POLAND IN SOCIO-ECONOMIC DEVELOPMENT RANKING OF THE EU COUNTRIES

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Abstract: The research objective is to provide a comparative analysis of the level of socio-economic development of the European Union (EU) countries and identification of typology groups of the states that are similar with respect to socio-economic situation. The author seeks to answer the following questions: How do economies of the EU states, including Poland develop, and what changes were observed between 2010 and 2015? What is the position of Poland in the EU? The methods applied in the research include the method of linear arrangement of objects based on synthetic variables, as well as the method of standard deviations and Ward's method as selected from among the methods of classification of multi-characteristic objects. Data for the analysis comes from databases of Eurostat and GUS. The hypothesis assuming gradual reduction of the gap between Poland and other EU states, and relative improvement of the rank of Poland as regards socio-economic situation is verified. In the ranking of the EU countries obtained with Z. Hellwig method of development pattern, both in 2010 and in 2015, Luxembourg and Sweden gained leading positions. There were also Austria, Finland and Germany in the top five places. Regardless of the applied synthetic indicator, Poland improved its position in prepared rankings. However, the development gap between Poland and the states of the so-called old Union as well as the countries that joined the European Union together with Poland in 2004, including Estonia, Czech Republic, Slovakia or Malta is still considerable. Bulgaria, Romania and Greece were in the group of states of low development level that Croatia joined in 2015.

Key words: *socio-economic development, synthetic indicator, taxonomy, European Union*

JEL codes: *C10, O10, O57*

1. Introduction

The main objective of the paper is to provide a comparative analysis of the level of socio-economic development of the European Union member states and determination of the place of Poland in obtained rankings. Classification of the countries into groups similar from the point of view of the analysed phenomenon is the indirect purpose of the paper. At the same time an attempt is made to obtain the answer to the following questions: How do economies of the EU countries, including Poland develop, and what changes were observed in the period 2010-2015? Two research hypotheses were tested: H1: a gradual reduction of the gap between Poland and other European Union states, and relative improvement in the position of Poland with respect to the level of development in the period of studied five-years' membership in the structures of the European Union is observed; H2: regardless of applied taxonomic measure, there is considerable compliance in the arrangement of the countries as regards the analysed phenomenon. The research subject area outlined in the paper title is focussed on the space of objects that include EU countries described by a set of 19 statistical features. Research was conducted for 2010 and 2015, and data that is the basis for the research comes from the Internet database of European Statistical Office, EUROSTAT (www1) and Polish Central Statistical Office (GUS) (www2).

According to *Encyclopaedia Britannica* (www3) economic development is the process of qualitative and quantitative changes whereby simple, low-income national economies are transformed into economies of high level of income. Acocella defines development as a more general notion, usually comprising growth, but also including other aspects of economic and social changes. Development occurs when prosperity is growing (Acocella, 2002). The World Bank describes economic development as improvement of the quality of people's life, while extending their capabilities to affect their life (Vinod et al., 2000). According to *The Princeton*

Encyclopaedia of the World Economy, economic development comprises three areas going beyond the growth of income per capita, i.e. development of the economic system of the country, distribution of profits coming from economic development that allows to escape from poverty and sustainability of development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Rejnert and Rajan, 2009).

Many Polish authors emphasise that economic and social development is inherently linked to the improvement in the quality of life of societies. It is not only related to GDP per capita growth, but it also includes positive changes in education and employment, improvement in health condition of the population and the state of natural environment as well as more effective legal and judicial system, better cultural life, and more political and civil freedom (Woźniak, 2004; Ziemiańczyk, 2010; Batóg, 2010).

Socio-economic development is a complex category and its description demands knowledge about many qualities, of both quantitative and qualitative nature. Characteristics of demography and health, living conditions, labour market, production and service activity, information society, international trade, economic growth and financial situation (GUS, 2014) are usually proposed as providing comprehensive description of the category. Statistical methods of multidimensional comparative analysis (MCA) that allow for objectivization of conducted studies and making conclusions are a helpful tool in this type of analyses (Baba, 2016; Bąk and Cheba, 2017; Fura et al., 2017; Chrzanowska and Drejerska, 2016).

European Union countries are characterised by diversified level of socio-economic development. Elimination of social and economic inequalities between the member states is the priority in European integration. EU aid resources used for this purpose are provided to regions or countries that considerably differ from average EU rates. Thus, continuous monitoring of changes in development of individual countries is an important issue because remarkable disparities in this sphere negatively affect the level of socio-economic development.

2. Methodology and data

Procedures adjusted to multidimensional comparative analysis, i.e. Hellwig's development measure, relative development index, rank method, and the method of standard deviations and cluster analysis (Ward's method) selected from among the methods of classification of multi-characteristics objects are applied to efficiently solve the research problems presented in the introduction.

