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MULTIDIMENSIONAL ANALYSIS OF THE GREEN GROWTH OF THE EUROPEAN UNION COUNTRIES IN 2019

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Abstract: Green growth is a new approach to the economy that assumes the efficient use of raw materials while minimizing the negative impact on the environment. The aim of the study is to assess green growth in the European Union countries in 2019. For this purpose, secondary data was used and a multidimensional analysis of sustainable development was performed. The non-pattern model together with the Hellwig and Ward methods were implemented. This enabled a comparison between countries, and their classification due to a similar level of development. Based on the analysis, a large discrepancy in terms of green growth was observed in the examined countries. It was noted that the disproportion may turn out to be a problem in the implementation of the sustainable development policy. The results also showed that the position of the country is reflected in its geographic location.

Keywords: green growth, Hellwig method, multivariate analyses, sustainable development taxonomic methods.

1. Introduction

Global changes attract the interest of researchers and decision-makers in many countries, as well as of general public. Growing environmental awareness and the shift towards sustainable development are conducive when focusing on green growth. Therefore, changes in the economy are possible (Kirchherr, Reike, and Hekkert, 2017). Changes can also be seen in the initiatives taken by companies. Enterprises take initiatives in the field of corporate social responsibility (CSR) and this allows them to stay ahead of regulations and gain favour with consumers.

Changes in green growth should be based on comprehensive indicators that will make it possible to compare progress across countries (Kim, Kim, and Chae, 2014). Thanks to which they can be used at national (development of policy, objectives, priorities) and international level. Currently there are studies on green economy, but quantitative research on green growth is still lacking. The aim of the study is to assess green growth in the European Union countries in 2019. To be able to achieve the goal of the study, secondary data were used and a multidimensional analysis performed. The following research questions were posed:

- What is the level of green growth in the European Union countries?
- Is there a similarity in the realization of green growth?

The period under study was limited to one year. Due to the lack of completeness of data, not all EU countries were included for the analysis.

The article consists of five parts. The second section is devoted to a literature review, while the third describes the methods and formulas used. The research results are presented in Section 4. The last section contains conclusions and recommendations for future research.

2. Literature review

One of the most popular issues in the 21st century is the concept of sustainable development. This is a popular research topic and a ubiquitous development paradigm (Ukaga, Maser, and Reichenbach, 2011). According to the United Nations (UN) definition, sustainable development is a “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (United Nations General Assembly, 1987).

Sustainable development can be understood as maintaining a balance between the key components of development (Ministerstwo Środowiska, 1999). The concept assumes the simultaneous protection of the natural environment, social justice and the achievement of economic development (Zarębska, 2017). The concept of sustainable development assumes benefits in three areas: nature, society and economy (Rokicka and Woźniak, 2016). This is the overall objective of the European Union, which is reflected, among others, in the Europe 2020 Strategy (2010), the Strategy for sustainable development (2001), the Lisbon Strategy (2000) and the Amsterdam Treaty (1997).

According to Stoddart et al. (2011), sustainable development should lead to a fair distribution of resources between generations. Ben-Eli (2015) stresses the relationship between the carrying capacities and the population. Human activities should use human potential but should not allow for irreversible changes. Therefore, human activity should be based on meeting needs without depleting natural resources (Thomas, 2015). The concept of sustainable development combines various levels, focusing on human responsibility for the environment.

Sustainable development should be considered on moral, economic, legal, political, ecological and technical levels (Pawłowski, 2006). Considering the concept of sustainable development, one can notice a common element shaping the quality of life of future generations and the participation of non-material aspects of the quality of life (Florczak, 2008). It has been noted that innovation is a driving force for sustainable development (Silvestrea and Țîrcă, 2019). The concept was the starting point for green growth (Wyszkowska and Rogalska, 2014). In 2008, the possibility of a new model of the economy and recovery from the economic crisis was noticed. Through the Global Green New Deal, countries are to meet the challenge according to their climate and environment. The plan is to be based on a just transformation in all social areas, with social inclusion.

With the growing public awareness and the implementation of sustainable development goals, new directions of economic development have emerged. In addition to the circular economy, one should mention the so-called ‘green growth’ (Kasztelan, 2015). The green growth of countries means promoting economic development with the rational use of natural resources which, through natural capital, will ensure human well-being (OECD, 2011). The World Bank defines it as effective growth that minimizes negative environmental impact (2012), and because of this it is possible to create more value in limiting resource use (European Commission, 2016). Thus green growth is based on environmentally friendly decisions. According to UNEP (2011), it contributes to the improvement of welfare while reducing environmental risks. It has been noted that green growth is the power of future development (Ryszkowska, 2013). This is reflected in the EU’s Europe 2020 strategy. The concept of green growth can be understood as long-term investments that are related to reducing the negative impact on the environment and increasing income at the same time (Dauvergne, 2021). Nevertheless, while performing such actions, one should take into account technological changes and the depletion of natural resources. Green growth is based on processes that are resource efficient. It can be seen that through green growth, benefits can be achieved at many economic and social levels (Acemoglu, Aghion, Bursztyn, and Hemous, 2011), and it is a response to an ecological breakdown (Hickel and Kallis, 2020).

In the framework, green growth should stimulate green investment and use natural resources efficiently. Such action will allow to maintain economic progress in the long term and improve the quality of life of the population. Green growth is a response to the oncoming environmental crisis and the popular interest in sustainable development.

