sciendo

Folia Oeconomica Stetinensia
Volume 18 (2018) Issue 1
DOI: 10.2478/foli-2018-0008

WYDZIAŁ NAUK EKONOMICZNYCH I ZARZĄDZANIA
UNIWERSYTET SZCZECIŃSKI

AN ANALYSIS OF DYNAMIC CHANGES IN SELECTED AREAS OF SUSTAINABLE DEVELOPMENT OF THE EUROPEAN UNION COUNTRIES

Iwona Bąk, Ph.D., Associate Professor[1]
Katarzyna Cheba, Ph.D.[2]

West Pomeranian University of Technology in Szczecin
Department of Applied Mathematics in Economics
Janickiego 31, 71-270 Szczecin, Poland
[1] *e-mail: iwona.bak@zut.edu.pl*
[2] *e-mail: katarzyna.cheba@zut.edu.pl*

Received 2 November 2017, Accepted 27 March 2018

Abstract

The aim of the study is to determine the pace and directions of changes (understood as: improvement or deterioration) occurring in selected areas of sustainable development of EU Member States. The paper analyzes dynamics of changes in selected areas of sustainable development monitored on the basis of headline indicators published by Eurostat from 2008 to 2015. In the paper, three variants of reference points of synthetic measure of development were considered. On the basis of the obtained results, the countries in which the improvement in the sustainable development and its deterioration can be observed were identified. The results have confirmed the existence of significant developmental disparities between EU Member States in this field, but it should be noted that the obtained results depend on the methodological approach both to the selection of features and the adoption of a specific standardization formula, as well as the considered variants of reference points. The results obtained can be utilized in subsequent years to examine the directions of change observed both from the point of view of European Union as one organization, and the individual EU Member States.

Keywords: sustainable development, dynamic analysis, European Union

JEL classification: C23, C32, O11

Introduction

The concept of sustainable development is currently one of the most important concepts of civilization development. Its origin dates back to the second half of the twentieth century when this term was used for the first time at the UN Conference in Stockholm on the environment of human life. The first definition of sustainable development was formulated in 1987 in the report 'Our common future', which was created under the auspices of the World Commission on Environment and Development. According to it, sustainable development is "development which meets current needs without the risk that future generations will not be able to meet their needs" (WCED, 1987). At present, many different definitions of this term are analysed, for example, particular components of sustainable development (economic, natural, or human), elements of space (e.g. sustainable development in the regional context, in cities, etc.) (Borys, 2002; Glavic, Lukman, 2007; Adams, 2009; Borys, 2011; Charlesworth, 2015; Duran, Gogan, Artene, Duran, 2015; Carlucci et al., 2017; Zhu, Hua, 2017).

The implementation of sustainability rules is conditioned by the access to information collected in various systems (e.g. sectoral, spatial, or temporal) to monitor the current level of implementation of this concept. Time is here one of the most essential dimensions of monitoring, also because the most important sustainability purposes are defined in terms of temporary, usually short-term ones. Time is also important when scheduling a way of realization of strategic goals. In the case of the European Union, one of the strategic development objectives is to reduce disparities between the EU Member States in the area of sustainable development. It means that two directions of analysis are important in this filed. One of them is connected with the evaluation of the level of diversity of EU countries, while the second – with identification of possible trends in this area. Time is also an important element considered, for example, when determining the pace of adaptation to particular sustainable development goals or determining the time to develop a balance between these goals (Korol, 2007). That is why it is so important to monitor the pace and direction of change over time in sustainable development.

The aim of the study is to try to determine the pace and directions of changes (understood as: improvement or deterioration) occurring in selected areas of sustainable development of the EU Member States. The paper analyzes dynamics of changes in the value of synthetic measure describing selected areas of sustainable development, monitored on the basis of headline indicators published by Eurostat from 2008 to 2015.

The Sustainable Development Indicators (SDIs) published by Eurostat have a hierarchical structure that reflects the three levels. The headline indicators are at the top of this hierarchical

structure, and their purpose is to monitor the most important goals of the sustainable development strategy (Eurostat, 2015).