The idea of construction of Hellwig's taxonomic measure of development is based on determination of distance of every object (country) from the "model" object. Calculation procedure includes several stages:

1. A model object ("model of development") of the "best" values for each variable is established on the basis of matrix of standardised output variables:

$$z_0 = [z_{01}, z_{02}, ..., z_{0j}, ..., z_{0m}], \tag{1}$$

where:

$$z_{0j} = \begin{cases} \max\limits_i z_{ij} & \text{if } Z_j \text{ is a stimulant} \\ \min\limits_i z_{ij} & \text{if } Z_j \text{ is a destimulant} \end{cases}, \quad i = 1, 2, ..., n; \quad j = 1, 2, ..., m. \tag{2}$$

2. Then similarity between objects and the best "abstract" object is analysed through calculation of the gap (most often Euclidean) d_{i0} between each object and development model:

$$d_{i0} = \sqrt{\sum_{j=1}^{m} (z_{ij} - z_{0j})^2}, \quad i = 1, 2, ..., n. \tag{3}$$

The more similar the object is to the model, the higher the level of the quality for this object.

3. On the last stage, synthetic measure referred to as development measure is determined for each object:

$$s_i = 1 - \frac{d_{i0}}{d_0} \tag{4}$$

where:

$$d_0 = \overline{d} + 2S(d_0), \tag{5}$$

$$\overline{d} = \frac{1}{n}\sum_{i=1}^{n} d_{i0}, \qquad S(d_0) = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(d_{i0} - \overline{d}\right)^2} \tag{6}$$

The measure constructed in this way assumes the values from the range [0, 1]. The closer its value is to 1, the greater the similarity of a given object to development model.

The assumption that the level can be evaluated by the sum of standardised values of particular variables is the basic idea behind the construction of a relative development index (in the method of standardised sums) (Panek, 2009). The measure takes the form presented by the following formula:

$$s_i = \frac{\sum_{j=1}^{m} z_{ij}^*}{\sum_{i=1}^{m} \max_i z_{ij}^*} \tag{7}$$

where: j is the feature number; i is the object number; m is the number of features; z_{ij}^* is a standardised and shifted value of the feature; $\max_i z_{ij}^*$ – the highest standardised value of a given feature. The index assumes the values from [0, 1] range, and the higher the level of the phenomenon, the higher the value of the development measure.

In the rank method, diagnostic features are brought to comparability and additiveness through ranking of each of them. If a given value of a variable occurs in more than one object, the same rank that is an arithmetic mean of inherent ranks is assigned to them. Then the value of synthetic variable is calculated as an arithmetic mean of ranks and on this basis, hierarchisation of objects is performed (Panek, 2009).

While clustering objects arranged in a linear way, they can easily be divided according to the level of studied phenomenon, into four separate typology groups (Panek, 2009). The limits of synthetic variable ranges s_i are determined on the basis of the value of arithmetic mean ($\bar{s}$) and standard deviation S(s): group I $s_i \geq \bar{s} + S(s)$; group I : $\bar{s} + S(s) > s_i \geq \bar{s}$; group III: $\bar{s} > s_i \geq \bar{s} - S(s)$; group IV: $s_i < \bar{s} - S(s)$.

Cluster analysis falls into the category of hierarchical agglomerative methods of classification that allow for identification of complete cluster hierarchy, in consequence of which a tree of hierarchically arranged clusters referred to as dendrogram is obtained. This enables precise establishment of the position in relation to each other of particular classes and objects included in them (Walesiak, 2004). Ward's method applied in the research aims at, minimisation of the sum of the squares of deviations inside clusters. In this method, on any stage, one pair of clusters is selected from among all pairs of clusters. Consequently, this gives a cluster of minimum diversity.

Selecting diagnostic features, it must be emphasised that while determining socio-economic development there is no standard concept of what partial measures should be included in observation. It is important that the measures should possibly describe the studied phenomenon in the most accurate way. The choice is often a result of a compromise between the authors' intentions and their capabilities in the sphere of data acquisition. Diagnostic variables that are the basis for construction of the synthetic measure should have high content-related value, high ability to distinguish analysed territorial units (the threshold value of variability coefficient is most often determined on the level of 10%), explicit nature of preferences (stimulant, destimulant, neutral) and should indicate the lack of mutual correlation for elimination of information repetition.

