

SUSTAINABLE DEVELOPMENT IN POLAND IN COMPARISON TO OTHER EUROPEAN UNION COUNTRIES

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Abstract: *The aim of this paper is to analyse the level of sustainable development in Poland and to determine the speed and directions of the development changes that were observed between 2009-2015. All the calculations were performed on the basis of the Eurostat databases within environment and packages of R. The hypothesis assuming relative level of improvement of sustainable development was verified with methods of classification (hierarchic agglomerative method) and multidimensional comparative analysis (linear arrangement of objects based on synthetic variables: Hellwig's development measure, Generalized Distance Measure). Regardless of the method used in the conducted analysis Scandinavian and rich European countries (Sweden, Finland, Denmark, France and Germany) were chosen as the leaders of sustainable development strategy. Poland, despite of the weak start is gradually improving its position and proving effectiveness of both economic and environment strategy. However observed changes may seem impressive, overall characteristic does not look so promising, placing Poland in the second half of the most sustainable developed countries.*

Key words: *sustainable development, taxonomy, European Union*

JEL codes: *C38, O11, O52, O57*

1. Introduction

According to *Encyclopaedia Britannica* (www1) sustainable development is *an approach to economic planning that attempts to foster economic growth while preserving the quality of the environment for future generations*. In reference to this definition, European Commission accepted a document (www2) which contains 17 sustainable development goals and 169 targets. As can be read in *Transforming our world: the 2030 Agenda for Sustainable Development* (www3) main assumptions of this initiative are very noble:

- End poverty in all its forms everywhere,
- End hunger, achieve food security and improved nutrition and promote sustainable agriculture,
- Ensure healthy lives and promote well-being for all at all ages,
- Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all,

- Achieve gender equality and empower all women and girls,
- Ensure availability and sustainable management of water and sanitation for all,
- Ensure access to affordable, reliable, sustainable and modern energy for all,
- Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all,
- Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation,
- Reduce inequality within and among countries,
- Make cities and human settlements inclusive, safe, resilient and sustainable,
- Ensure sustainable consumption and production patterns,
- Take urgent action to combat climate change and its impacts,
- Conserve and sustainably use the oceans, seas and marine resources for sustainable development,
- Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss,
- Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels,
- Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development.

The general strategy and its application not always head in the same direction, especially in times of economic slowdown and social disruptions. Due to that reason, constant monitoring of sustainable development is therefore necessary as sustainable feature in the European Union space can be realized only if all of the European countries work together and in the same direction. In reference to this thesis, the main goal of this paper is to determine overall level, tendencies and speed of changes observed in sustainable development in Poland during the chosen time period (2009-2015) and compare it to other European Union countries. Applying multidimensional comparative analysis and linear arrangement methods made it possible to determine if the general strategy is equally implemented in all European countries and define Poland's contributions to this noble goal of transforming world into better place.

The critical analysis of Polish and foreign literature shows that sustainable development topic has been gaining popularity in recent years. Despite of multiple papers created on this subject there is still room for the research on Polish case. In Poland main research about

sustainable development are conducted at the University of Szczecin. Especially worth recommending, due to scientific value in this field, are the following papers: Bąk & Cheba (2017), Bartłomowicz & Cheba (2017), Cheba & Szopik-Depczyńska (2017), Szopik-Depczyńska et. al (2017) and Szopik-Depczyńska et. al (2018).

2. Methodology and Data

All the calculations were performed on the basis of the Eurostat database of *sustainable development indicators* (www4). However, some of the 169 available metrics were excluded (Grabiński, 1984) due to the lack of data, low volatility or high correlation with other variables. With the use of these three criteria, a set of available data was limited to 23 countries (including Poland) and 30 targets, measured in Eurostat databases. From initial dataset three goals were excluded, namely: “Clean water and sanitation” and “life below water” and “partnerships for the goals”. The first two were deleted because of the lack of data in case of the countries that have no direct access to large water reservoir and high correlation with other features. Targets included in the last goal were all highly correlated with other features which resulted of exclusion of the whole category from the performed analysis. In case of analysed countries, from the default list of 28 European Union (EU 28) five of them (Malta, Croatia, Bulgaria, Romania, Cyprus) were excluded due to the lack of data. Excluding these countries does not affect the main goal of this analysis, however their inclusion would significantly affect the number of available features. Complete lists of analysed variables split by goals are shown in below table.