The study presented in the paper was conducted in several stages. In the first one, changes were analysed in the spatial diversity of the EU Member States' sustainable development, based on synthetic measures of development calculated on the basis of different reference points. Three variants of these points were considered: a) the mean value of *j*-th diagnostic features in the first year of the analysis; b) the mean value of *j*-th feature in the subsequent years; and c) the coordinates of a so-called 'pattern'. In the next step, the research was carried out in a dynamic perspective. On the basis of the obtained results, the countries in which the improvement in the sustainable development and its deterioration can be observed were identified. The results have confirmed the existence of significant developmental disparities between the EU Member States.

The paper is organized as follows: the second part describes the statistical materials including the indicators description which were utilized in the analysis. The next part presents the stages of the applied method. The fourth part of the paper presents study results divided into two topics: the results of the EU Member States' ranking in the field of sustainable development, and the findings of the dynamic analysis in this area. The final part of the article puts forward conclusions.

1. Research method

1.1. Statistical material

The analyses presented in the paper utilize information on the indicators used to monitor the implementation of the objectives of the EU Sustainable Development Strategy published by Eurostat. These Sustainable Development Indicators (SDIs) have a hierarchical structure that reflects three levels. At the top, there are so-called headline indicators, which monitor the main objectives of the key challenges of the Sustainable Development Strategy. The second level (lower) represents operational indicators, while the third (lowest) level includes the indicators describing actions. There is also information about so-called contextual indicators that are not used directly for measuring sustainability, but can be used as the background for the research (Eurostat, 2015). In the study of the spatial differentiation, and to estimate trends of the EU countries' sustainable development, headline indicators were used. As already shown in previous works (Bąk, Cheba, 2017; Szopik-Depczyńska et al., 2017), in the analysis conducted, on this level of the EU sustainable development (monitored on the basis of headline indicators), only 12 indicators describing 8 thematic areas can be applied, but not all of them are available at the

EU Member States' level. The analysis does not take into account area 10 – Good governance, which has no headline indicator, and the indicator of natural resources (common bird species) that is available only for some EU Member States in the Eurostat database.

The data set analyzed in the paper covered the information from 2008 to 2015. It was decided that due to the collapse of many of the observed trends in the 2007–2008 crisis, the first period to be included in the study will be 2008. In addition, due to the gaps in country-specific sustainability data for 2016, it was decided that the research would be completed on the data from 2015. To the potential set of diagnostic features, the following indicators were selected:

a) in the area of the socio-economic development: real GDP per capita (x_1, current prices Euro per capita);
b) in the area of sustainable consumption and production: resource productivity (x_2, Euro per kilogram);
c) in the area of social inclusion: persons at-risk-of-poverty or social exclusion (x_3, percentage of the total population);
d) in the area of demographic changes: employment rate of older workers (x_4, %);
e) in the area of public health: healthy life years (x_5, female, years; x_6, male, years) and life expectancy at birth (x_7, female, years; x_8, male, years);
f) in the area of climate change and energy: greenhouse gas emissions (x_9, in CO_2 equivalent, base year 1990) and primary energy consumption (x_{10}, million tons of oil equivalent – TOE);
g) in the area of sustainable transport: energy consumption of transport relative to GDP (x_{11} – S, Index – 2010 – 100%); and
h) in the area of global partnership: official development assistance as a share of gross national income (x_{12}, %).

Indicators: x_1, x_2, x_4, x_5, x_6, x_7, x_8, and x_{12} are stimulants whose higher values indicate a higher level of development of the analyzed phenomenon. In contrast, the characteristics: x_3, x_9, x_{10}, and x_{11} are destimulants, which means that they are indicators that have the opposite effect to the stimulant, i.e. lower values are desirable.

To assess the variability, a coefficient of variation in the subsequent years, calculated on the basis of the following formula was used:

$$V_j = \frac{S_j}{\overline{x}_j} \tag{1}$$

where: $\overline{x}_j$ – arithmetic mean of X, S_j standard deviation of j-th feature, $j = 1, 2, ..., m$, m – feature count.

The lowest variation (the threshold value is usually assumed to be 10%, $V_s < 10\%$) occurred in public health (x_5, x_6, x_7, x_8) and in the area of sustainable transport (x_{11}). These features, due to the low value of the coefficient of variation, have been eliminated from the set of potential diagnostic features. The same should be done for the features that are too strongly correlated with other features included in the study, because they are carriers of similar information. The Hellwig's parametric method (1981) can be used for this purpose. In the paper, for the final set of diagnostic features, which has become a basis for further empirical studies, the following features have been selected: $x_1, x_2, x_3, x_4, x_9, x_{10}$, and x_{12}.