The study of the level of socio-economic development in EU countries was characterised through measures describing various spheres of life. The output characteristics included 21 features describing basic substantive aspects of the development, including macro-economic situation of the country, labour market, demographic situation as well as social and technological infrastructure (telecommunication and tele-information market, health care, environment protection and transport): X1 – GDP per capita by purchasing power parity (PPP) in dollars, Z2 – GDP dynamics in % - relationship between export of goods and services and GDP, X4 – inflation rate in %, X5 – debt of the sector of government and self-government institutions as % of GDP, X6 – investments in research and development activity as % of GDP, X7 – employment rate of people aged 20-64 in %, X8 – unemployment rate in %, X9 – employment in high technology sector in % of total employment, X10 – rate of people with university education in 30–34 age group (in % of the total population of the given age group), X11 – infant mortality per 1000 live births, X12 – population growth per 1000 people, X13 – population density in people per km^2, X14 – mobile phone subscribers per 1000 people, X15 – Internet users per 1000 people, X16 – cars in use per 1000 people, X17 – fatal accidents per 1 million inhabitants, X18 – CO_2 emission in thousand tons per km^2, X19 – Gini coefficient, X20 – percent rate of poverty or social exclusion risk and X21 – the number of people per 1 doctor.

Finally, after the variables had been statistically verified the following of them were deleted: X7 and X19, i.e. the variables that were characterised by small diversity, and X19 that showed rather significant correlation with X20 variable. Among selected 19 features, eight have the nature of destimulants (X4, X5, X8, X11, X17, X18, X20, X21), and others are stimulants of socio-economic development of EU countries.

3. Results and Discussion

Before starting the analysis of results obtained from taxonomic research it seems relevant to analyse several rates included in the set of diagnostic features to establish the place of Poland in the group of EU countries with reference to the analysed variable.

GDP per capita by parity of purchasing power (X1), i.e. in the approach eliminating the differences in income and purchasing relationships between the states is an essential measure of the level of socio-economic development. The highest level of the rate in 2015 was achieved by Luxembourg ($104 206), at average level in the whole Union at $37 866 per capita, whereas the lowest level per capita was observed in Bulgaria ($18 249) and Portugal $13 230). What is more, their place in the ranking did not change over 2010-2015. The GDP distribution is characterised by right-sided asymmetry which means that majority of the countries have GDP per capita below EU average. Poland that was 21st in the ranking of 28 countries in 2015($ 26 856) was behind the countries that joined the European Union in the same year, i.e. Lithuania (ranked 20th), Estonia (ranked 19th), Slovakia (ranked 18th), Cyprus (ranked 17th), Slovenia (ranked 16th) and Czech Republic (ranked 15th. In the case of Poland, the relationship between GDP per capita and the Union average grew from 66% in 2010 to 71% in 2015, however the increase in the rate did not affect advancement of the rank of Poland. On the other hand, as regards the GDP dynamics (X2) Poland was ranked 5th in 2010 and 7th in 2015.

Inflation is another factor affecting economic growth. High inflation economy is characterised in a long term by smaller economic activity (Wojtyna, 1996). Inflation rate (variable X4) in Poland was relatively high in 2010 (2.2% - 22nd in the ranking of the countries); in 2015, Poland was within the ten EU countries of the lowest inflation rate while being ranked 4th. To be precise, the country dealt with deflation, i.e. a negative index of prices of the basket of goods and services that in 2015 was -0.9%. The countries that reported decline in prices higher than Poland included Greece (-1.7%), Cyprus (-1.5%) and Bulgaria (-1.1%). As regards the debt of the sector of government and self-government institutions, (approached as % GDP) variable X5, Poland advanced in the studied period from being ranked 13th to 10th. In 2015 the debt was 51% GDP in comparison with 72% in the EU. In 2015 permissible level of debt was exceeded by seventeen countries, including the highest level in Greece, Italy, Portugal and Cyprus where this relationship ranged between 177% and 107% of GDP. The lowest debt-to-GDP ratio was reported in Estonia, Luxembourg and Bulgaria (in 2015 between 10.1% and 26%). However, the position of Poland did not change (21st in the ranking) among the EU countries with reference to variable X6 that describes the GDP percentage share in expenditures on research and development activity. In 2015 the expenditures on research and development constituted only 1% GDP and were lower than in Slovenia (2.2%), Czech Republic (1.95%), Estonia (1.5%), Hungary (1.38%) Slovakia (1.18%) or Lithuania (1.04%). The leading countries in the sphere of innovativeness include Sweden (3.26%), Austria (3.07%), Denmark (3.03%), Finland (2.9%) and Germany (2.87%) whereas Cyprus and Romania are characterised by the lowest investments in R&D activity (0.46% and 0.49% GDP in 2015 respectively).

As regards features characterising the situation on labour market, Poland's position clearly improved. With respect to unemployment rate (X8) Poland advanced from 17th rank in 2010 to 13th rank in 2015, and considering the rate of people employed in high technology sector (X9) from 14th to 9th rank.

The level of population's education, acquisition of new skills and their development in the context of changing needs of the labour market is a very important element of effectively functioning economy. In all member states except for Belgium, Finland and Spain between 2010 and 2015 an increase in the rate of people aged 30-34 with university education was observed (variable X10). From the point of view of this quality, Poland was ranked relatively high, on 12th place with the rate reaching 43.4%. Only three countries from the group of states that joined the Union in 2004, i.e. Lithuania, Cyprus and Estonia reported higher rates.