It was found that a pro-environmental approach can be the engine of economic growth (Jacobs, 2012), while green growth is supposed to be a cleaner approach to the economy without slowing it down (Hallegatte, Heal, Fay, and Treguer, 2012). By protecting the environment, countries gain natural capital that contributes to the productive function which in turn, leads to an increase in income. The living environment is improving as people breathe cleaner air, drink clean water and eat healthier food. As a result, expenditure on health care is reduced and the satisfaction of the population is improved. To talk about sustainable development, one should consider the social, economic and environmental pillars (Perło and Roszkowska, 2011). Therefore, measuring GDP is an imperfect measure of growth as it does not take into account, among others, the living conditions of the population and environmental issues. Green growth should create optimal conditions for the market to avoid unfavorable activities for the economy and the environment. For green growth to become possible, not only concepts and regulations are necessary, but also regular measurement. Thanks to this, it will be possible to track changes taking place in the economy, as well as to identify the greenest countries.

Green growth is enjoying growing interest (Stoknes and Rockstrom, 2018), as reflected in the initiatives of OECD, UNEP and the World Bank. OECD has prepared the Green Growth Indicators 2017 report, in which the actions of countries are assessed on the basis of the presented indicators. In turn, the World Bank contributes to the popularization of the economics of green growth (e.g. Economics of Green Growth Peer-Assisted Learning). The implementation of practices favouring green growth by companies can be felt by their employees. Green investments have a positive effect on the condition of the natural environment and can be noticed in the workplace (Sulich, Grudziński, and Kulhanek, 2020).

Nowadays, green growth is the basis for the development of development strategies for OECD countries and their regulations (Wang, Sun, and Guo, 2019). Green growth is also reported on in scientific publications (Khoshnava et al., 2020). It should be emphasized that for a green growth policy to be effective, increased awareness of decision makers is necessary (Alrasheedi et al., 2020).

3. Methodology

A multivariate analysis of the level of green growth of the EU countries in 2019 was performed on the basis of secondary data. The data was taken from the OECD.stat website and then calculations were made using SPSS and Excel software.

The multidimensional analysis of the level of sustainable development in the European Union countries in 2019 was made on the basis of indicators used to monitor progress towards green growth. The indicators are divided into five groups (OECD, 2017):

- environmental and resource productivity,
- natural asset base,
- environmental dimension of quality of life,
- economic opportunities and policy responses,
- socio-economic context.

The groups were divided into individual thematic areas using the methods of taxonomic analysis. The indicators were proposed in the Green Growth Indicators 2017 study, and were the starting point for considering the assessment of green growth in the EU countries. Taking into account the substantive, formal and statistical criteria, a selection of variables was made (Strahl, 2006).

Based on the obtained data, the variables were selected. Due to the lack of data, some countries were omitted from the analysis, namely Bulgaria, Croatia, Cyprus, Malta and Romania. Considering the completeness of the data and the substantive premises, 23 variables were selected. Then, the coefficient of variation was calculated and those variables with the coefficient of variation greater than 10% were selected for further analysis. It was assumed that variables with a coefficient of variation above 10% can be considered diagnostic. The number of variables included in the analysis was 18.

In order to examine the level of sustainable development, the Hellwig method was used, a Hellwig synthetic development measure was constructed and a non-pattern was employed. Groups of countries with high, medium and low development were distinguished. To complete the analysis, the spatial classification of countries was made using Ward's method, which made it possible to classify them according to a similar level of development. The results are presented in the form of dendrograms. Using the radar chart, the positions of the countries under the Hellwig method and non-pattern are shown.

Table 1. Diagnostic variables

Area	Name	Variable
Environmental and resource productivity	x_1	Production-based CO_2 productivity, GDP per unit of energy--related CO_2 emissions
	x_2	Production-based CO_2 emissions
	x_3	CO_2 emissions from air transport per capita
	x_4	Energy productivity, GDP per unit of TPES
	x_5	Renewable energy supply, % total energy supply
	x_6	Non-energy material productivity, GDP per unit of DMC
Natural asset base	x_7	Annual surface temperature, change since 19511980
Environmental dimension of quality of life	x_8	Mean population exposure to PM2.5
	x_9	Percentage of population exposed to more than 10 micro-grams/m^3
	x_{10}	Mortality from exposure to ambient PM2.5
	x_{11}	Mortality from exposure to ambient ozone
	x_{12}	Mortality from exposure to lead
	x_{13}	Mortality from exposure to residential radon
Economic opportunities and policy responses	x_{14}	Environmentally related taxes, % GDP
	x_{15}	Terrestrial protected area, % land area
Socio-economic context	x_{16}	Real GDP, Index 2000=100
	x_{17}	Total fertility rate, children per woman
	x_{18}	Population density, inhabitants per km^2

Source: own elaboration based on data OECD.stat.

As many as 18 indicators were selected for the analysis of green growth which formed the basis of the ratio analysis, the construction of the synthetic measure of sustainable development, and the classification. The selected diagnostic variables are presented in Table 1.

Among the selected indicators, the variables X_2, X_3, X_7-X_{13}, X_{18} are destimulants. This means that a lower value has a positive effect on the analyzed phenomenon. The diagnostic variables represent all areas of green growth that were highlighted in the Green Growth Indicators 2017 report.

3.1. The Hellwig synthetic development measure

This study uses the Hellwig method and the Hellwig synthetic indicator. The calculations were made as follows (Hellwig, Siedlecka, and Siedlecki, 1997):

1. Change of variables into stimulants and destimulants and change of destimulants into stimulants
2. Standardization of features to ensure comparability

$$z_{ik} = \frac{x_{ik} - \overline{x}_k}{S_k}$$

for: $x \in 1$; $i = 1, \ldots, n$; $k = 1, \ldots, m$,

where: 1 – collection of stimulants; Z_{ik} – standardized value of feature k for country i; X_{ik} – value of the k feature in country i; $\overline{x}_k$ – the mean of the sample; S_k – the standard deviation of the sample; m – number of variables; n – number of countries.