1.2. Research stages and analysis method applied

The study was implemented through three tasks. In the first step, the disproportion between the EU Member States on the basis of headline indicators was analyzed. Then, for the study of the spatial differentiation of the EU sustainable development indicators, a taxonomic measure of development (z_i), determined on the basis of the standardized features, was used. In the research, according to the proposal of prof. Zeliaś, normalization of the features by setting a reference point was used, according to the following formula (Zeliaś et al., 2000):

$$z_{ij} = \frac{x_{ij}}{x_{0j}} \quad (i = 1, \ldots, m; j = 1, \ldots, k) \tag{2}$$

where: z_{ij} – normalized value of j-th feature for i-th country, x_{oj} – reference point for j-th diagnostic feature.

To transform destimulants into stimulants the following formula was implemented:

$$x_{ij}^{\{S\}} = 2\overline{x}_j - x_{ij}^{\{D\}} \quad (i = 1, \ldots, m; j = 1, \ldots, k) \tag{3}$$

where: $\overline{x}_j$ – mean value calculated for 28 analyzed countries in t year for j-th feature, S – stimulant, D – destimulant.

In the paper, three variants for the reference points were used: a) the mean value of the diagnostic feature in the first year of the analysis in 2008, and it is a so-called constant pattern (V1), b) the mean value of the j-th diagnostic feature in year t, thus in the following years a so-called changeable pattern (V2), and c) the coordinates of the 'pattern', thus the model object with the optimal values of the analyzed features, the maximum values for the stimulants, and the minimum for the destimulants (V3).

A taxonomic measure of development was determined on the basis of the standardized values of the diagnostic features, based on the formula (Nowak, 1990):

$$z_i = \frac{1}{K}\sum_{k=1}^{K} z_{ki} \tag{4}$$

where: z_i – value of a taxonomic measure of development for i-object, z_{ki} – standardized value of *k*-feature in *i*-object, K – number of features examined.

For the comparative analysis of the results of various variants, the following formula was used:

$$z_i' = \frac{z_i}{\max\limits_i \{z_i\}} \quad (i = 1, \ldots, m) \tag{5}$$

The arithmetic mean of the measure determined in this way equals one. This enables to conduct comparisons of the development of the objects characterized by many features. If the following inequality appears for the object examined: $z_i > 1$, then the object examined reaches a higher level of development than the average in the whole set of objects. In the case when $z_i < 1$, then the object examined reaches a lower level of development than the average in the set of the compared units (Nowak, 1990).

In the next step, the study was conducted in the dynamic perspective for all the analyzed years. Including time in the spatial differentiation of the sustainable development enabled to select the countries in which the improvement in the sustainable development is observable, and those in which the sustainable development is deteriorating, thanks to the possibility of using the methods of time series analysis (Zeliaś, 2004). As a result of the transformation manner used, the analyzed features are measured in the interval scale. The dynamic analysis was, therefore, conducted using the methods which can be used in the case of this type of scales. The analysis of dynamics was conducted using the absolute chain increment on the basis of the formula (Zeliaś, 2000):

$$\Delta z_{i(t+1,t)} = z_{it+1} - z_{qit} \quad (i = 1, \ldots, 28;\ t = 1, \ldots, 7) \tag{6}$$

where: $\Delta z_{i(t+1,t)}$ –absolute chain increment of a z_i synthetic measure for an *i* object calculated for *t* and *t* + 1 time units. Subsequently, the average absolute increase was determined on the basis of the formula:

$$G_i = \frac{z_{i8} - z_{i1}}{7} \quad (q = 1, \ldots, 8;\ i = 1, \ldots, 28) \tag{7}$$

where: G_i – average absolute increase of the z_i synthetic measure for the *i* object.

In sustainable development studies, two approaches were considered for the reference point used in formula 1 and in transformation 2: a) the mean value for the UE from time unit $t = 1$ (for 2008) constant pattern, and b) the highest observed value for a given feature in a given time unit – a changeable pattern.