With respect to infant mortality, the highest places in the ranking of the European Union countries in 2015 were occupied by Slovakia (1.6‰), Sweden (1.7‰), Czech Republic, Estonia, Great Britain (2.5‰). Poland with the rate of 3.1 deaths of children aged up to 1 per 1000 live births was in ranked 11th. In comparison with 2010. this represents advancement by 8 places. It is a positive phenomenon in all respects (Sojka, 2016).

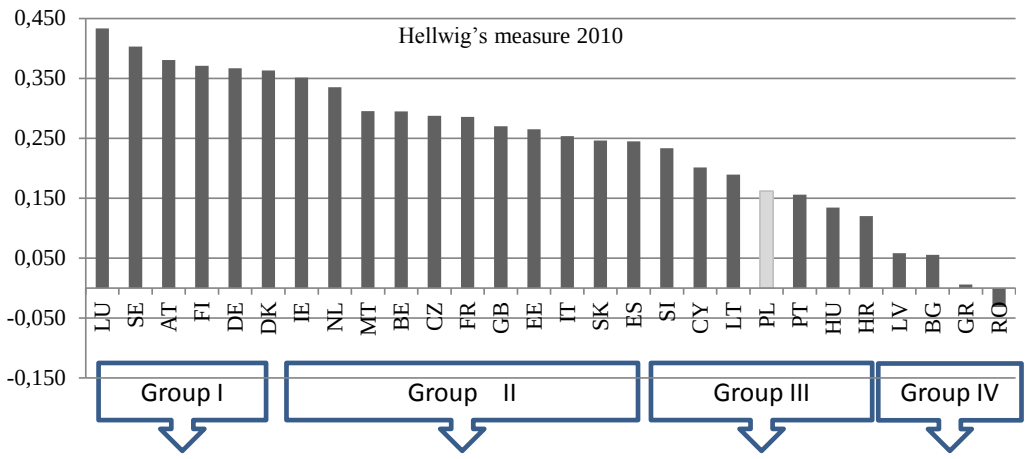
Starting from 2013, a natural decline of population was reported in Poland. This represented a surplus of deaths over births, which brought a decline of Poland in the ranking of countries from 16th place in 2010 in which a positive natural growth was observed, to 17th place in 2015. Decline in population higher than in Poland as calculated per 1000 inhabitants was reported in Estonia, Portugal, Germany, Greece, Italy, Romania, Latvia and Lithuania (from -1‰ to -3.5‰), as well as in Croatia, Hungary and Bulgaria (from -4‰ to -6.2‰). Positive natural growth was observed in 14 EU countries, the highest in Ireland (7.6 per 1000 people), Cyprus (3.9‰) and in Luxembourg (3.7‰), whereas zero population growth occurred in Czech Republic and Spain (Sojka, 2016).

Within the group of variables describing socio-technological infrastructure, a special attention should be focussed on variable X21. The largest number of people per 1 doctor was reported in Poland (in 2015 – 439) at Union average of 297 people per 1 doctor. This ranks the country in the worst, last place among 28 EU member states. Furthermore, the position in the ranking did not improve over the studied period.

Despite growth in the number of Internet users per 1000 people (from 623 to 680), the place of Poland with respect to this variable (X15) declined from 20th place 24th in the ranking. Regarding the number of mobile subscribers as calculated per 1000 people (X14) Poland was in 2015 in the 5th place in the ranking and in comparison with 2010 it advanced by 4 places. The same was observed in the case of variable X16, the advancement of Poland from 16th to 8th place in 2015 (546 cars per 1000 people in 2015 at the average for the European Union of 481). In the studied period there was also a considerable improvement of Poland's place in the sphere of risk of poverty or social exclusion rate (advancement from rank 22 to 14). In 2015 this rate was 23.4% and it was by 4.4% lower than the one reported six years before. Apart from Poland, the rate of people at risk of poverty or social exclusion decreased in twelve countries, including Bulgaria, Lithuania, Latvia and Slovakia in the highest degree. Unfavourable trends in this sphere and increase in the rate was observed in Greece, Italy and Cyprus among others. Poland is ranked 20th with respect to CO_2 emission (in tons per km^2). The least amount of carbon dioxide is emitted by Baltic countries such as Sweden, Latvia, Finland, Lithuania, whereas the largest amount by Belgium, Holland, Luxembourg and Malta. Presented changes were reflected in results of research conducted with the use of taxonomic methods.