3. Designating a pattern with the highest values for stimulants

$$P_0 = [z_{01}, z_{02}, \ldots z_{0k}],$$

where: $Z_{0k} = \max \{z_{ik}\}$ – when x_k is stimulant.

4. Calculation of the Euclidean distance

$$C_{i0} = \sqrt{\sum_{k=1}^{m} (Z_{ik} - Z_{0k})^2}$$

$i = 1, 2, 3, \ldots n$.

5. Constructing a taxonomically relative measure of development that takes values from 0-1. The closer the value is to 1, the closer the object is to the pattern, and therefore shows a higher level of green growth

$$d_i = 1 - \frac{c_{i0}}{c_0}$$

$i = 1, 2, 3, \ldots n$.

where:

$$c_0 = \overline{c}_0 + 2 \cdot s_0$$

$\overline{c}_0$, s_0– arithmetic mean and standard deviation of the sequence (i = 1, 2, 3, … n); d_i – synthetic indicator

wherein:

$$\overline{c}_0 = \frac{1}{n} \cdot \sum_{i=1}^{n} c_{io}$$

and

$$s_0 = \sqrt{\frac{1}{n} \cdot \sum_{i=1}^{n} (c_{i0} - \overline{c}_0)^2}.$$

6. Classification of countries according to identified development. There are three groups according to the level of development: high, medium, low:

I. high: $d_i > \overline{d}_i + S_{d_i}$,
II. medium: $\overline{d}_i - S_{d_i} < \mathrm{d}_\mathrm{i} < \overline{d}_i + S_{d_i}$,
III. low: $d_i < \overline{d}_i - S_{d_i}$,

where: d_i – value of the synthetic indicator; $\overline{d}_i$ – arithmetic mean of the synthetic indicator; S_{d_i} – standard deviation of the synthetic indicator.

3.2. Non-pattern measure of development

The study uses the non-pattern measure of development (Młodak, 2006), which is the arithmetic mean of normalized characteristics. The method is described by the formula:

$$h_i = \frac{1}{p} \sum_{j=1}^{p} x_{ij}$$

$i = 1, \ldots, n$.

Then the classification was made into three intervals:

I. high: $h_i > \overline{h}_i + S_{h_i}$,
II. medium: $\overline{h}_i - S_{h_i} < h_i < \overline{h}_i + S_{h_i}$,
III. low: $h_i < \overline{h}_i - S_{h_i}$,

where: h_i – value of a non-pattern synthetic measure; $\overline{h}_i$ – arithmetic average non--pattern synthetic measure; S_{h_i} – standard deviation non-pattern synthetic measure.

3.3. Ward's method

In order to classify countries into cluster, Ward's hierarchic method was performed. The measure of the diversity of the cluster in relation to the mean values is ESS (Error Sum of Squares), which is defined by the following formula (e.g. Kubiczek and Hadasik, 2021; Walesiak, 2009; Ward, 1963):

$$EES = \sum_{i=1}^{k}\left(x_i - \overline{x}\right)^2,$$

where: x_i – value of the variable which is the segmentation criterion for the *i*-th object; *k* – number of objects in a cluster.

The assumption of this method is to minimize the sum of the squared deviations of any two clusters that may be formed at any step of analysis. Ward's method is perceived as effective due to the creation clusters even of a small size. Nonetheless, Ward's method is generally regarded as the most effective agglomeration methods (Basiura and Sokołowski, 2005).

In this study, Ward's method was used to classify countries due to a similar level of development. The results are presented in the form of a dendrogram created in the SPSS program. Furthermore, the map shows the spatial variation of the results.

4. Results

Table 2 presents the calculated taxonomic values of the green growth measure by three groups. The synthetic Hellwig indicator was ordered linearly according to decreasing values. On its basis, three groups of countries were distinguished, differing in the level of development. The first group that reports a high level of sustainable development includes three countries: the United Kingdom, Denmark, Ireland; 16 of the surveyed countries have an average level of development: Sweden, France, Luxembourg, Lithuania, Latvia, Austria, Estonia, Spain, Finland, Slovenia, Portugal, the Netherlands, Germany, the Slovak Republic, Italy, Belgium. There are four countries in the low level of development group: the Czech Republic, Poland, Greece, Hungary.

Table 2. Taxonomic values of Hellwig's development by groups

Country	d_i
1	2
Group I – high level of development $d_i \geq 0.288$	
United Kingdom	0.346
Denmark	0.335
Ireland	0.323

Table 2, cont.

1	2
Group II – medium level of development $0.096 \leq d_i \leq 0.288$	
Sweden	0.286
France	0.272
Luxembourg	0.263
Lithuania	0.258
Latvia	0.253
Austria	0.239
Estonia	0.218
Spain	0.206
Finland	0.201
Slovenia	0.191
Portugal	0.188
Netherlands	0.173
Germany	0.140
Slovak Republic	0.138
Italy	0.129
Belgium	0.121
Group III – low level of development $d_i < 0.096$	
Czech Republic	0.054
Poland	0.035
Greece	0.023
Hungary	0.015

Source: own elaboration.

The development of green growth is presented in Figure 1.

