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RANKING OF EU COUNTRIES IN TERMS OF THE VALUE OF ENVIRONMENTAL GOVERNANCE INDICATORS IN 2010 AND 2015, USING THE HELLWIG METHOD

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ABSTRACT: The purpose of this study is to analyze the indicators of environmental governance as one of the elements of sustainable development. The results of the study show the ranking of EU countries in terms of the value of selected indicators in the years 2010 and 2015, and the analysis of how these indicators influenced the position of individual countries in the ranking. The Hellwig method was used to analyze the data in this study. The main findings are that relatively low greenhouse gas emission in CO2 equivalent, a high share of renewable energy in transport fuel consumption and a high recycling rate of packaging waste are main determinants of sustainable development on the environmental field. This factors are affecting the position of individual states in the ranking.

KEY WORDS: indicators of environmental governance, sustainable development, the Hellwig method, EU countries

Introduction

The aim of this study is two-fold: to analyze the indicators of environmental sustainability that concern environmental governance, and to rank EU countries in terms of the value of these indicators in the years of 2010 and 2015. This knowledge will help in better understanding what determine the position of each country in the rank. The reader is able to state which from considered countries corrected one's position, and which not and what reasons for these changes were. It is also showing indicators which peculiarly contributed to get places in the ranking. The sphere of environmental governance is one of four principles of sustainable development (SD), along with the economic, social and institutional-political spheres. This encompasses such diverse areas as climate change, energy use, air protection, marine ecosystems, freshwater resources, land use, biodiversity, and waste management.

An overview of literature

A review of the literature showed that sustainable development (SD) is generally treated in a holistic manner. There are no studies that analyze only one element of sustainable development.

Elaborate descriptions of SD indicators can be found in older sources (Pearce, 1996; Kates, 2005; Opschoor, 1991; Bossel, 1999; Segnestam, 2003) as well as in more recent studies (Jeniček, 2013; Sachs, 2015). It is worth emphasizing that many of the authors drew attention to only selected areas of sustainable development in their analysis. These areas are as follows: industry (Azapagic, 2000), economic development (Callens, 1999) and the natural environment (Palme, 2005). SD is also analyzed based on different measurements from different countries (Rosenström, 2007; Nader, 2008; Rinne, 2013). The most recent contribution in Poland on the topic of SD indicators was published in 2015 (*Wskaźniki zrównoważonego rozwoju Polski*, 2015). However, this work complements a previous publication from 2011 (*Wskaźniki zrównoważonego rozwoju Polski*, 2011).

What the authors of this study did not find in the review of the literature was a ranking of countries in terms of their level of sustainable development. It seems that few authors have taken on the issue of ranking countries in terms of sustainable development. Research being focused exclusively on one of the sustainable development pillar are missing. This situation confirmed the legitimacy of the topic chosen and contributed to the cyclical study of the authoritative ranking of EU countries according to the four pillars of

sustainable development. The novelty of this study is the preparation of a ranking of EU countries based on the value of environmental governance indicators for two separate years: 2010 and 2015.

This analysis distinguishes the indicators that determine the positions of individual EU countries in the ranking. This information may be useful to potential stakeholders who have an impact on the natural environment and the economy of any given country. Recipients of this study may also be representatives of the political sphere who have an impact on the economical processes that influence the natural environment.

Research methods

The study only analyzed the indicators of sustainable development that concern environmental governance. The ranking of European Union countries was completed using Hellwig's synthetic measure of development. Hellwig's measure is one method of ranking multivariate objects (Roszkowska, Karwowska, 2014; Iwacewicz-Orłowska, Sokołowska, 2016).

A total of 29 indicators were identified in the context of environmental governance. The Statistical Office in Katowice developed a set of indicators for sustainable development in 2011 (*Wskaźniki zrównoważonego rozwoju Polski*, 2011). This list was updated in 2015 (*Wskaźniki zrównoważonego rozwoju Polski*, 2015). Eight new indicators were added to environmental governance. These indicators provide the basis for analysis within this study.

The selection of indicators used in the analysis (called "diagnostic variables") comprised the first stage of this study. Data published by the Statistical Office in Katowice included information on SD indicators up to the year 2015. For the study, 16 indicators were selected based on the fact that they had complete data for both periods analyzed. In using Hellwig's method (Hellwig, 1968) as the model for this study, indicators were divided into two groups: stimulants that caused a country to have a higher position in the ranking in terms of environmental governance, and inhibitors, which caused countries to have a lower position in the ranking (table 1).