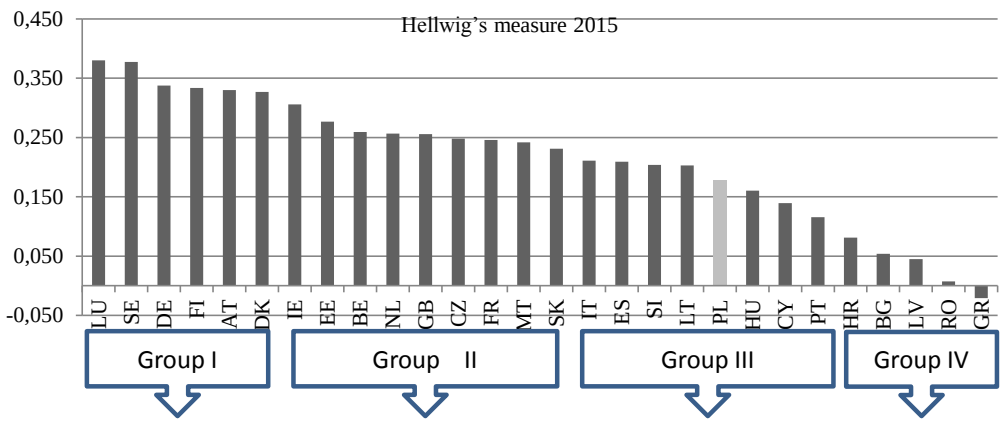
Due to limitations of the paper volume, figures 1 and 2 show results of arrangement (with measure value provided) of the EU-28 countries by the level of socio-economic development obtained with the Hellwig method of development pattern. In the case of two other methods of linear arrangement, i.e. the method of standardised sums and rank method, only places that particular countries have in obtained rankings are presented (compare table 1).

Fig. 1 Ranking and classification of EU-28 countries by Hellwig development measure in 2010



Source: Own case study based on data from (www1; www2)

Fig. 2 Ranking and classification of UE-28 states by Hellwig development measure in 2015



Source: Own case study based on data from (www1; www2)

In the ranking of EU countries obtained with the method of development model (fig. 1 and 2) both in 2010 and in 2015 Luxembourg and Sweden were in the leading places. Other countries in the top five were Austria, Finland and Germany, while only Finland was in the same fourth place in both studied years in the ranking. High result of Luxembourg is not surprising. A small country of developed industry and banking sector every day attracts thousands of people from neighbouring countries, who consequently contribute to local economy growth. In Luxembourg nearly every second citizen is a foreigner. It is the highest rate of foreigners (residing over 12 months) in total population among all member states. Romania and Greece were in the last places in the ranking. The latter country experienced the results of the global crisis most severely. Poland with the rate of 0.162 was ranked only 21st in 2010 and in 2015 it ranked higher by one place. Among the countries that joined the EU together with Poland, six countries were higher in the ranking: Estonia (8th place), Czech Republic (12th place), Malta (14th place) Slovakia (15th place) and Lithuania (19th place). The countries ranked lower than Poland included Hungary (21st rank), Cyprus (22nd rank) and Latvia (26th rank).

Despite little advancement of the place in the ranking of the European Union countries, development gap between Poland and the countries of the so-called old Union, but also the countries that joined the European Union with Poland in 2004 is still considerable. High compliance regarding the place occupied by individual countries in developed rankings can be noticed (table 1). In 2010, Bulgaria, Croatia, Latvia and Poland, and in 2015 Cyprus, Greece, Romania and Hungary had identical places in all the rankings. Slight shifts up or down (by 1-3 ranks) occurred in 18 countries in both studied years. The greatest differences in locations occupied by EU countries were observed in the case of Belgium, Spain, Holland, Malta, Slovakia and Italy. In the case of Poland, the largest shift up (by three ranks) was reported in the ranking developed with the use of the methods of standardised sums.

Tab. 1 Ranking of EU-28 countries in 2010 and (2015)

Country	Hellwig measure	Sums method	Rank method
Austria	3 (5)	7 (6)	5 (5)
Belgium	10 (9	15 (16)	11 (15)
Bulgaria	26 (25)	26 (24)	26 (23)
Croatia	24 (24)	24 (26)	24 (26)
Cyprus	19 (22)	20 (22)	18 (22)
Czech Republic	11 (12)	9 (9)	16 (11)
Denmark	6 (6)	5 (4)	7 (6)
Estonia	14 (8)	14 (8)	12 (7)
Finland	4 (4)	3 (3)	3 (2)
France	12 (13)	11 (13)	9 (12)
Greece	27 (28)	27 (28)	28 (28)
Spain	17 (17)	18 (20)	17 (16)
Holland	8 (10)	8 (14)	8 (9)
Ireland	7 (7)	4 (7)	8 (8)
Lithuania	20 (19)	19 (15)	20 (18)
Luxembourg	1 (1)	1 (2)	1 (3)
Latvia	25 (26)	25 (25)	25 (25)
Malta	9 (14)	10 (10)	14 (14)
Germany	5 (3)	6 (5)	4 (4)
Poland	**21 (20)**	**21 (18)**	**21 (19)**
Portugal	22 (23)	23 (23)	22 (24)
Romania	28 (27)	28 (27)	27 (27)
Slovakia	16 (15)	13 (12)	10 (13)
Slovenia	18 (18)	17 (17)	15 (17)
Sweden	2 (2)	2 (1)	1 (1)
Hungary	23 (21)	22 (21)	23 (21)
Great Britain	13 (11)	12 (11)	13 (10)
Italy	15 (16)	16 (19)	19 (20)