2. Study results

Table 1 presents descriptive characteristics of the selected headline indicators of sustainable development for 28 EU countries analyzed in the years 2008–2015, characterized by the highest level of differentiation ($V_s \geq 10\%$). In this table, the descriptive characteristics for 7 out of 12 headline indicators available in Eurostat database were compared. For other indicators describing: the area of public health (x_5, x_6, x_7, and x_8) and the area of sustainable transport (x_{11}), the differences between the countries are relatively low. As it was indicated in the previous part of the paper, evaluating the coefficients of variation over the years for these characteristics is well below 10%, which, according to the standard selection criteria (Böhringer, Jochem, 2007), is too low for the coefficient of variation, and these features should therefore be eliminated from the set of potential diagnostic indicators.

Table 1. Descriptive statistics of EU sustainable development indicators in 2008–2015

x_i	Descriptive statistics	Years							
		2008	2009	2010	2011	2012	2013	2014	2015
1	2	3	4	5	6	7	8	9	10
x_1	$\bar{x}$	24,779.00	23,200.00	24,089.00	24,886.00	25,164.00	25,471.00	26,175.00	27,536.00
	Vs, %	62.17	63.40	64.71	65.22	65.09	65.67	66.35	66.55
	min	5,000.00	5,000.00	5,200.00	5,600.00	5,700.00	5,800.00	5,900.00	6,300.00
	max	77,900.00	74,200.00	79,200.00	83,000.00	83,000.00	85,300.00	89,500.00	91,500.00
x_2	$\bar{x}$	1.33	1.41	1.52	1.54	1.67	1.74	1.76	1.85
	Vs, %	63.51	59.98	60.32	61.33	60.16	61.12	63.32	63.52
	min	0.24	0.28	0.32	0.30	0.30	0.33	0.31	0.30
	max	3.43	3.41	3.68	3.97	4.09	4.18	4.22	4.48
x_3	$\bar{x}$	23.94	24.07	24.58	25.19	25.61	25.49	24.89	24.32
	Vs, %	32.01	32.72	33.38	32.78	32.96	31.79	27.64	27.33
	min	14.90	14.00	14.40	15.30	15.00	14.60	14.80	14.00
	max	44.80	46.20	49.20	49.10	49.30	48.00	40.30	41.30
x_4	$\bar{x}$	45.94	46.01	45.94	46.54	47.57	48.73	50.04	53.60
	Vs, %	22.05	20.38	18.82	19.40	19.20	19.08	18.76	17.83
	min	30.10	29.10	31.90	31.20	32.90	33.50	34.00	36.30
	max	70.10	70.00	70.40	72.00	73.00	73.60	74.00	75.50
x_9	$\bar{x}$	95.67	88.80	90.64	88.28	85.70	83.00	80.93	80.58
	Vs, %	30.94	32.87	30.33	30.25	30.66	28.83	30.18	29.87
	min	45.88	41.42	43.20	44.41	44.22	41.62	41.50	41.99
	max	172.40	168.18	163.77	159.47	151.04	138.83	144.73	144.45

1	2	3	4	5	6	7	8	9	10
x_{10}	$\bar{x}$	60.44	57.07	59.17	56.94	56.61	56.07	53.88	54.63
	Vs, %	133.74	133.65	133.81	132.48	134.29	136.30	135.26	135.19
	min	0.90	0.90	0.90	0.90	1.00	0.90	0.90	0.80
	max	314.60	295.30	309.90	293.40	296.10	302.80	291.10	292.90
x_{12}	$\bar{x}$	0.33	0.34	0.34	0.33	0.31	0.31	0.32	0.33
	Vs, %	84.93	90.02	86.93	85.26	89.25	90.79	93.24	97.82
	min	0.03	0.03	0.03	0.03	0.04	0.07	0.08	0.09
	max	0.98	1.12	1.05	1.02	1.00	1.01	1.09	1.40

Source: authors' own elaboration based on the Eurostat data, where: $\bar{x}$ – mean value, Vs – coefficient of variation, min – minimum, max – maximum.

As shown in Table 1, the greatest disproportions between the analyzed EU Member States over the time period ($V_s > 100\%$) covered the indicator x_{10} (primary energy consumption), which describes the area of climate change and energy, while the lowest variation (17.83–22.05%) was related to the indicator x_4 (employment rate of older workers) describing the area of demographic changes. For the majority of the analyzed features, the level of their differentiation in the following years remains similar. The largest changes were recorded in x_{12} (official development assistance as a share of gross national income), where the difference in variability in 2008 and 2015 (increase in variability) was close to 13 p.p. These differences did not exceed 5 points with respect to the features: x_3 (the area of social inclusion: persons at-risk-of-poverty or social exclusion), x_4 (the area of demographic changes: employment rate of older workers), and x_9 (the area of climate change and energy: greenhouse gas emissions) – there was a decrease in the level of variability.