Based on 16 standardized input variables, a reference object with coordinates is defined as:

$$z_{0k} = \begin{cases} \max\limits_{i}(z_k) \text{ for stimulant} \\ \min\limits_{i}(z_k) \text{ for inhibitor} \end{cases} \quad (1)$$

where:
$i = 1, \ldots m$, $k = 1, \ldots n$,
m – is the number of countries,
n – the number of indicators.

Table 1. List of 16 diagnostic variables*

No.	Indicators – Environmental Governance	
61	Greenhouse gas emissions, CO_2 equivalent, in % (year 1988=100)	Inhibitor
62	GHG emissions by sectors – TOTAL, in tons in CO_2 equivalent/km^2 *(industries: energy, manufacturing and construction, transportation, industrial processes, agriculture, waste, other)*	Inhibitor
63	Greenhouse gas emissions per unit of energy consumption, in % (year 2000=100)	Inhibitor
64	Share of renewable energy in gross final energy consumption, in %	Stimulant
65	Share of renewable energy in transport fuel consumption, in %	Stimulant
67	Energy intensity of the economy, Kgoe/1000 euro **	Inhibitor
69	Average CO_2 emissions per 1 km from new vehicles, g/km	Inhibitor
71	Emission of acid rain pollution, tons/km^2	Inhibitor
72	Size of Fishing fleet, kW ***	Inhibitor
74	Percentage of population using waste water treatment plants (at least II degree), in %	Stimulant
79	Forest cover, in %	Stimulant
82	Damage of forest stands by defoliation, in %	Inhibitor
85	Non-perishable waste per capita, in kg	Inhibitor
86	Municipal waste generated per capita, in kg	Inhibitor
87	Disposal of municipal waste per capita, in kg	Inhibitor
88	Recycling of packaging waste, in %	Stimulant

* Indexing is not an ordinal number.
** Ratio of gross energy consumption (coal, electricity, oil, natural gas and renewable energy sources available for use) to GDP, at fixed prices from the base year of 2010.
*** The size of the fishing fleet determines the total power of the fishing fleet engines.
Source: author's own work.

The next step was to calculate for each object (country) the distance from the reference object using the Euclidean metric (Malina, 2004, p. 37):

$$d_{i0} = \sqrt{\sum_{k=1}^{n} (z_{ik} - z_{0k})^2} \tag{2}$$

The final step in the Hellwig method was to establish a synthetic measure of development for the *i*-th country according to the formula:

$$q_i = 1 - \frac{d_{i0}}{\overline{d}_{i0} + 2S(d_{i0})} \tag{3}$$

where:
$\overline{d}_{i0}$ – arithmetic mean of distance d_{i0},
$S(d_{i0})$ – standard deviation of distance d_{i0}.

The measure q_i is usually a value in the interval [0,1]. The higher the value, the closer the object (country) is to the set pattern (Panek, 2009, p. 69).

Results of the research

In the first step basic statistical calculations were carried out for the variables accumulated.

Table 2. Descriptive statistics of selected environmental governance indicators of SD for EU countries in 2010 and 2015

Indicator	Average		Minimum		Maximum		standard deviation		coefficient of variation	
	2010	2015	2010	2015	2010	2015	2010	2015	2010	2015
61	82.6	73.5	42.1	40.7	123.1	115.8	23.4	20.9	28.4	28.5
62	1 776	1 544	149	125	11,085	8,596	2 311	1,875	130	121
63	95.1	88.2	83.8	74.2	124.0	112.0	9.1	8.6	9.5	9.8
64	15.9	19.8	1.0	5.0	47.2	53.9	11.0	11.9	69.1	60.1
65	4.1	6.6	0.0	0.4	10.9	24.0	2.5	5.2	62.9	79.4
67	192.2	165.8	82.4	62.0	464.9	448.5	95.8	87.2	49.8	52.6
69	144.1	124.7	126.2	107.3	162.0	140.9	10.0	9.9	6.9	8.0
71	7.0	5.3	0.6	0.0	56.3	40.3	10.4	7.5	149.1	142.4
72	233.220	228.199	0	0	1,106,214	999,040	331,688	304,971	142	134
74	70.9	77.1	6.6	36.9	99.5	100.0	22.9	17.3	32.3	22.4
79	33.4	33.7	1.1	1.1	73.1	73.1	17.3	17.2	51.7	51.0
82	23.4	23.4	8.1	4.4	54.2	52.0	10.6	12.1	45.5	51.5
85	2,044.2	1,975.1	627.0	674.0	8,612.0	9,514.0	1,602.4	1,691.6	78.4	85.6
86	490.5	457.4	305.0	56.0	770.0	789.0	126.8	143.9	25.9	31.5
87	237.6	171.9	3.0	1.0	591.0	558.0	158.6	145.1	66.7	84.4
88	59.9	62.4	28.5	41.1	84.0	81.3	12.0	8.3	20.0	13.3