Source: Own case study based on data from (www1; www2)

Analysis of changes when individual countries took the ranks allowed for formulation of several observations:

1. while applying Hellwig's development measure, ten countries were ranked higher, ten were ranked lower and 8 countries were in the same places. The highest advance was reported for Estonia (from 14th place in 2010 to 8th place in 2015), whereas the highest decline in the rank was observed for Malta (from 9th to 14th place);
2. while applying the method of standardised sums, 12 states were ranked higher, ten were ranked lower and the other six were ranked in the same place. In this method Estonia was similarly ranked six places higher. Lithuania also achieved good result – advance from 19th to 15th place. On the other hand, Holland reported the largest decline from 8th to 14th place;
3. while applying rank method, increase and decline in the place was obtained in the same number of countries (10 in each case) as when Hellwig measure was applied. In this case the rank was higher in the case of Estonia that ranked higher from 12th to 7th place and Czech Republic (from 16th to 11th place). On the other hand, Belgium and Cyprus reported decline by 4 ranks;
4. regardless of applied synthetic measure for the evaluation of socio-economic development, Poland was ranked higher while the largest change was reported in the method of standardised sums (from 21st in 2010 to 18th place in 2015).

Spearman rank correlation coefficient is the measure allowing for the evaluation of arrangement compliance. Calculated values of the coefficient for each pair of arrangements (separately for both studied years) were between 0.957 and 0.979 which confirms high compliance of rankings obtained with the use of three various synthetic measures. A conclusion occurs that in comparative analyses of socio-economic development of EU countries all methods provided comparable results and their application in this type of research seems relevant.

Searching for clusters of EU countries of similar level of development, the method of standard deviations and Ward agglomerative method with the use of Euclidean distance were applied (figures 1-3). With the use of the first of these methods, in both studied years such countries as Luxembourg, Sweden, Germany, Finland, Austria and Denmark were classified in the first group of states of very high level of socio-economic development in the light of diagnostic features adopted for the study. At the opposite end (group IV) there were Bulgaria, Latvia, Romania and Greece, and in 2015 Croatia also joined this group. Poland, together with Slovenia, Lithuania, Hungary and Cyprus were included in the group of states where the level of development can be described as average. It is also seen in figures 1-2 that out of the ten countries that joined the Union thirteen years ago, four of them, i.e. Estonia, Czech Republic, Malta and Slovakia were in the group II with high level of socio-economic development. As it is shown in conducted analyses, internal diversification of EU countries with respect to socio-economic development is still observed.

As a result of clustering with J.H. Ward's method, while applying diagnostic variables normalised with standardisation methods, dendrograms were obtained (figure 3). Thereby classification of objects into clusters of relatively large internal similarity at relatively high differences between clusters were obtained. It results from the literature of the subject that Ward method has the best formal properties among hierarchic agglomerative methods. Its effectiveness in discovering a true data structure is around 40% better than in the method of single-linkage clustering (Berbeka, 2006).

Analysing the dendrogram obtained on the basis of data from 2010 (vertical axis representing Euclidean linking space), it seems reasonable to divide the countries into four clusters:

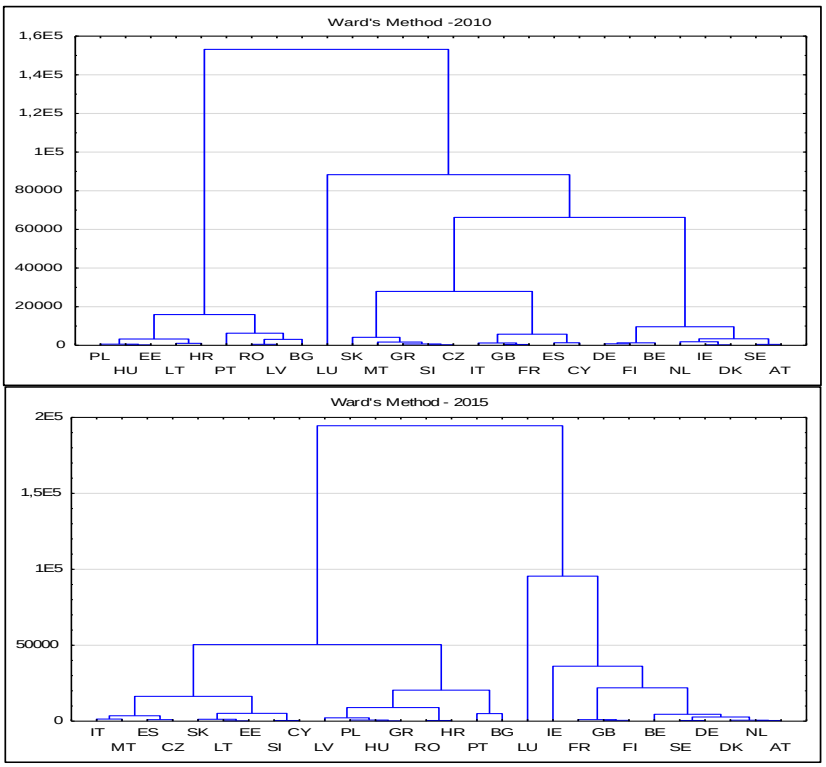
- cluster I (9 states) – Poland, Hungary, Estonia Latvia, Croatia, Portugal, Romania, Lithuania, Bulgaria,
- cluster II (1) – Luxembourg,
- cluster III (10) – Slovakia, Malta, Greece, Slovenia, Czech Republic, Italy, Great Britain, France, Spain, Cyprus,
- cluster IV (8) – Germany, Finland, Belgium, Holland, Ireland, Denmark, Sweden, Austria.