Based on the data, a large variation in development within green growth can be seen. Although the United Kingdom shows the greatest green growth, it is not a leader in any area, while Denmark is the best when it comes to environmental performance and resources. Sweden has the highest rate of green growth in the environment area and ranks first in the environmental dimension of quality of life, while Ireland ranks first in the natural asset base area. The area of economic opportunities and policy responses is headed by Slovenia. In the area of the socio-economic context, Ireland stands out with the highest level of the indicator. The taxonomic values of the development measure broken down by areas are presented in Table 3.

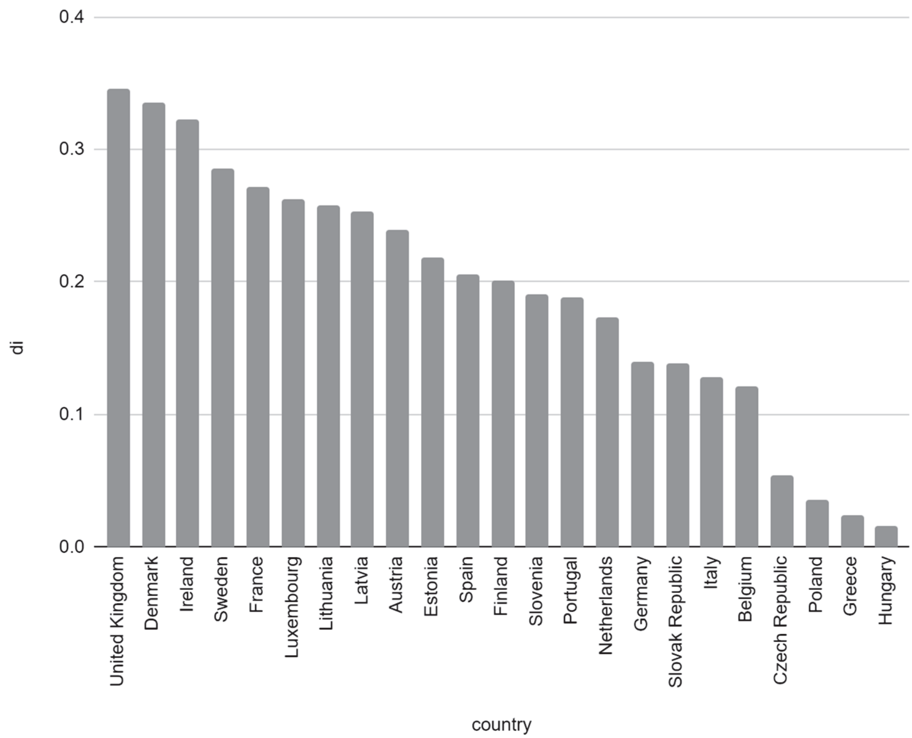

Fig. 1. Green growth indicator in the selected EU countries

Source: own elaboration based on data OECD.stat.

Table 3. Taxonomic values of Hellwig's development divided into areas

Environmental and resource productivity		Natural asset base		Environmental dimension of quality of life		Economic opportunities and policy responses		Socio-economic context	
Country	d_i	Country	d_i	Country	d_i	Country	d_i	Country	d_i
1	2	3	4	5	6	7	8	9	10
Group I – high level of development $d_i \geq 0.304$		Group I – high level of development $d_i \geq 0.802$		Group I – high level of development $d_i \geq 0.677$		Group I – high level of development $d_i \geq 0.569$		Group I – high level of development $d_i \geq 0.660$	
Denmark	0.433	Ireland	1.00	Sweden	0.849	Slovenia	0.973	Ireland	0.913
United King-dom	0.324	United Kingdom	0.968	Finland	0.774	Poland	0.605	Lithuania	0.793
Italy	0.318	Portugal	0.931	Ireland	0.769	-	-	Latvia	0.763
Sweden	0.314	Spain	0.887	Estonia	0.731	-	-	Estonia	0.685
-	-	Finland	0.848	-	-	-	-	-	-
-	-	Greece	0.834	-	-	-	-	-	-

Table 3, cont.

1	2	3	4	5	6	7	8	9	10
Group II – medium level of development $0.102 \leq d_i \leq 0.305$		Group II – medium level of development $0.267 \leq d_i \leq 0.802$		Group II – medium level of development $0.226 \leq d_i \leq 0.677$		Group II – medium level of development $0.190 \leq d_i \leq 0.569$		Group II – medium level of development $0.220 \leq d_i \leq 0.660$	
Austria	0.283	Sweden	0.790	United Kingdom	0.668	Luxem-bourg	0.520	Slovak Republic	0.601
Spain	0.281	Italy	0.727	Lithuania	0.629	Slovak Republic	0.499	Sweden	0.585
Portugal	0.263	France	0.553	Luxembourg	0.575	Germany	0.445	Czech Republic	0.582
Latvia	0.253	Belgium	0.501	France	0.574	Austria	0.443	Slovenia	0.523
Ireland	0.248	Netherlands	0.463	Denmark	0.556	Nether-lands	0.419	Poland	0.513
Luxemburg	0.228	Denmark	0.451	Netherlands	0.534	United Kingdom	0.415	Hungary	0.474
France	0.225	Luxembourg	0.443	Germany	0.487	Italy	0.407	France	0.454
Lithuania	0.223	Estonia	0.422	Austria	0.438	France	0.401	Denmark	0.439
Netherlands	0.222	Germany	0.355	Latvia	0.431	Greece	0.382	Austria	0.395
Greece	0.198	Austria	0.336	Portugal	0.397	Portugal	0.375	United Kingdom	0.372
Belgium	0.156	Slovenia	0.330	Spain	0.368	Estonia	0.365	Finland	0.363
Slovenia	0.152	Hungary	0.312	Belgium	0.340	Belgium	0.358	Luxembourg	0.351
Slovak Republic	0.129	Latvia	0.289	Slovenia	0.318	Czech Republic	0.355	Germany	0.319
Hungary	0.120	Slovak Republic	0.283	Slovak Republic	0.267	Latvia	0.353	Spain	0.282
-	-	-	-	-	-	Hungary	0.343	Belgium	0.250
-	-	-	-	-	-	Spain	0,342	-	-
-	-	-	-	-	-	Denmark	0.292	-	-
-	-	-	-	-	-	Finland	0.241	-	-
-	-	-	-	-	-	Lithuania	0.211	-	-
Group III – low level of development $d_i<0.102$		Group III – low level of development $d_i<0.267$		Group III – low level of development $d_i<0.226$		Group III – low level of development $d_i<0.190$		Group III – low level of development $d_i<0.220$	
Finland	0.082	Czech Republic	0.229	Italy	0.215	Ireland	0.081	Portugal	0.173
Germany	0.077	Lithuania	0.187	Czech Republic	0.187	Sweden	0,999	Greece	0.113
Czech Republic	0.067	Poland	0.167	Poland	0.151	-	-	Italy	0.103
Estonia	0.043	-	-	Greece	0.067	-	-	Netherlands	0.076
Poland	0.030	-	-	Hungary	0.048	-	-	-	-

