark	1.517	2.744	1.398	Poland	1.165	1.286	0.471
Estonia	1.409	1.662	0.585	Portugal	1.463	1.380	0.619
Finland	1.460	2.650	1.154	Romania	0.260	0.486	0.380
France	1.237	1.803	1.070	Slovakia	1.399	0.674	0.558
Germany	1.686	2.132	1.111	Slovenia	1.493	1.145	0.660
Greece	1.343	0.345	0.642	Spain	1.653	1.239	0.790
Hungary	1.201	1.004	0.471	Sweden	1.572	2.650	1.372
Ireland	1.410	1.850	1.124	United Kingdom	1.537	2.038	1.001

5) Calculation of the composite index of sustainable development – This phase includes the summarizing (aggregation) of weighted values of chosen indicators and calculating of the value of the *composite index of sustainable development*. Value of this Index ranges from 1 to 7. The value 7 means the highest level of sustainable development while the value 1 presents the minimum reached level of sustainability. "The linear aggregation method is useful when all individual indicators have the same measurement unit, provided that some mathematical properties are respected" (Handbook On Constructing Composite Indicators – Methodology and User Guide 2012, 33).

The last step in methodological procedure implies the calculation of the *composite index of sustainable development*, which is shown as Eq. (2).

$$CISD_i = \sum_{j=1}^{3} w_j SI_{tji} \qquad (2)$$

whereby:

$CISD_i$ – *composite index of sustainable development* for *i*th country, i=1,…,27

w_j – weight given to *j*th indicator, j=1,2,3

SI_{tji} – transformed value of *j*th indicator for *i*th country.

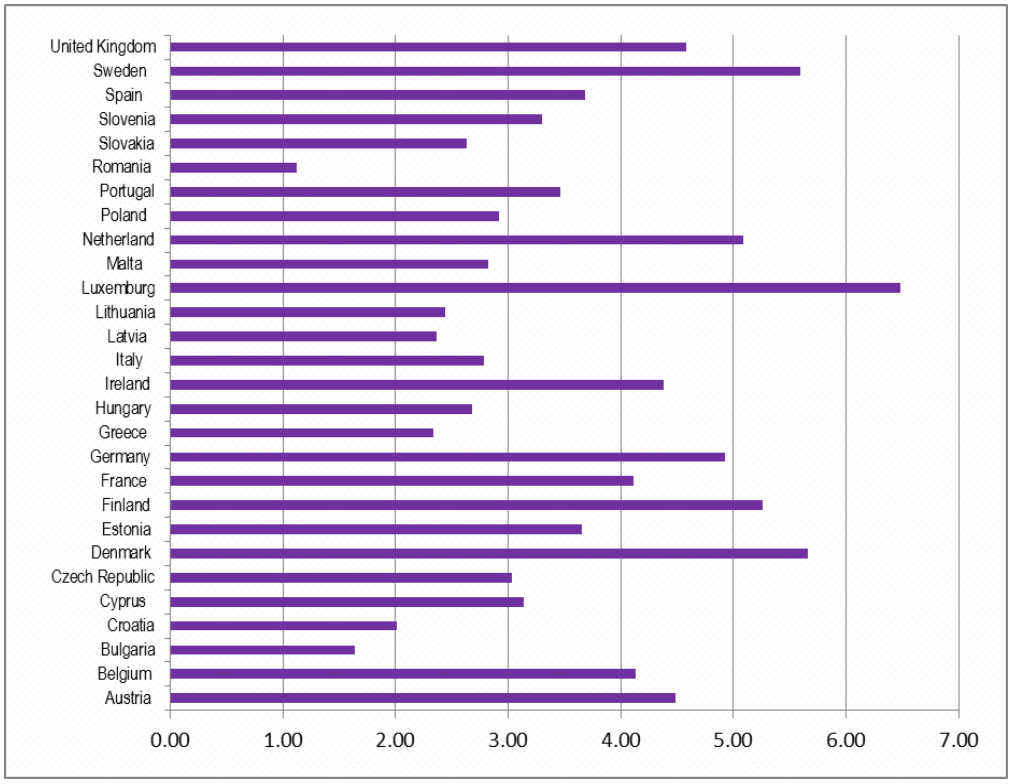
Table 6. Values of the composite index of sustainable development for EU countries in 2013