In this classification Luxembourg is significantly different from other countries and thus it forms a single-element cluster. There is considerable gap between the states belonging to cluster I and the countries of the "old Union" (cluster IV). If the division into 4 clusters is adopted, in 2015 their composition was the following:

- cluster I (9) – Italy, Malta, Spain, Slovakia, Lithuania, Estonia, Slovenia, Cyprus,
- cluster II (8) – Latvia, Poland, Hungary, Greece, Romania, Croatia, Portugal, Bulgaria,
- cluster III (1) – Luxembourg,
- cluster IV (10) – Ireland, France, Great Britain, Finland, Belgium, Sweden, Germany, Denmark, Holland, Austria.

Similarly to previous classification Luxembourg can be considered a different object. This country constitutes a single-element cluster. Poland was classified in group II the composition of which is like the previous classification, with one exception, i.e. Estonia, that shows larger similarity to countries forming cluster I. Obtained results of classification with Ward's method are generally compliant with results obtained with the method of standard deviations.

Fig. 3 Dendrograms of classification of EU-28 states with Ward's method for data of 2010 (top) and 2015 (down)



Source: Own case study based on data from (www1; www2)

4. Conclusions

On the basis of conducted research several conclusions can be formulated:

- Analysing results of conducted linear arrangement, it must be remembered that they are based on nineteen selected variables. They, in turn, to a certain extent result from subjective choice of the author (starting from the choice of the measure type, its model, through selection of diagnostic variables and their standardisation) and data availability. Probably, slightly different results would be obtained if we added or eliminated one of the variables. However, it certainly does not underestimate the value of the study as evaluation of the level of socio-economic development of the European Union countries;
- In the ranking of EU countries obtained with Z. Hellwig's development pattern method in both studied years Luxembourg and Sweden were ranked as leaders. The top five countries also included Austria, Finland and Germany while only Finland maintained the same fourth place. Greece and Romania were ranked last. Poland with the rate of 0.162 was ranked 21st in 2010 and in 2015 it was higher by one place up. Among the countries that joined the EU together with Poland, six countries were ranked higher. They were Estonia (8th place), Czech Republic (12th place), Malta (14th place), Slovakia (15th place), Slovenia (18th place), Lithuania (19th place), whereas those ranked lower included Hungary (21st place), Cyprus (22nd place) and Latvia (26th place).
- Regardless of applied synthetic measure, Poland advanced its position in prepared rankings while the largest change was reported in the case of standardised sums method (from 21st in 2010 to 18th in 2015). Despite being ranked higher, development gap between Poland and both the countries of the so-called old Union and the states that joined the European Union together with Poland is still remarkable. This was affected by ranks of Poland with respect to specific rates. Only in the case of six socio-economic features (X2, X4, X5, X9, X14, X16) it was found in 2015 in the group of top ten countries. Relatively high GDP dynamics, low inflation rate, relatively low debt of the sector of government and self-government institutions calculated as % GDP, significant rate of people employed in high technology sector, considerable number of mobile subscribers as well as the number of passenger cars in use per 1000 people were Poland's strengths. The level of functioning of health care in terms of the number of people per 1 doctor (X21) is a clear weakness of Poland. Therefore, Poland was last in the ranking of EU countries. Considering the number of Internet users (X15), the place of Poland is not satisfactory either – ranked sixth from the last.

- High values of Spearman rank correlation coefficient calculated for each pair of arrangement confirmed high compliance of rankings obtained with the use of three various synthetic measures. Therefore, it is concluded that in comparative analyses of socio-economic development of EU countries all methods provided comparable results and their application in this type of research is relevant.

Summing up it must be stated that conducted studies verified research hypotheses presented at the beginning.