Source: own elaboration.

Calculations were also made on the non-pattern grouping measure. The results are presented in Table 4.

Table 4. Taxonomic values of the development of a non-pattern measure by groups

Country	h_i
Group I – high level of development $h_i \geq 0.621$	
Sweden	0.706
Ireland	0.697
Estonia	0.638
Finland	0.635
Group II – medium level of development $0.422 \leq h_i \leq 0.621$	
Denmark	0.616
United Kingdom	0.606
Latvia	0.583
Lithuania	0.577
France	0.549
Luxembourg	0.546
Portugal	0.533
Slovenia	0.517
Netherlands	0.516
Austria	0.510
Spain	0.501
Slovak Republic	0.456
Belgium	0.443
Germany	0438
Italy	0.422
Group III – low level of development $h_i < 0.422$	
Czech Republic	0.395
Poland	0.382
Greece	0.376
Hungary	0.350

Source: own elaboration.

Sweden is the country with the highest overall index calculated using a standardized measure. It also ranks first in the area of environmental and resource productivity and in high-development groups in the areas of the environmental dimension of quality of life and the socio-economic context. Ireland stands out for its high level of development in the areas of the natural asset base, the environmental dimension of quality of life and the socio-economic context. Estonia is in the high development group when it comes to environmental quality of life and socio-economic context, while Finland is in the environmental dimension of quality of life and the natural asset base. The taxonomic values of the measure by area are presented in Table 5.

Table 5. Taxonomic values of the non-pattern measure with the division into areas

Environmental and resource productivity		Natural asset base		Environmental dimension of quality of life		Economic opportunities and policy responses		Socio-economic context	
Country	h_i	Country	h_i	Country	h_i	Country	h_i	Country	h_i
1	2	3	4	5	6	7	8	9	10
Group I – high level of development $h_i \geq 0.569$		Group I – high level of development $h_i \geq 0.763$		Group I – high level of development $h_i \geq 0.782$		Group I – high level of development $h_i \geq 0.653$		Group I – high level of development $h_i \geq 0.745$	
Sweden	0.676	Ireland	1	Finland	0.927	Slovenia	0.984	Ireland	0.945
Denmark	0.667	United Kingdom	0.960	Sweden	0.922	Luxembourg	0.688	Lithuania	0.832
Latvia	0.599	Portugal	0.917	Ireland	0.876	-	-	Latvia	0.817
-	-	Spain	0.917	Estonia	0.875	-	-	Sweden	0.782
-	-	Finland	0.818	-	-	-	-	Estonia	0.754
-	-	Greece	0.800	-	-	-	-	-	-
Group II – medium level of development $0.397 \leq h_i \leq 0.569$		Group II – medium level of development $0.121 \leq h_i \leq 0.763$		Group II – medium level of development $0.359 \leq h_i \leq 0.782$		Group II – medium level of development $0.294 \leq h_i \leq 0.653$		Group II – medium level of development $0.373 \leq h_i \leq 0.745$	
Austria	0.547	Sweden	0.748	United Kingdom	0.734	Poland	0.646	Slovak Republic	0.670
Italy	0.527	Italy	0.672	Lithuania	0.706	Netherlands	0.591	France	0.664
Ireland	0.519	France	0.464	Luxembourg	0.675	Estonia	0.563	Czech Republic	0.642
Lithuania	0.509	Belgium	0.401	Denmark	0.670	Slovak Republic	0.558	Slovenia	0.606
Netherlands	0.508	Netherlands	0.355	France	0.642	Italy	0.537	Poland	0.605
Portugal	0.507	Denmark	0.341	Netherlands	0.634	Germany	0.516	Denmark	0.599
United Kingdom	0.505	Luxembourg	0.332	Portugal	0.631	Latvia	0.511	Hungary	0.554
Spain	0.487	Estonia	0.307	Germany	0.554	Austria	0.495	Finland	0.524
Greece	0.475	Germany	0.226	Latvia	0.546	Germany	0.469	United Kingdom	0.522
Luxembourg	0.464	Austria	0.203	Spain	0.532	United Kingdom	0.469	Austria	0.506
Slovenia	0.462	Slovenia	0.196	Austria	0.532	Greece	0.459	Luxembourg	0.431
Belgium	0.459	Hungary	0.175	Belgium	0.451	France	0.459	Germany	0.430
Finland	0.457	Latvia	0.145	Slovenia	0.426	Portugal	0.451	Belgium	0.427
France	0.443	Slovak Republic	0.139	Slovak Republic	0.392	Czech Republic	0.428	Spain	0.410
Slovak Republic	0.423	-	-	-	-	Belgium	0.418	-	-
Estonia	0.423	-	-	-	-	Hungary	0.410	-	-
Hungary	0.401	-	-	-	-	Spain	0.403	-	-
-	-	-	-	-	-	Finland	0.370	-	-
Group III – low level of development $h_i < 0.397$		Group III – low level of development $h_i < 0.121$		Group III – low level of development $h_i < 0.359$		Group III – low level of development $h_i < 0.294$		Group III – low level of development $h_i < 0.373$	
Czech Republic	0.390	Czech Republic	0.075	Italy	0.332	Lithuania	0.289	Portugal	0.319
Germany	0.336	Lithuania	0.024	Czech Republic	0.320	Ireland	0.165	Netherlands	0.298