Table 2 compares the values of synthetic measures describing the selected areas of sustainable development and the ranking positions of the EU Member States as a result of the 3 variants of reference points. This table summarizes the results obtained for 2008 and 2015 data.

Table 2. The value of the synthetic measure of sustainable development for the EU countries in 2008 and 2015 according to the 3 variants of reference points

Country	Ranking	2008		2015		
		V1/V2*	V3	V1	V2	V3
1	2	3	4	5	6	7
Austria	z_i'	0.5732	0.6612	0.5537	0.5318	0.6521
	Rank	13	12	13	13	12
Belgium	z_i'	0.6347	0.7113	0.6342	0.6054	0.7202
	Rank	10	9	9	9	10
Bulgaria	z_i'	0.2597	0.3653	0.2635	0.2732	0.4142
	Rank	28	28	28	28	26
Croatia	z_i'	0.2971	0.4149	0.3108	0.3062	0.4591
	Rank	27	26	25	25	24

1	2	3	4	5	6	7
Cyprus	z_i'	0.3501	0.4575	0.3221	0.2946	0.4075
	Rank	24	25	25	27	28
Czech Republic	z_i'	0.4717	0.6239	0.4498	0.4513	0.6456
	Rank	14	14	14	14	13
Denmark	z_i'	0.7551	0.8709	0.7548	0.7270	0.8612
	Rank	7	6	7	7	7
Estonia	z_i'	0.4106	0.6036	0.3872	0.3916	0.6040
	Rank	16	15	17	17	14
Finland	z_i'	0.5984	0.7184	0.6039	0.5945	0.7337
	Rank	11	8	10	10	9
France	z_i'	0.9036	0.8536	0.8699	0.8727	0.8706
	Rank	4	7	5	4	6
Germany	z_i'	1.0000	0.9317	0.9789	1.0000	0.9676
	Rank	1	4	2	1	2
Greece	z_i'	0.4161	0.5011	0.3233	0.3144	0.4137
	Rank	15	21	24	24	27
Hungary	z_i'	0.3486	0.4648	0.3552	0.3553	0.5118
	Rank	25	23	22	21	22
Ireland	z_i'	0.5967	0.6881	0.6036	0.5311	0.6751
	Rank	12	10	11	11	11
Italy	z_i'	0.6997	0.6855	0.7284	0.7022	0.7528
	Rank	8	11	8	8	8
Latvia	z_i'	0.3618	0.5229	0.336	0.3383	0.5347
	Rank	23	18	23	23	19
Lithuania	z_i'	0.3807	0.5446	0.3688	0.3699	0.5708
	Rank	21	17	20	18	17
Luxembourg	z_i'	0.9356	1.0000	0.9354	0.8702	0.9396
	Rank	2	1	3	5	4
Malta	z_i'	0.4053	0.5174	0.3859	0.3666	0.5155
	Rank	18	19	18	20	21
Netherlands	z_i'	0.8718	0.9511	0.8211	0.7816	0.8841
	Rank	5	3	6	6	5
Poland	z_i'	0.4047	0.4643	0.4125	0.4262	0.5351
	Rank	19	24	15	15	18
Portugal	z_i'	0.4069	0.5113	0.3570	0.3447	0.4663
	Rank	17	20	21	22	23
Romania	z_i'	0.3054	0.3956	0.2895	0.3042	0.4398
	Rank	26	27	27	26	25
Slovakia	z_i'	0.3939	0.5472	0.3988	0.3967	0.5957
	Rank	20	16	16	16	15
Slovenia	z_i'	0.3722	0.4994	0.3800	0.3670	0.5250
	Rank	22	22	19	19	20
Spain	z_i'	0.6432	0.6504	0.5647	0.5431	0.5947
	Rank	9	13	12	12	16
Sweden	z_i'	0.8393	0.9526	0.8952	0.8777	0.9513
	Rank	6	2	4	3	3
United Kingdom	z_i'	0.9272	0.9192	1.0000	0.9725	1.0000
	Rank	3	5	1	2	1

Source: authors' own elaboration based on the Eurostat data, * The results of 2008 ranking, because of the same reference point (the first year of the analyzed period), are the same.