Tab. 5 Final database

Goal	Measured target
No poverty	People living in households with very low work intensity
	Population living in a dwelling with a leaking roof, damp walls, floors or foundation or rot in window frames of floor by poverty status
	Self-reported unmet need for medical examination and care by sex
Zero hunger	Agricultural factor income per annual work unit
	Gross nutrient balance on agricultural land by nutrient
Good health and well-being	Share of people with good or very good perceived health by sex
	People killed in road accidents
Quality education	Tertiary educational attainment by sex
	Underachievement in reading, maths or science
	Early leavers from education and training by sex
Gender equality	Inactive population due to caring responsibilities by sex
	Seats held by women in national parliaments and government
	Positions held by women in senior management positions
Affordable and clean energy	Energy dependence by product
Decent work and economic growth	Investment share of GDP by institutional sectors
	Long-term unemployment rate by sex
	People killed in accidents at work

Goal	Measured target
Industry, innovation and infrastructure	Employment in high- and medium-high technology manufacturing sectors and knowledge-intensive service sectors
Reduced inequities	Income share of the bottom 40 % of the population
Sustainable cities and communities	Share of busses and trains in total passenger transport Overcrowding rate by poverty status Exposure to air pollution by particulate matter
Responsible consumption and production	Energy productivity
Climate action	Greenhouse gas emissions Share of forest area
Life on land	Surface of terrestrial sites designated under NATURA 2000 Artificial land cover
Peace, justice and strong institutions	Population reporting occurrence of crime, violence or vandalism in their area by poverty status General government total expenditure on law courts Population with confidence in EU institutions by institution

Source: author's calculations based on Eurostat data (www4)

During preparations of the exact statistical analysis some further transformations were applied. At first, due to the comparison procedures (Grabiński, 1992), (Jajuga & Walesiak, 2000) all of the variables were standardized using the following formula:

$$z_{ij} = \frac{x_{ij} - \bar{x}_j}{S(x_j)} \quad (1.1)$$

where:

z_{ij} - standardized value of j-th variable and i-th country

x_{ij} - value of j-th variable and i-th country

\bar{x}_j - mean value of j-th variable

$S(x_j)$ - standard deviation of j-th variable

As the study required, coefficient of variation was also calculated to determine weight of particular variables in linear arrangement methods. In case of many different variables this approach can be used to promote features with higher discriminant values, as they bring more information about studied problem to the used model. As performed in (Grabiński, 1984) weights can be determined in the following way:

$$w_j = \frac{V_j}{\sum_{i=1}^n V_j} \quad (j=1,2,\dots,m) \quad (1.2)$$

$$V_j = \frac{S(x_j)}{\bar{x}_j} \quad (1.3)$$

where:

w_j - weight of j-th feature

V_j - coefficient of variation of j-th variable

$S(x_j)$ - standard deviation of j-th feature

For the purpose of determining similarities or dissimilarities in the level of sustainable development, methods of multidimensional comparative analysis were applied. Among all available methods, two were chosen: Hellwig's development measure (Hellwig, 1968) and Generalized Distance Measure proposed by Walesiak (2000). Both methods are very similar in their constructions. However, they differ in accordance to the used measurement methods. In Hellwig's development measure Euclidean distance was chosen, while in Generalized Distance Measure (GDM) the one proposed by Prof. Walesiak was chosen.