1	2	3	4	5	6	7	8	9	10
Poland	0.313	Poland	0.00	Poland	0.314	Sweden	0.012	Greece	0.290
-	-	-	-	Greece	0.221	-	-	Italy	0.230
-	-	-	-	Hungary	0.206	-	-	-	-

Source: own elaboration.

Two linear methods (Hellwig and non-pattern) were used to assess green growth. In order to organize the results of both methods, Table 6 was prepared which presents the positions of countries according to the taxonomic measure of Hellwig's development and the non-pattern synthetic measure.

Table 6. Positions in the ranking of countries according to two scales of development level

Country	Ranking position d_i	Change in ranking	Ranking position h_i
Austria	9	5	14
Belgium	19	2	17
Czech Republic	20	0	20
Denmark	2	3	5
Estonia	10	7	3
Finland	12	8	4
France	5	4	9
Germany	16	2	18
Greece	22	0	22
Hungary	23	0	23
Ireland	3	1	2
Italy	18	1	19
Latvia	8	1	7
Lithuania	7	1	8
Luxembourg	6	4	10
Netherlands	15	2	13
Poland	21	0	21
Portugal	14	3	11
Slovak Republic	17	1	16
Slovenia	13	1	12
Spain	11	4	15
Sweden	4	3	1
United Kingdom	1	5	6

Source: own elaboration.

The results of assigning countries are relatively similar. The measures show similar results for low-developed countries but differ among high-developed countries. The obtained results may be different because the method of Hellwig's development pattern uses a synthetic development indicator. In turn, the non-pattern measure is based on the arithmetic mean of the normalized features. The graphical representation of the obtained result is presented on the radar chart below.

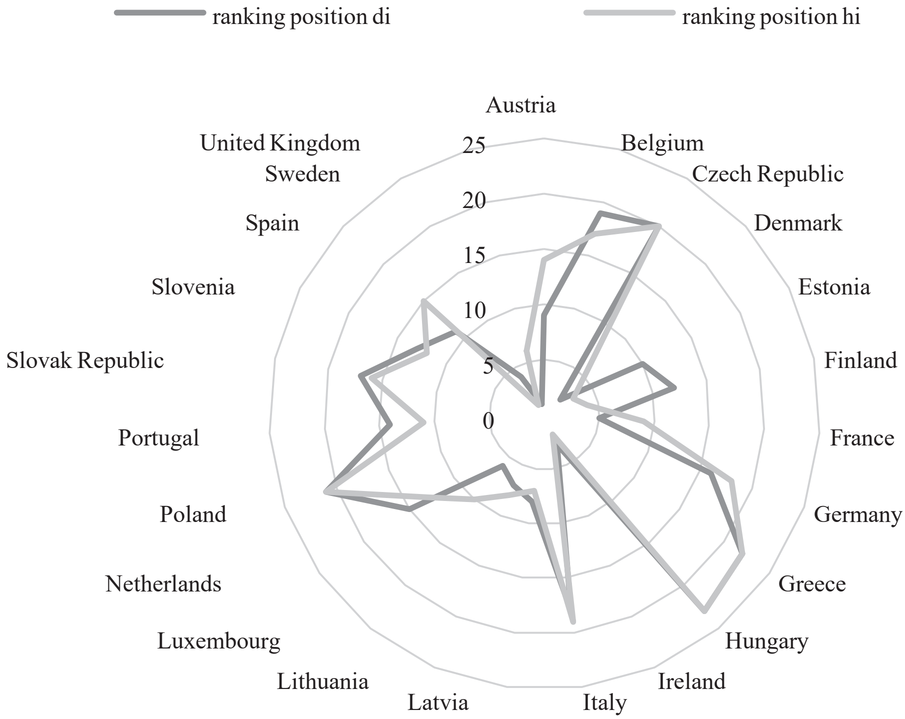

Fig. 2. Country positions by synthetic variables di and hi

Source: own elaboration.

5. Assessment of green growth in the EU countries with the use of cluster analysis

Ward's method used in the study helped to complete the analysis, thus it was possible to notice the similarities of the examined objects without taking into account their hierarchy. The aggregation process is shown in Figure 3.

The graphic interpretation is the dendrogram shown in Figure 4.