The results presented in Table 2 differ due to the considered variant of setting the reference point. In 2008, 12 out of 28 analyzed countries recorded at least 3 points of difference in the created rankings, and 8 in 2015. In these results, significant changes in the ranking can be observed for the countries such as:

– in the 2008 ranking (significant changes were recognized by at least 5 items): Greece (a drop of 6 places from the 15th position in variant V1/V2 to the 2nd position in variant V3), Latvia (an increase from the 23rd position in variant V1/V2 to the 18th position in variant V3), and Poland (a drop from the 19th position in variant V1/V2 to the 24th position in variant V3);
– in the 2015 ranking (significant changes were recognized by at least 4 items): Spain (a drop of 4 places from the 12th position in variants V1 and V2 to the 16th position in variant V3), and Latvia (an increase from the 23rd position in variants V1 and V2 to the 19th position in variant V3).

The countries which did not change their position throughout the study variants include:

– in the 2008 ranking: Bulgaria (the 28th position), the Czech Republic (the 14th position), and Slovenia (the 22nd position); and
– in the 2015 ranking: Denmark (the 7th position), Ireland (the 11th position), and Italy (the 8th position).

Changes in the positions held by the individual countries are also shown between both analyzed time units. The biggest changes are in countries such as: Greece (e.g. in variant V1/V2 – the 15th position in 2008 and the 24th position in 2015), and Poland (e.g. in variant V3 – the 24th position in 2008, and the 18th position in 2015).

In the next step, the analysis of dynamics of synthetic measures of sustainable development according to 2 variants of patterns was conducted. Table 3 presents the values of the average absolute increase for the 28 EU countries estimated on the basis of the data from 2008 to 2015, while Table 4 contains the descriptive characteristics of this increase.

Table 3. The value of the average absolute increase in 2008–2015

Country	Pattern:		Country	Pattern:	
	constant	changeable		constant	changeable
1	2	3	4	5	6
Austria	0.0123	0.0011	Italy	0.0086	–0.0018
Belgium	–0.0071	–0.0051	Latvia	0.0111	0.0065
Bulgaria	–0.0011	–0.0011	Lithuania	0.0012	–0.00003
Croatia	–0.005	–0.0026	Luxemburg	–0.0081	–0.0065
Cyprus	–0.0038	–0.0027	Malta	0.0089	0.0044
Czech Republic	0.0034	0.0003	Netherlands	0.0033	–0.0025

1	2	3	4	5	6
Denmark	–0.0038	–0.0034	Poland	0.0026	–0.0006
Estonia	0.0074	0.0037	Portugal	–0.0004	–0.0013
Finland	–0.0066	–0.0038	Romania	0.0011	–0.0001
France	0.0011	–0.003	Slovakia	0.0003	–0.001
Germany	0.0185	0.0009	Slovenia	–0.0028	–0.0029
Greece	–0.0003	–0.001	Spain	0.0033	–0.0009
Hungary	0.0075	0.0031	Sweden	0.015	–0.0003
Ireland	0.0239	0.0066	United Kingdom	0.0163	0.0001

Source: authors' own elaboration based on the Eurostat data.

The values above zero (in Table 3) indicate positive changes of the average absolute increase of the synthetic measure of sustainable development. The average absolute increase in the years 2008–2015 is characterized by a right-handed asymmetry in both studied variants. The median value, lower than the mean, means that a bigger number of the EU countries (18 countries in the constant pattern and 16 countries in the changeable pattern) achieved a level of development lower than the average for the EU in the analyzed period. In the first variant of the pattern, the highest increase in the synthetic measure in 2015 in relation to 2008, 18 countries were noted, while in the second variant of the pattern – only 9 countries.

Table 4. Descriptive characteristics of the average absolute increase in the years 2008–2015

Descriptive characteristics	Constant pattern	Changeable pattern
Mean value	0.0038	–0.0005
Standard deviation	0.0080	0.0031
Median	0.0019	–0.0009
Highest value	–0.0081	–0.0065
Lowest value	0.0239	0.0066

Source: authors' own elaboration based on the Eurostat data.