References

Acocella N. (2002): *Zasady polityki gospodarczej [Principles of Economic Policy]*. PWN.

Baba W. (2016): *Changes in Level of Socio-Economic Development of EU Member Countries in the 2004-2013 Period – Taxonomic Analysis*. In: *Proceedings of the 3rd International Conference on European Integration 2016 (ICEI 2016)*. Technical University of Ostrava, pp. 37-45.

Bak I., Cheba K. (2017): *Multidimensional Comparative Analysis of Sustainable Development in European Union*. In *Proceedings of the 2017 International Conference Economic Science for Rural Development*. No. 45, Jelgava, Latvia, University of Agriculture, pp. 14-20.

Batóg J. (2010): *Konwergencja dochodowa w krajach Unii Europejskiej. Analiza ekonometryczna [Income Convergence in the Countries of the European Union. Econometric Analysis*. Scientific Papers of the University of Szczecin.

Berbeka J. (2006): *Poziom życia ludności a wzrost gospodarczy w krajach Unii Europejskiej [Standard of Living of the Population and Economic Growth in the Countries of the European Union]*. Wydawnictwo Akademii Ekonomicznej w Krakowie [*Publisher of Krakow University of Economics*].

Chrzanowska M., Drejerska N. (2016): *Statistical Comparative Analysis of Socio-Economic Development Level of Polish Border Regions (NUTS 3)*. In *Proceedings of the International Scientific Conference on Quantitative Methods in Economics - Multiple Criteria Decision Making XVIII*. Vratna, Slovakia, The Slovak Society for Operations Research, Department of Operations Research and Econometrics, Faculty of Economic Informatics, University of Economics in Bratislava, pp. 170-176.

Fura B., Wojnar J., Kasprzyk B. (2017): *Ranking and Classification of EU Countries Regarding their Levels of Implementation of the Europe 2020 Strategy*. "Journal of Cleaner Production", No. 165, pp. 968-979.

GUS (2014): *Polska w Unii Europejskiej 2004*—2014 [*Poland in the European Union 2004-2014*]. GUS.

Hellwig Z. (1968): *Zastosowanie metody taksonomicznej do typologicznego podziału krajów ze względu na poziom ich rozwoju oraz zasoby i strukturę wykwalifikowanych kadr [Application of Taxonomic Method for Typological Division of the States According to their Development, Resources and the Structure of Qualified Workers]*. "Przegląd Statystyczny" ["*Statistical Review*"], No. 4, pp. 307-327.

Panek T. (2009): *Statystyczne metody wielowymiarowej analizy porównawczej [Statistical Methods of Multidimensional Comparative Analysis]*. Oficyna Wydawnicza SGH, Warszawa.

Reinert K.A., Rajan R.S. (red.) (2009): *The Princeton Encyclopaedia of the Word Economy*. Vol. 1, Princeton University Press.

Sojka E. (2016): *Tendencje rozwojowe wybranych charakterystyk sytuacji demograficznej w krajach Europy Centralnej i Wschodniej [Development Trends of Selected Characteristics of Demographic Situation in the Countries of Central and Eastern Europe]*. "Studia Ekonomiczne – Zeszyty Naukowe UE Katowice" [*Economic Studies – Scientific Papers of the University of Economics in Katowice*], No. 291, pp. 139-155.

Vinod T., Mansoor D., Ashok D., Kaufmann D., Kishor N., Lopez R., Wang Y. (2000): *The Quality of Growth*. World Bank, Oxford University Press.

Walesiak M. (2004): *Metody klasyfikacji [Classification Methods]*. In Gatnar E., Walesiak M. (eds): *Metody statystycznej analizy wielowymiarowej w badaniach marketingowych [Methods of Statistical Multidimensional Analysis in Marketing Research]*. Wydawnictwo Akademii Ekonomicznej im. O. Langego we Wrocławiu [*Publisher of O. Lange University of Economics in Wroclaw*], pp. 316-350.

Woźniak G.M. (2004): *Wzrost gospodarczy. Podstawy teoretyczne [Economic Growth. Theoretical Foundations]*. Wydawnictwo Akademii Ekonomicznej in Krakow [*Publisher of Krakow University of Economics*].

Ziemiańczyk U. (2010): *Ocena poziomu społeczno-gospodarczego gmin wiejskich i miejsko--wiejskich w województwie małopolskim [Assessment of socio-economic level of rural communes and municipal-rural communes in Małopolskie voivodeship]*. "Infrastruktura i Ekologia Terenów Wiejskich" [“*Infrastructure and Ecology of Rural Areas*”], No. 14.

Online sources

(www1) http://ec.europa.eu/eurostat/data/database

(www2) http://stat.gov.pl/statystyka-miedzynarodowa/porownania-miedzynarodowe/

(www3) https://www.britannica.com/topic/economic-development