Source: author's own work based on GUS, *Wskaźniki zrównoważonego rozwoju Polski*, 2015 and 2010.

As a result of the research, the ranking of EU countries were obtained for the years 2010 and 2015. The countries that took first, second and third place in 2010 were Sweden, Austria and Germany in the context of environ-

mental governance in sustainable development. Poland was ranked 13th. The countries with the lowest positions were Cyprus, Bulgaria and Malta.

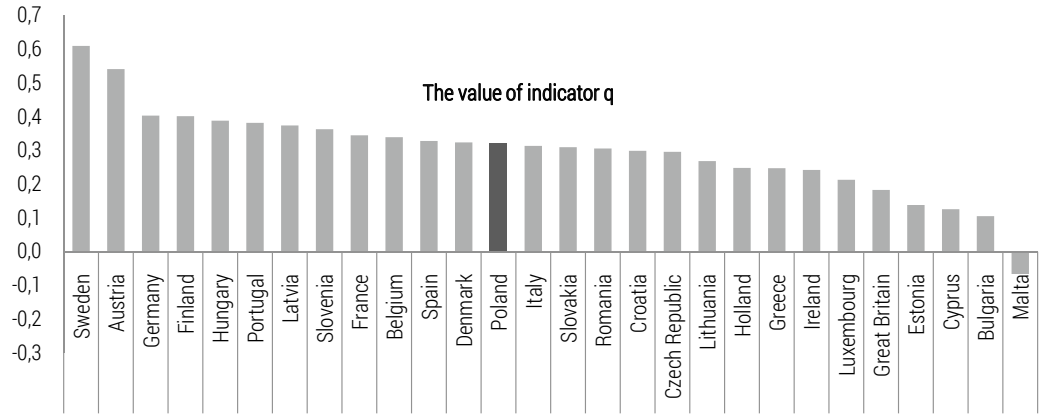

Figure 1. Ranking of EU countries in the context of environmental governance – 2010

Source: author's own work.

The following variables influenced Sweden being ranked the highest in terms of environmental governance:

- It had the lowest level of greenhouse gas emissions by sector in the EU. Greenhouse gas emissions are treated as an inhibitor to development in this study. This indicator presented the amount of greenhouse gas emissions (expressed in CO_2 equivalent) produced per capita, from different sources (economic sectors), per square kilometer. In Sweden, this amounted to 149.1 tons of CO_2 per km^2 in 2010. In comparison, the average for all countries analyzed was 1,776.3 tons of CO_2 per km^2.
- It had the highest share of renewable energy in the EU in gross final energy consumption. This indicator is considered a stimulant to development in this study and represents the gross final energy consumption from renewable sources divided by gross final energy consumption from all sources. In Sweden 27.2% of all energy was produced from renewable resources in 2010, whereas the EU average was 15.9%.
- It had the second highest share (after Austria) of renewable energy in fuel consumption in transport in the EU. This indicator is considered a stimulant and represents the % share of renewable energy used in all modes of transport in the final consumption of energy in transport. In 2010, this amounted to 9.2% in Sweden, whereas the EU average amounted to 4.1%.
- It was the second lowest emitter of acid rain pollution per 1 km^2 in the EU (after Croatia). This indicator, treated as an inhibitor of development,

takes into account the following acidifying pollutants (in 1 km^2): sulfur oxides, nitrogen oxides, and ammonia. In Sweden it amounted to 0.6 tons per 1 km^2 in 2010; the EU average amounted to 6.7 tons per 1 km^2.