Figures 1–2 show values of the average absolute increments based on the selected headline indicators of sustainable development in terms of both development patterns.

The following countries noted the highest increase in the synthetic measure in 2015 in relation to 2008 in both studied variants of pattern: Austria, the Czech Republic, Estonia, Germany, Hungary, Ireland, Latvia, Malta, and United Kingdom. On the other hand, a negative rate of change was noted in the case of 10 countries in both variants of pattern: Belgium, Bulgaria, Croatia, Cyprus, Denmark, Finland, Greece, Luxemburg, Portugal, and Slovenia. It corresponds with the changes of the position taken by these countries in the rankings. It should also be noted

that sometimes a high decrease in the case of the average absolute increment, i.e. Luxembourg, does not mean a high decrease of the position taken by this country in the ranking (Luxembourg dropped down from the 1st position to the 4th in V3, so its position is still very high in this ranking).

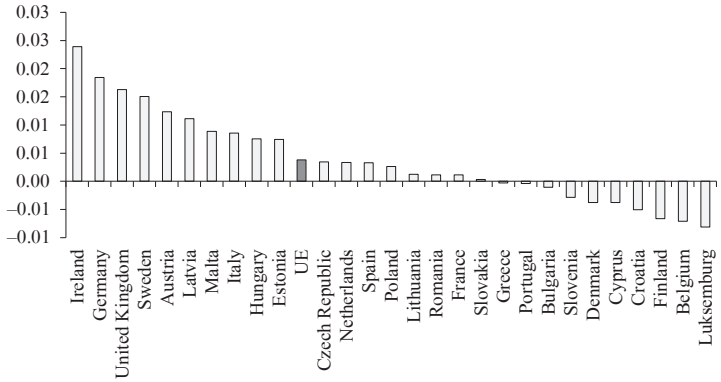

Figure 1. The average absolute increments of sustainable development (compared to the EU level in 2008)

Source: authors' own elaboration.

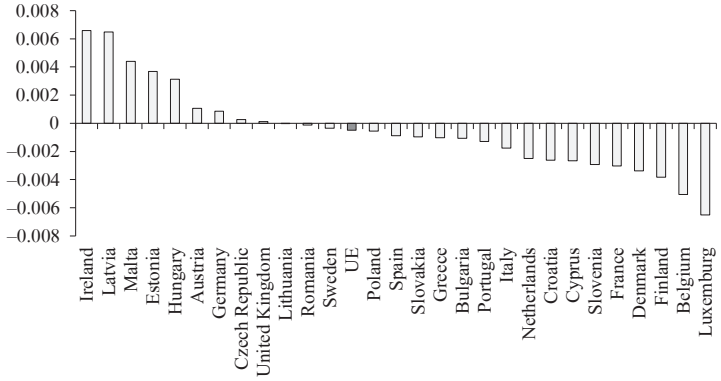

Figure 2. The average absolute increments of sustainable development (in relation to the highest value changing in time)

Source: authors' own elaboration.

Conclusions

The results of the research presented in the study confirm the considerable variation in the pace and directions of changes in the EU Member States in certain areas of sustainable development monitored by Eurostat. The obtained results, depending on the methodological approach, differ from one another. It should also be noted that limitations of the analyses presented in this paper have to be taken into account. These limitations relate both to the selection of features used in the subsequent analyses, the determination of the nature of the effects of these features on the studied phenomenon, as well as the procedures used to convert the destimulants to stimulants, and the adoption of a specific standardization formula (Bal-Domańska, Wilk, 2011).

According to the results of the dynamic analysis presented in the paper, it can be seen that only a part of the EU Member States increased their synthetic measure describing selected areas of sustainable development.

This situation applies both to the relative model determined in relation to the state which in a given year can be obtained, and the model relative to the EU value in 2008. In the analyzed models, some differences in the order of the EU Member States in terms of the average rate of change were also observed. Despite these differences, the same countries were ranked the first (Ireland) and the last (Luxembourg) in both models.

The differences also apply to the average absolute increments in both analyzed models. For the constant pattern, the average absolute increase for 2008–2015 was positive, which means that in most countries (18) the level of sustainable development estimated on the basis of headline indicators increased. On the other hand, in the case of a changeable pattern, the average absolute increase was negative, which means that for most countries (19) the distance between the best and the highest possible level in a given year increased.