The idea behind both taxonomic measures construction is the same and is based on calculating the object distance from abstract ideal point. In both of the chosen methods this point is exactly the same, and should be performed in the following way:

$$z_{0j} = \begin{cases} \max_i z_{ij} & \text{if } Z_j \text{ is a stimulant} \\ \min_i z_{ij} & \text{if } Z_j \text{ is a destimulant} \end{cases} \quad (1.4)$$

where:

z_{0j} - abstract "best" value of j-th feature

Created in this way the so called "best" (abstract) objects for each variable may be used to determine the distance between them and the studied object. Distance measures used for this purpose are thoroughly presented by Walesiak (2002), Jajuga et al (2003) or Walesiak & Dudek (2017). From all of these measures, two mentioned earlier: Euclidean measure and GDM were chosen for further analysis performed in this paper:

$$d_{i0} = \sqrt{\sum_{j=1}^m (z_{ij} - z_{0j})^2} \quad (1.5)$$

$$GDM_i = \frac{1}{2} \frac{\sum_{j=1}^m w_j (x_{ij} - x_{kj})(x_{kj} - x_{ij}) + \sum_{j=1}^m \sum_{\substack{l=1 \\ l \neq i, k}}^n w_j (x_{ij} - x_{lj})(x_{lj} - x_{ij})}{2 \sqrt{\sum_{j=1}^m \sum_{l=1}^n w_j (x_{ij} - x_{lj})^2 \sum_{j=1}^m \sum_{l=1}^n w_j (x_{kj} - x_{lj})^2}} \quad (1.6)$$

where:

d_{i0} - i-th object Euclidean distance from z_{0j}

GDM_i - GDM i-th measure

x_{ij}, x_{kj}, x_{lj} - i-th, k-th, l-th observation of j-th feature

Generalized Distance Measure, in its construction contains correction which mechanism ensure that received values remain between $[0,1]$. In case of Hellwig's measure, further calculations are needed to ensure this condition.

$$s_i = 1 - \frac{d_{i0}}{d_0} \quad (1.7)$$

$$d_0 = \bar{d} + 2S(d_0) \quad (1.8)$$

$$\bar{d} = \frac{\sum_{i=1}^n d_{i0}}{n} \quad (1.9)$$

$$S(d_0) = \sqrt{\frac{\sum_{i=1}^n (d_{i0} - \bar{d})^2}{n}} \quad (1.10)$$

where:

s_i - Hellwig's synthetic similarity measure of i-th object

As a result of performed analysis the general level of the sustainable development in each country was calculated. For such measures hierarchic agglomerative methods with Ward distance metric (Walesiak & Gatnar, 2012) was applied, which allowed to classify analysed countries into group of similar sustainable development level. Results of performed classification with values of particular sustainable development index are presented both in tabular and graphical (as dendrogram plot) form in the next chapter.

3. Results and Discussion

As a result of performed analysis the general ranking of the sustainable development index was created. Results containing all of the index values for each of the 28 analysed countries split by two different methods (each with two variant) and 3 analysed time periods was outlined in tab 2.

Tab. 2 Ranking of the sustainable development index by year, method and country
 (in brackets raking obtained by the use of weighted method)

country	2009		2012		2015	
	GDM	Hellwig	GDM	Hellwig	GDM	Hellwig
SE	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
FI	2 (2)	2 (2)	2 (2)	2 (2)	2 (2)	2 (2)
DK	3 (3)	3 (3)	3 (3)	3 (3)	3 (3)	3 (3)
NL	4 (7)	6 (9)	7 (7)	7 (8)	7 (8)	7 (10)
FR	5 (4)	4 (4)	5 (5)	5 (5)	6 (5)	5 (5)
DE	6 (5)	5 (5)	4 (4)	4 (4)	4 (4)	4 (4)
CZ	7 (9)	7 (7)	8 (8)	8 (7)	15 (12)	14 (12)
AT	8 (8)	8 (8)	6 (6)	6 (6)	5 (6)	6 (6)
IE	9 (12)	11 (13)	12 (16)	16 (16)	11 (13)	12 (16)
BE	10 (13)	9 (12)	9 (11)	9 (10)	10 (11)	9 (11)
ES	11 (6)	10 (6)	17 (9)	17 (9)	16 (7)	16 (7)
SI	12 (11)	12 (11)	10 (10)	10 (11)	9 (10)	10 (9)
SK	13 (14)	14 (15)	15 (14)	15 (14)	17 (15)	17 (14)
LU	14 (15)	16 (17)	14 (15)	12 (15)	12 (14)	11 (15)
EE	15 (16)	13 (14)	11 (13)	11 (13)	13 (17)	15 (20)
UK	16 (10)	17 (10)	13 (12)	13 (12)	8 (9)	8 (8)
HU	17 (17)	15 (16)	21 (20)	21 (20)	21 (21)	22 (21)
PL	18 (20)	19 (21)	16 (17)	14 (18)	14 (16)	13 (13)
IT	19 (19)	18 (18)	20 (19)	19 (17)	20 (19)	20 (17)
EL	20 (21)	20 (19)	23 (23)	23 (23)	23 (23)	23 (23)
LT	21 (18)	22 (20)	18 (18)	18 (19)	18 (18)	19 (19)
PT	22 (22)	21 (22)	22 (21)	22 (21)	22 (22)	21 (18)
LV	23 (23)	23 (23)	19 (22)	20 (22)	19 (20)	18 (22)