- It had the second lowest indicator of municipal waste disposal per capita in the UE (after Denmark). This indicator is considered an inhibitor to development in this study. In the case of Sweden, it was 4 kg per capita in 2010, while the EU average was 236.8 kg per capita.
- It had one of the highest indicators for the recycling of packaging waste in the EU. This indicator is considered a stimulant of development and is calculated as the ratio of the mass or quantity of packaging waste recycled to the mass or quantity of recyclable packaging placed on the market. For Sweden it amounted to 69.2% in 2010 while the EU average was 58.7%.
- It had the second highest indicator of forest cover in the EU (after Finland); this means the ratio of the forest area to the total geodetic territorial area. This indicator is considered a stimulant for development. For Sweden it amounts to 68.4%, while the average is 33.4% for all EU countries.

Aside from the indicators mentioned above, attention should also be paid to the percentage of the population using wastewater treatment plants of at least second degree, such as biological wastewater treatment plants with enhanced biogenic compound removal,as a percentage of the total population. For Sweden the ratio amounts to 86%, which is very high compared to other EU countries (EU average is 55.1%).

Malta took last place in this ranking in 2010. What caused the country to be ranked the lowest among EU countries in the context of environmental governance? The position of this country in the ranking was influenced by the following factors:

- The high amount of greenhouse gas emissions by sector.This value amounted to 11,085.3 tons in CO_2 equivalent per km^2 in Malta in 2010. The average for all EU countries is more than six times lower and amounted to 1,776.3 tons in CO_2 equivalent per km^2. The Netherlands has the second highest greenhouse gas emissions after Malta (this indicator amounted to 5,183.5 tons in CO_2 equivalent per km^2, half of the value of Malta). This indicator is considered an inhibitor of development in this study. There are two main reasons for high greenhouse gas emissions in Malta. Firstly, the country did not comply with EU obligations concerning the reduction of carbon emissions for a long time. A drop in CO_2 emissions took place in 2015. Secondly, Malta is a very small country with an area of 316 km^2. It is the smallest country in the EU in terms of area and

186th in the world. In calculating the level of CO_2 emissions in terms of the size of the country, the coefficient is quite high.

- Malta has the lowest share of renewable energy in final gross energy consumption and fuel consumption in transport within the EU. These indicators are considered stimulants to development. In Malta they amount to 1% and 0% respectively for 2010 and 2015 (the EU average is 15.9% and 4.1%).
- Malta has the highest emission of acid rain pollution in the EU per 1 km^2, amounting to 56,3% (the EU average is 6.7%).
- The lowest indicator of forest cover in the EU (1.1%). The climate and the terrain have an impact on the island's flora, where forests are only found on a very small area of the island.
- It has the highest indicators in the EU (after Cyprus) of municipal waste generated per capita (601 kg) and municipal waste disposal per capita (545 kg) per year. There are two reasons for such high rates of waste production in Malta. First of all, tourism is the dominant economic sector in this country. Waste generated by tourists are statistically included in waste generated by residents. This greatly overstates the statistics on Maltese waste production. Secondly, a relatively small number of inhabitants (about 440,000 people) and a large number of tourists visiting Malta (nearly 2 million tourists a year), translates into a proportionally large amount of municipal waste being produced.

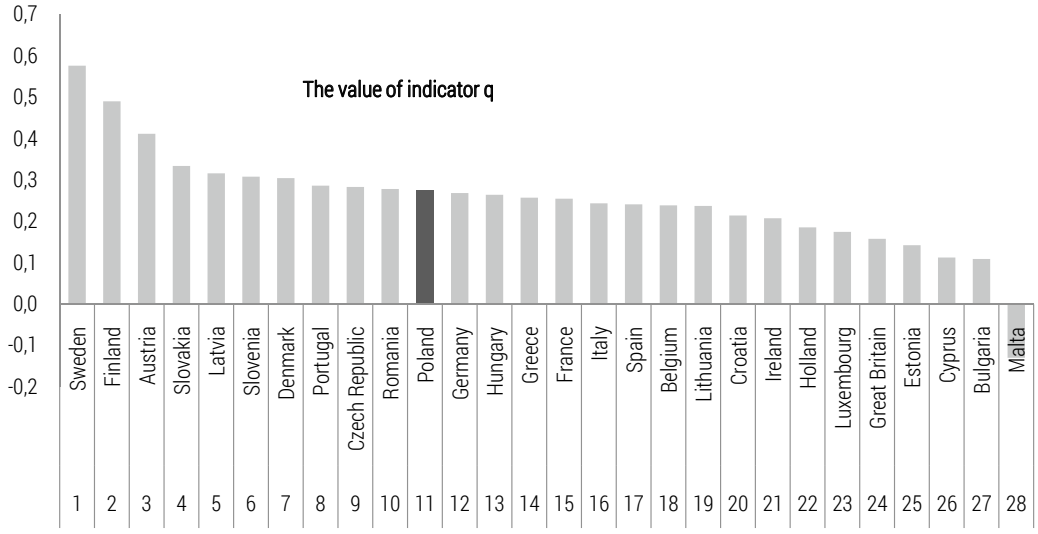

Figure 2. Ranking of EU countries in the context of Environmental governance – 2015

Source: author's own work.