Five relatively homogeneous spatial group were distinguished in the study:

A. Group 1: the Czech Republic, Hungary, Poland, the Slovak Republic, Slovenia

B. Group 2: Italy, Spain, Greece, Portugal

C. Group 3: Belgium, the Netherlands, France, the United Kingdom, Germany, Luxembourg

D. Group 4: Estonia, Finland, Austria, Denmark, Latvia, Lithuania, Sweden

E. Group 5: Ireland

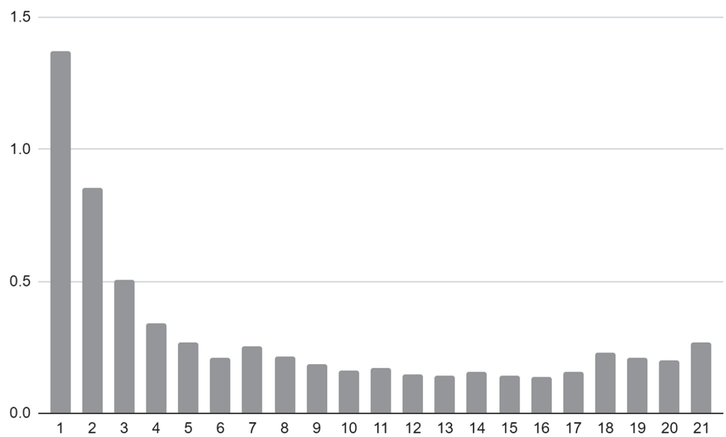

Fig. 3. Clustering rate

Source: own elaboration.

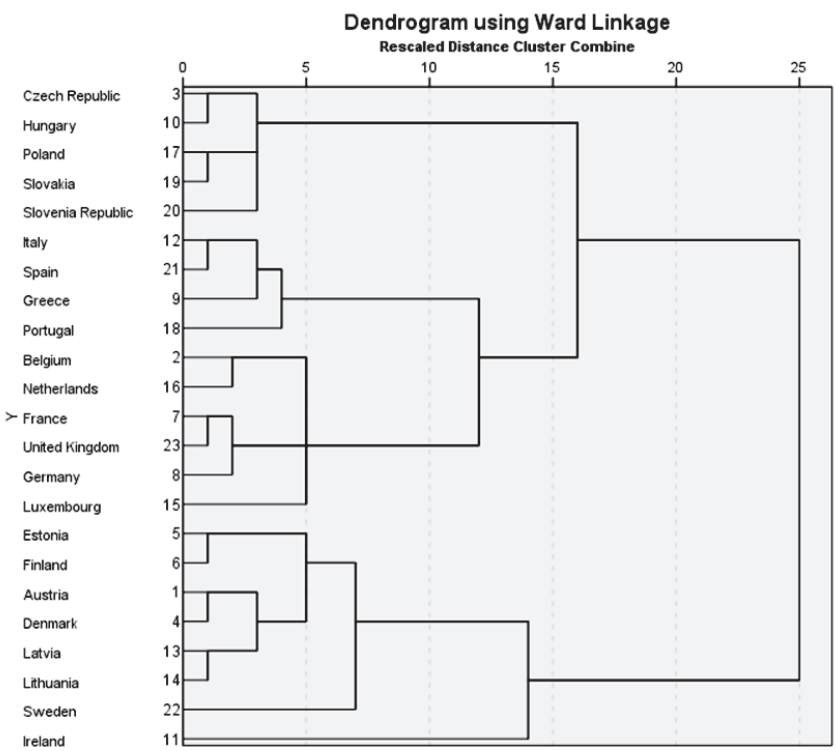

Fig. 4. The process of merging into clusters

Source: own elaboration.