Country/Indicator	*CISD*	Country/Indicator	*CISD*
Austria	4.48	Italy	2.78
Belgium	4.14	Latvia	2.37
Bulgaria	1.64	Lithuania	2.44
Croatia	2.01	Luxembourg	6.48
Cyprus	3.14	Malta	2.82
Czech Republic	3.04	Netherlands	5.09
Denmark	5.66	Poland	2.92
Estonia	3.66	Portugal	3.46
Finland	5.26	Romania	1.13
France	4.11	Slovakia	2.63
Germany	4.93	Slovenia	3.30
Greece	2.33	Spain	3.68
Hungary	2.68	Sweden	5.59
Ireland	4.38	United Kingdom	4.58

Table 6 shows the values of the CISD for the countries covered by the analysis for the year 2013. The CISD values for EU countries are also presented in Figure 1. It can be noted that Luxemburg has the highest value of the CISD. Luxembourg is followed by Denmark, Sweden, Finland, Netherland, Germany, and United Kingdom. Bulgaria and Romania have the lowest values.

By analysing the observed values of the CISD, it can be noticed that the lowest value of this Index amounts to 1.13, while the maximum value amounts to 6.48. The average value of the CISD in this analysis is 3.60, while the average deviation amounts to 1.323, or 36,77% of the average value.

Figure 1. The CISD values for EU countries in 2013



The values of the GCI in the observed countries range from 3.93 to 5.54 (see Table 2). The average value of the GCI for this group of countries is 4.69, while the average deviation of countries according to the GCI values is 0.49, which amounts to 10.64% of the average value.

The correlation between the composite index of sustainable development and the Global Competitiveness Index

After the calculation, the obtained composite index's relationship with other variables can be tested; in addition, the obtained index can be compared with other indicators or indices (Jovičić 2007, 182). Thus, in this research, the *composite index of sustainable development* is tested with regard to its connection with the Global Competitiveness Index using the correlation analysis. The value of Spearman's rank correlation coefficient between the CISD and the GCI amounts to 0.881. This means that within the analysed group of countries there is a direct and strong correlation between the achieved level of competitiveness and the achieved level of sustainable development.

Besides, according to the data about the CISD and the GCI, it can be noted that:

- the average value of the GCI is higher than the average value of the CISD in observed countries;
- the rang is much wider by the CISD then by the GCI;
- average deviation from the average values of the CISD is much higher in comparison to the average deviation from the GCI average value (36,77% vs. 10.64%). This parameter indicates greater heterogeneity between the observed countries according to the CISD than according to the GCI.

Facts on the high correlation between the CISD and the GCI, and greater heterogeneity of countries according to the CISD in comparison to the GCI have served as the basis for grouping EU countries into homogenous unities according to these two indicators. For this purpose the statistical method, called cluster analysis, was applied.

Classification of EU countries into homogenous groups according to the composite index of sustainable development and the Global Competitiveness Index

Cluster analysis of the mentioned countries according to the *composite index of sustainable development* and the GCI determined the following size of clusters:

- Cluster 1: 8countries;
- Cluster 2: 9 countries;
- Cluster 3: 11 countries.

The structure of clusters is presented in Table 7.

Table 7. Cluster membership of EU countries

Cluster 1	Cluster 2	Cluster 3
1. Austria	1. Belgium	1. Bulgaria
2. Denmark	2. Cyprus	2. Croatia
3. Finland	3. Czech Republic	3. Greece
4. Germany	4. Estonia	4. Hungary
5. Luxembourg	5. France	5. Italy
6. Netherland	6. Ireland	6. Latvia
7. Sweden	7. Poland	7. Litvania
8. United Kingdom	8. Slovenia	8. Malta
	9. Spain	9. Poland
		10. Romania
		11. Slovakia

With the purpose of describing the clusters, we decided to use the *Final Cluster Centers*. These cluster centers are the mean of all variables calculated after the last iteration in cluster analysis.