Although the year 2015 brought changes in the ranking, these changes did not concern the countries that occupied the first and the last six places in the ranking (i.e. Sweden and Malta). Finland took second place. Austria took third place. The countries that reached the lowest positions in the ranking in 2015 are: Cyprus, Bulgaria and Malta. During the period studied, Poland took 11th place.

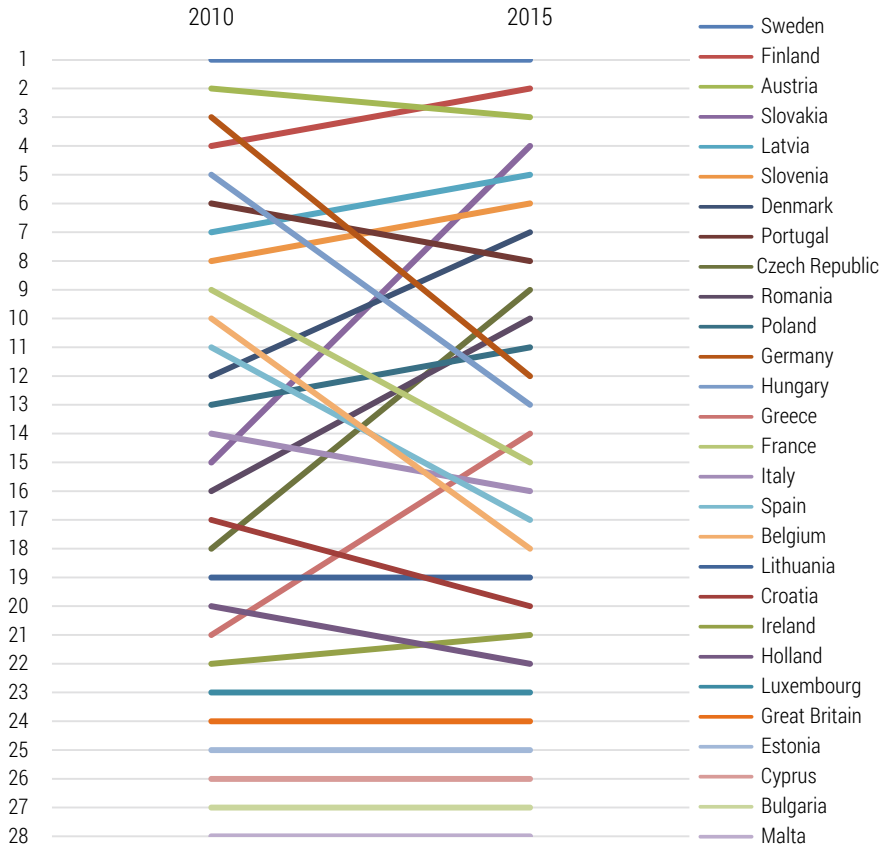

Figure 3. Changes in the ranking of countries from 2010 and 2015

Source: author's own work.

Figure 3 is demonstrating changes which occurred in the ranking of countries in years 2010 and 2015. Even though the period of analysis was short changes are significant. Ten of the countries analyzed experienced a rise in the ranking, ten experienced a drop, whereas the last eight did not change their position.

Slovakia experienced the highest increase in the ranking when comparing the two time periods (in 2010 the country was in 15th position, in 2015

it was in 11th). In terms of environmental governance, this country has made tremendous progress. All indicators taken into account have seen improvement. The main contributors to the change in ranking were:

- Relatively low greenhouse gas emission in CO_2 equivalent, amounted to 57.3% in 2015 (the EU average – 73.5%) and a related indicator of greenhouse gas emission (GHG) by total sectors amounted to 845.2 tons in CO_2 equivalent in 2015 (the EU average – 1,544.2 tons). These ratios were respectively 64.6% and 952.9 tons in CO_2 equivalent in 2010. A clear reduction of greenhouse gas emissions in Slovakia is therefore visible.
- A high share of renewable energy in transport fuel consumption in 2015 – 8.5% (in 2010 this share was 5.3%). The EU average is respectively 6.6% for 2015 and 4.1% for 2010.
- A high recycling rate of packaging waste, understood as the ratio of the mass or quantity of packaging waste recycled to the mass or quantity of recyclable packaging placed on the market. This ratio amounted to 45.7% in 2010 (the EU average for this period was 59.9%). This ratio has increased by 19.7 percentage points in Slovakia within five years and in 2015 it amounted to 65.4% (the EU average in this period was 62.4%). Recycling of packaging waste in Slovakia has therefore exceeded the average for all EU countries.