Source: author's calculations based on Eurostat data (www4)

As shown in the above table regardless of the chosen method Scandinavian countries (Sweden, Finland, Denmark) are undisputed leader of sustainable development. Poland in this ranking was as the beginning classified pretty low (18-21 place, depending on the method used). Relatively low start base allowed gradual growth. As shown in Tab. 3 this increase was not only steady, but also one of the highest among all of the other analysed countries. In fact, Poland and the UK may be defined as leader of the successful implementation of the sustainability development strategy. On the opposite side countries like: Spain, Hungary, Czechia and Greece hold the infamous title of the anti-leader.

Tab. 3 Change in the sustainable development ranking by year, method and country (in brackets ranking obtained by the use of weighted method)

country	2009-2012		2012-2015	
	GDM	Hellwig	GDM	Hellwig
EE	+4 (+3)	+2 (+1)	-2 (-4)	-4 (-7)
LV	+4 (+1)	+3 (+1)	0 (+2)	+2 (0)
LT	+3 (0)	+4 (+1)	0 (0)	-1 (0)
UK	+3 (-2)	+4 (-2)	+5 (+3)	+5 (+4)
AT	+2 (+2)	+2 (+2)	+1 (0)	0 (0)
DE	+2 (+1)	+1 (+1)	0 (0)	0 (0)
PL	+2 (+3)	+5 (+3)	+2 (+1)	+1 (+5)
SI	+2 (+1)	+2 (0)	+1 (0)	0 (+2)
BE	+1 (+2)	0 (+2)	-1 (0)	0 (-1)
DK	0 (0)	0 (0)	0 (0)	0 (0)
FI	0 (0)	0 (0)	0 (0)	0 (0)
FR	0 (-1)	-1 (-1)	-1 (0)	0 (0)

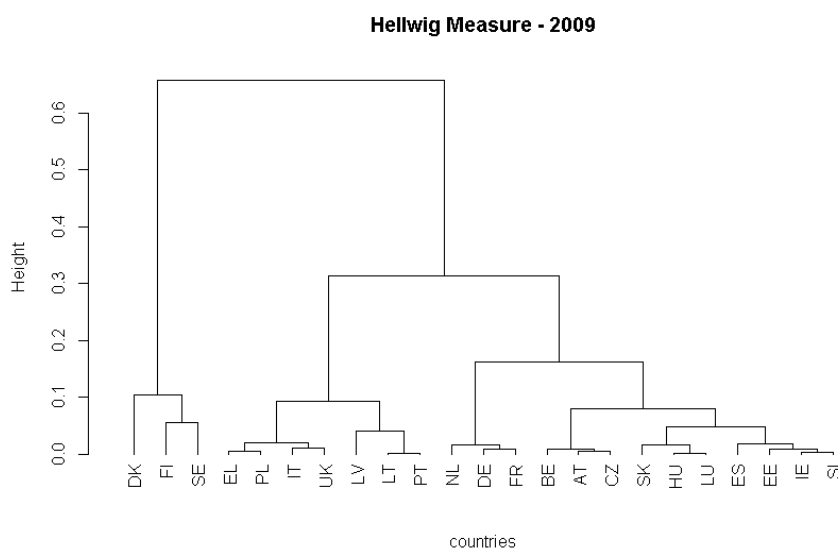
LU	0 (0)	+4 (+2)	+2 (+1)	+1 (0)
PT	0 (+1)	-1 (+1)	0 (-1)	+1 (+3)
SE	0 (0)	0 (0)	0 (0)	0 (0)
CZ	-1 (+1)	-1 (0)	-7 (-4)	-6 (-5)
IT	-1 (0)	-1 (+1)	0 (0)	-1 (0)
SK	-2 (0)	-1 (+1)	-2 (-1)	-2 (0)
EL	-3 (-2)	-3 (-4)	0 (0)	0 (0)
IE	-3 (-4)	-5 (-3)	+1 (+3)	+4 (0)
NL	-3 (0)	-1 (+1)	0 (-1)	0 (-2)
HU	-4 (-3)	-6 (-4)	0 (-1)	-1 (-1)
ES	-6 (-3)	-7 (-3)	+1 (+2)	+1 (+2)