Table 8. Final Cluster Centers

	Cluster		
	1	2	3
CISD	5.26	3.66	2.34
GCI	5.34	4.63	4.28

The *Final Cluster Centers*, shown in Table 8, have demonstrated that cluster 1 has the highest value of both the CISD and the GCI. Cluster 2 includes countries with medium values of the CISD and the GCI, while Cluster 3 consists of the countries with the lowest values of the CISD and the GCI.

5. Conclusion

Implementation of sustainable development and adoption of sustainability principles at all levels of resource management represents an important objective for each country nowadays. During the 1970s, European Union developed a strong interest in environmental management and implementation of common policies and legislations in the field of sustainable development and resource maintenance. This interest has remained active to this day. In this respect, this segment of development policy occupies an important place within the legislation of the European Union. What is more, sustainable development has been involved into all sector policies and development strategies. Sustainable development stands for the global aim and multidimensional concept of development.

In addition to establishing the institutional framework and raising awareness of the importance of managing this development concept, it is necessary to monitor the achieved level of sustainable development. This process is enabled through the establishment and implementation, i.e. measurement of a wide set of indicators and indices within the process of management of the natural environment, economic and social development. Thus, there are indicators for the global monitoring of the achieved level of sustainable development. In addition, each country, in accordance with the international commitments in this area, has its own indicators with which it is possible to evaluate the progress in achieving the national goals regarding sustainable development.

In order to create opportunities for comparing the situation in the economic, environmental and social areas among different countries, it is necessary to establish a synthetic indicator of sustainable development. In this paper, the composite index of sustainable development has been calculated, on the basis of the information about the most important indicators about the conditions in areas that reflect the level of sustainable development. Baseline indicators for the composite index of sustainable development calculation have been GDP, EPI and CPI for each country included in the analysis. After the calculation of the composite index of sustainable development, it has been tested whether this index, as the indicator of the achieved level of sustainable development, is correlated with the achieved level of competitiveness in the observed countries. Calculated Spearman's correlation coefficient confirmed that there was a high level of correlation between the achieved level of sustainable development and the achieved level of country’s competitiveness. After that, EU countries have been classified into homogeneous groups according to the achieved level of sustainable development and competitiveness of their national economies. This classification enabled recognition of countries that managed to face the global challenge in an efficient way. This challenge was reflected in achieving the high level of competitiveness of national economy and high level of sustainable development. The results obtained in this analysis can serve as the solid basis for the development policy makers and decision makers to direct future economic, environmental and social development. Focusing of these aspects of development policies on achieving the goals of sustainable

development will enable the achievement of higher levels of competitiveness of national economies. Main results, findings and future research should be presented.

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Composite Index of Sustainable Development in the Function of Examination of Balanced Environmental and Economic Development in EU Countries

KOMPOZITNI INDEKS ODRŽIVOG RAZVOJA U FUNKCIJI URAVNOTEŽENOG EKOLOŠKOG I EKONOMSKOG RAZVOJA ZEMALJA EVROPSKE UNIJE

Rezime: Realizacija koncepta održivog razvoja kroz održavanje i unapređenje konkurentnosti domaće privrede predstavlja izazov sa kojim se svaka zemlja suočava u savremenim uslovima razvoja . Predmet istraživanja u ovom radu je pitanje dostignutog nivoa održivog razvoja zemalja Evropske unije (EU). Rad ima za cilj izračunavanje kompozitnog indeksa održivog razvoja (CISD) i klasifikaciju zemalja EU u homogene grupe na osnovu dostignutog nivoa održivog razvoja i konkurentnosti njihovih nacionalnih ekonomija.

Ključne reči: kompozitni indeks; Evropska unija; održivi razvoj.