Other countries that recorded a favorable change in their ranking were the following: the Czech Republic (from 18th to 9th place – 9 positions); Greece (from 21st to 14th place – 7 positions); Romania (from 16th to 10th place – 6 positions); and Denmark (from 12th to 7th place – 5 positions).

Ten countries have noted a decrease in 2015 in relation to 2010. The largest decrease was recorded by Germany (this country was in 3rd position in 2010 and in 12th position five years later). The main reason for Germany's low position in 2015 was the lack of progress in most of the analyzed factors. The indicators from 2010 were very close to the ones from 2015. If the country does not improve its environmental situation, as evidenced by the lack of progress in the indicators compared to other countries, such a country may worsen its position in the ranking. This situation took place in Germany in 2015. Only one indicator had improved over the five year period – the share of renewable energy in gross final energy consumption (10.5% in 2010 and 14.6% in 2015).

Poland was in 13th position in 2010 and in 2015 the country was promoted to 11th place. There were three indicators that particularly distinguished Poland among the other analyzed countries:

- The size of the fishing fleet as the total power of fishing fleet engines. This value was 86,892 kW for Poland in 2010 and 81,545 kW in 2015 (the average for EU countries in 2010 amounted to 233,219 kW and in 2015

it was 228,198 kW). It should be noted that some EU countries do not have a fishing fleet due to lack of access to the sea (The Czech Republic, Slovakia, Austria, Hungary, etc.). The dominant countries, due to the size of the fishing fleet are as follows: France, Italy, Spain and the United Kingdom. This indicator was considered an inhibitor of development.

- One of the lowest indicators of municipal waste produced per capita per year in the EU. This indicator – also treated as an inhibitor of development – amounted to 316 kg per capita in 2010 and 286 kg per capita in 2015. Only Greece and Romania produced less municipal waste than Poland per inhabitant in 2015. The average amount of waste produced in the EU in 2010 and 2015 was respectively 490.5 kg and 457.4 kg per capita.
- Favorable indicator of municipal waste disposal per capita amounted to 195 kg in 2010 and 127 kg in 2015 (the EU average per capita is 237.6 kg in 2010 and 171.9 kg in 2015). The low rate of municipal waste disposal is related to the low total waste generation rate. However, it should be emphasized here that the low amount of generated waste in Poland causes less of it to be disposed, therefore this indicator is not proportionally low at all.

The main findings based on above research are that relatively low greenhouse gas emission in CO_2 equivalent, a high share of renewable energy in transport fuel consumption or a high recycling rate of packaging waste are main determinants of sustainable development on the environmental field. This factors are affecting the position of individual states in the ranking and the environmental responsibility of each of them.

Conclusions

In conclusion, it is important to state that the dominant areas in this analysis ofenvironmental sustainability were played by climate change, air protection and waste management. In particular, the high positions of certain countries in the ranking are due to their low greenhouse gas emissions, high share of renewable energy, including a high share of renewable energy in transport fuel consumption, low emission of pollutants, and a high rate of recycling of packaging waste. The top ranking countries were those that had the above mentioned ratios on a high and stable level (for stimulants) or on a low level (for inhibitors to development). The methodology used in research is an innovative approach of authors of the study. In the assumed form it wasn't used before for analysis of sustainable development pillars.

It is important to point out that is it possible for any particular country to improve its position in the ranking even if it has not made any progress in

terms of environmental governance, in cases where there is a regression in environmental governance in other countries. This factor needs to be taken into account during analysis of the data. Other indicators that were not considered carefully in the ranking were the state of coastal ecosystems, freshwater resources, land use, and biodiversity. These indicators played only a minor role in determining the position of the analyzed European Union countries in the ranking.

The contribution of the authors

Anna Iwacewicz-Orłowska – concept and objectives, literature review, research – 50%
Dorota Sokołowska – concept and objectives, literature review, research – 50%

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