Source: author's calculations based on Eurostat data (www4)

Analysis of the constructed dendrogram plots confirm earlier conclusions. In 2009 Poland was in the same basket of similar countries as UK, Italy and Greece. Where Greece and Italy had experienced a considerable economic slowdown, and pretty low position of UK (that was corrected by the weights usage) is strictly connected to: low confidence in EU institutions, high crime occurrence in poverty area and large development discrepancies between rich agglomerations and poor periphery.

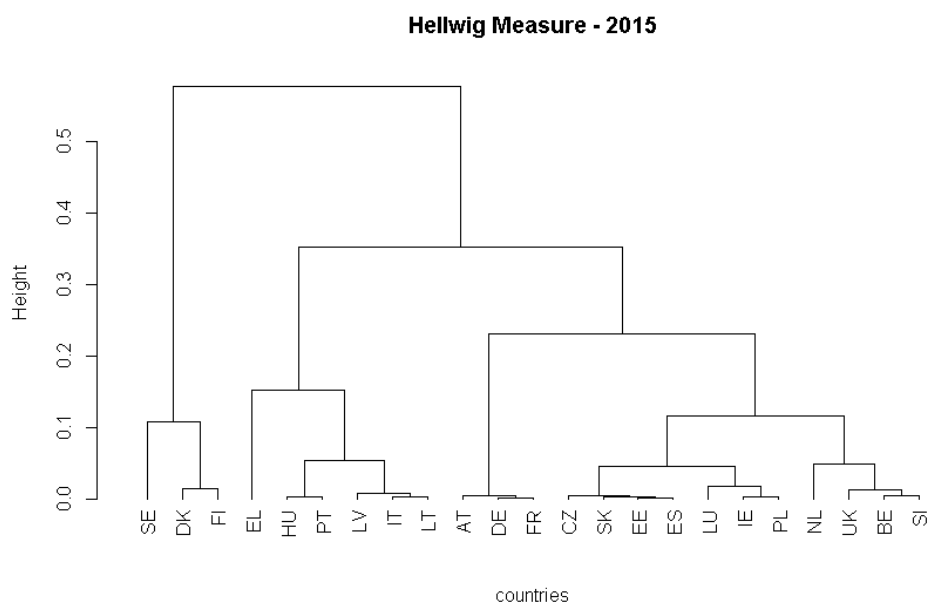
While in 2015 year Poland is classified equally to the much richer countries: Luxembourg and Ireland. This confirms that chosen development path is consistent with the adopted strategy of sustainable development.

Fig. 3 Classification of EU countries with Ward's measure for data of 2009



Source: author's calculations

Fig. 4 Classification of EU countries with Ward's measure for data of 2015



Source: author's calculations

4. Conclusions

Applied methods allowed to identify the similarities and differences in the field of the sustainable development levels between analysed EU countries. Received results are comparable not only between analysed sample of features and methods but also among other publications. Similarly, as presented by Bartłomowicz & Cheba (2017) Poland is currently located in the middle of the EU countries in the area of sustainable development. Equally, just like in paper Bak & Cheba (2017), has been shown that significant sustainable growth was observed in case of Poland. Despite the use of different features and methods received results clearly indicate Scandinavian countries as an unrivalled leaders of the sustainable development level. The above observations supported by the results of the studies and analyses presented in this paper confirm the hypothesis set in the introduction.

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