The results of the analyses presented in the paper, taking into account the time factor used in the studies, allow us to trace the changes taking place in the selected areas of sustainable development not only in static, but also in dynamic terms. In this respect, they may be complementary to the more frequently analysed static studies in this area presented in the literature.

References

Adams, W.M. (2009). *Green Development: Environment and Sustainability in a Developing World*. 3rd Edition. London, UK: Routledge.

Bal-Domańska, B., Wilk, J. (2011). Gospodarcze aspekty zrównoważonego rozwoju województwa – wielowymiarowa analiza porównawcza. *Przegląd* Statystyczny, 58 (3–4), 300–322.

Bąk, I., Cheba, K. (2017). Multidimensional comparative analysis of sustainable development in European Union. *Economic Science for Rural Development Conference Proceedings, 45*, 14–20.

Borys, T. (2002). Wskaźniki rozwoju zrównoważonego. Podstawowe kierunki badań i zastosowań. *Ekonomia i Środowisko*, *1*, 39–59.

Borys, T. (2011). Zrównoważony rozwój – jak rozpoznać ład zintegrowany. *Problemy Ekorozwoju*, *6* (2), 75–81.

Böhringer, C., Jochem, P.E.P. (2007). Measuring the immeasurable – A survey of sustainability indices. *Ecological Economics*, *63* (1), 1–8. DOI: https://doi.org/10.1016/j.ecolecon.2007.03.008.

Carlucci, F., Cira, A., Immordino, G., Ioppolo, G., Yigitcanlar, T. (2017). Regional heterogeneity in Italy: Transport, devolution and corruption. *Land Use Policy*, *66*, 28–33. DOI: https://doi.org/10.1016/j.landusepol.2017.04.020.

Charlesworth, M. (2015). *Transdisciplinary solutions for sustainable development. From planetary management to stewardship*. New York: Routledge.

Duran, D.C., Gogan, L.M., Artene, A., Duran, V. (2015). The components of sustainable development – a possible approach. *Procedia Economics and Finance*, *26*, 806–811. DOI: https://doi.org/10.1016/S2212-5671(15)00849-7.

Eurostat (2015). *Sustainable development in the European Union 2015 monitoring report of the EU Sustainable Development Strategy*. Luxembourg: Eurostat Statistical Books.

Glavic, P., Lukman, R. (2007). Review of sustainability terms and their definitions. *Journal of Cleaner Production*, *15* (18), 1875–1885. DOI: https://doi.org/10.1016/j.jclepro.2006.12.006.

Hellwig, Z. (1981). *Wielowymiarowa analiza porównawcza i jej zastosowanie w badaniach wielocechowych obiektów gospodarczych.* Warszawa: PWE.

Korol, J. (2007). *Wskaźniki zrównoważonego rozwoju w modelowaniu procesów regionalnych*. Toruń: Wydawnictwo Adam Marszałek.

Nowak, E. (1990). *Metody taksonomiczne w klasyfikacji obiektów społeczno-gospodarczych*. Warszawa: PWE.

Szopik-Depczyńska, K., Cheba, K., Bąk, I., Kiba-Janiak, I., Saniuk, S., Dembińska, I., Ioppolo, G. (2017). The application of relative taxonomy to the study of disproportions in the area of sustainable development of the European Union. *Land Use Policy*, *68*, 481–491. DOI: https://doi.org/10.1016/j.landusepol.2017.08.013.

WCED (World Commission on Environment and Development). (1987). *Our Common Future. Un Documents: Gathering a Body of Global Agreements has been compiled by the NGO Committee on Education of the Conference of NGOs from United Nations web sites with the invaluable help of information & communications technology.* New York: United Nations.

Zeliaś, A. (ed.) (2000). *Taksonomiczna analiza przestrzennego zróżnicowania poziomu życia w Polsce w ujęciu dynamicznym.* Kraków: Wydawnictwo AE w Krakowie.

Zeliaś, A. (ed.) (2004). *Poziom życia w Polsce i w krajach Unii Europejskiej*. Warszawa: PWE.

Zhu, J., Hua, W. (2017). Visualizing the knowledge domain of sustainable development research between 1987 and 2015: a bibliometric analysis. *Scientometrics*, *10*, 893–914. DOI: 10.1007/s11192-016-2187-8.