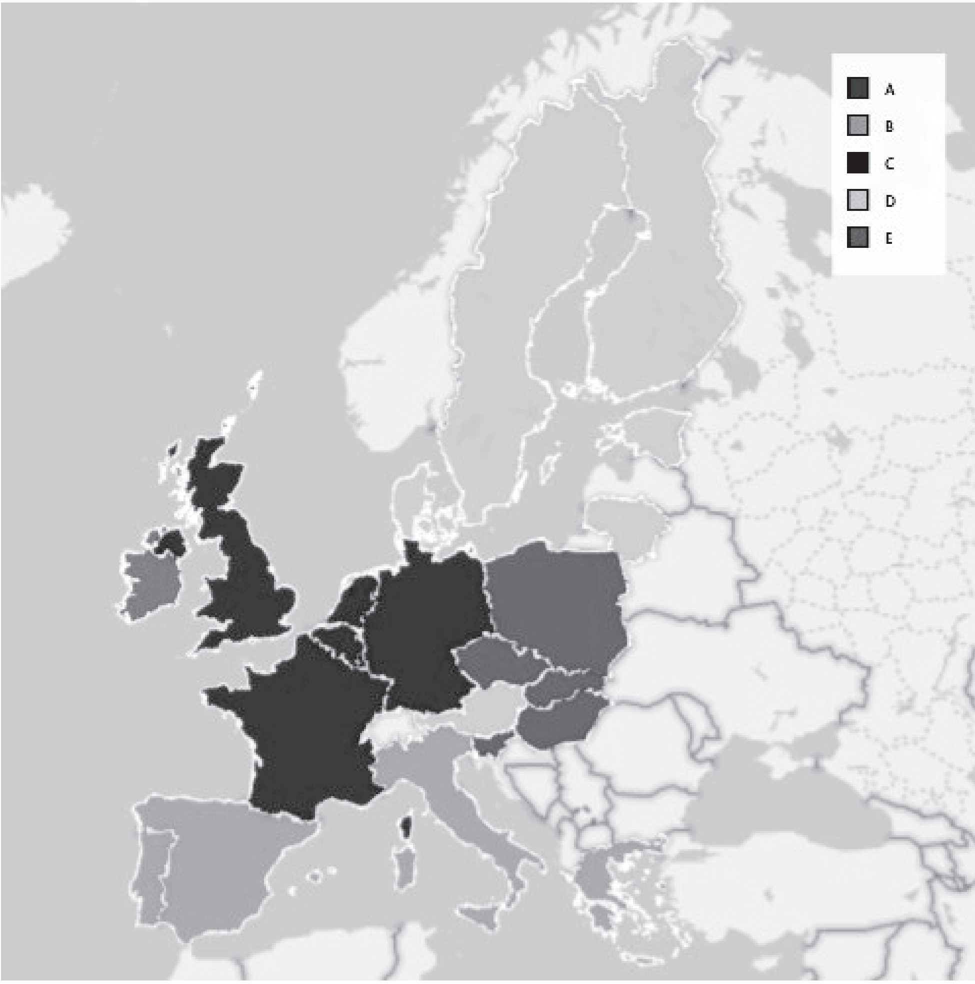

Fig. 5. Spatial differentiation of countries using Ward's method

Source: own elaboration.

Relatively similar countries were distinguished on the basis of Ward's method. They are diverse in relation to each other but some similarities can be found. Group A consists of countries with the lowest (Poland, Hungary, the Czech Republic) and average level of development (the Slovak Republic, Slovenia). Group B consists of countries with a low (Greece) and medium development level (Italy, Portugal, Spain). Group C consists of countries with the highest level of development (the United Kingdom) and medium (the Netherlands, Belgium, Germany). Group D includes countries located in the middle group, but close to the high level of development. Ireland is a country showing a high level of development. The similarity of the groups can also be seen in the non-pattern method. Group A consists of countries with a low level of development (the Czech Republic, Hungary, Poland) and medium development (the Slovak Republic and Slovenia). Group B is distinguished by slightly higher growth and, with the exception of Greece (low level of development), the countries are classified at the average level of development. Group C is distinguished by average measures (average level of development). Group D includes countries with a high level of development and the upper limit of middle development (excluding Austria). Ireland is at a high level of development. The countries show great similarities in terms of territoriality, as shown in Figure 5.

6. Conclusion

The green growth analysis which used linear (Hellwig's, non-pattern model) and non-linear (Ward's) methods, allowed for a comprehensive assessment of the phenomenon under study. A variety of approaches were taken to make it possible to compare countries, establish a hierarchy, and define the level of development in relation to other countries.

On the basis of the analysis performed, there is a large variation among the European Union countries regarding green growth. Although it is impossible to distinguish one leader who would dominate among all groups of indicators, there are countries that are classified in the area of high development. Based on Hellwig's method, it can be seen that the difference between the first (the United Kingdom, $d_i = 0.346$) and the last country (Hungary: $d_i = 0.015$) shows a large discrepancy. On the basis of the non-pattern method, a substantial difference can be noted (first place: $h_i = 0.706$ and last place: $h_i = 0.350$). Disproportion may prove to be a problem in the implementation of the sustainable development policy and in delivering on promises to improve the environment and citizens' quality of life in Europe.

It should be emphasized that most European Union countries are characterized by an average level of green development (16 countries in the II class according to the Hellwig method and 15 according to the non-pattern method). Based on Ward's method, five groups of countries that are relatively similar were distinguished. Ireland, which constitutes a separate group, deserves a special distinction. The countries show spatial similarity, which means that the level of green growth depends on location factors.

It can be seen that the level of green growth between the countries considered shows spatial similarity. The Czech Republic, Hungary, Poland, Slovenia and the Slovak Republic are the worst in terms of environmental factors, but have socio-economic potential. It should be noted that Poland, Slovakia, Hungary and the Czech Republic are countries which make up the Visegrad Group. Therefore, their further analysis may be an interesting research field. Economically strong countries whose actions indicate respect for the natural environment, have similar indicators in each of the areas of green growth. Scandinavian countries that focus on high environmental care achieve high rates in the first three areas (environmental and resource productivity, natural asset base, environmental dimension of quality of life).

This study can be used in further research and can form the basis for further analyses of sustainable development and green growth in the examined EU countries. It is possible to apply the selected research methodology to the analysis of other groups of countries. The study also has practical implications, as it may become a valuable source of knowledge for authorities at all levels. The conducted research may be extended with data from previous years, which would allow to find out about the level of development of given countries and their involvement in the implementation of the green growth policy. The information contained in the article can be used for further analyses and constitute a starting point for defining an action strategy.

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WIELOWYMIAROWA ANALIZA ZIELONEGO WZROSTU KRAJÓW UNII EUROPEJSKIEJ W 2019 ROKU

Streszczenie: Zielony wzrost jest nowym podejściem do gospodarki, które zakłada efektywne wykorzystywanie surowców przy minimalizowaniu negatywnego wpływu na środowisko. Celem pracy jest ocena zielonego wzrostu w krajach Unii Europejskiej w roku 2019. W tym celu wykorzystano dane wtórne oraz posłużono się wielowymiarową analizą zrównoważonego rozwoju. Wykorzystano metodę bezwzorcową, Hellwiga oraz Warda. Umożliwiło to porównanie między krajami oraz ich klasyfikację ze względu na podobny poziom rozwoju. Na podstawie analizy stwierdzono dużą rozbieżność w zakresie zielonego wzrostu w analizowanych krajach. Zauważono, że dysproporcja może się okazać problemem w realizacji polityki zrównoważonego rozwoju. Wyniki badań pokazały, że pozycja kraju ma odzwierciedlenie w położeniu geograficznym.

Słowa kluczowe: analiza wielowymiarowa, analiza taksonomiczna, metoda Hellwiga, zielony wzrost, zrównoważony rozwój.