ANALYSIS AND EVALUATION OF THE EU MEMBER STATES DEVELOPMENT COHERENCE– SELECTED SOCIAL AND ECONOMIC ASPECTS (2000- 2012 period)

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Key words: societal energy transition, EU states stratification, cluster analysis, Low Carbon Society

Summary. The paper presents results of EU countries grouping into homothetic clusters, according to their similarity in terms of socio-cultural and techno-economic development level recorded in different periods (2000, 2005, 2012). Advanced statistical methods have been applied to assess the EU states clustering structural movements within the period analysed. The clusters' representatives have been appointed, also with the use of statistical methods. The analysis of change in time of most differentiating variables has been also presented in the article. These semi-dynamic approaches can more adequate supporting of energy transition forecasting processes observed within 2000-2012 period, e.g. in climate or energy polices design including their key interactions with societal and economic environment. The article clearly displays the intra- EU Member States heterogeneity in respect of scientific research performed.

1. INTRODUCTION

The low carbon economy transition of the European Union should be designed taking into account the differences in the EU member states development levels. The choice of homothetic clusters' representative is important to evaluate the potential impact of low-carbon transformation policy on GDP growth rate, changes in energy intensive industries' operational costs and overburden on households' budgets. Within the project MILESECURE-2050, authors conducted such an analysis [1], the main results of which are presented in the following article.

2. SCOPE OF THE ARTICLE AND THE METHODOLOGY APPLIED

To assess the similarity of EU countries different discrimination methods were applied, including Ward's method, verified by: k-means and multidimensional scaling methods (MDS). These analyses have been conducted on three sets of data including: (i) 63 diagnostic variables spread into; (ii) 42 variables describing societal changes; (iii) 21 variables describing economic changes; all observed in 2000, 2005, 2012 years.

Following statistical literature recommendations [2], the Ward's method was chosen as a basic one in the conduced research. This method belongs to agglomerative hierarchical methods, in which every object is initially considered as a separate cluster and then step by step pairs of clusters are merged. In Ward's method these pairs are merged which minimizes the increase in total within-cluster variance after merging, including isolated (singleton) groups. In literature mutual distances of subsequently merged clusters (subgroups) are called the agglomerative (grouping) distances. Ward's method in the classical form in order to define similarities between two subsequent clusters uses the sum of Euclidian distances between the centre of gravity of one cluster and the objects creating it and the centre of gravity and objects of the merged cluster.

To assess the EU states' similarity two perspectives of development have been considered, reflecting the following effects:

a. Business (techno-economic, including the pollutants emissions to the atmosphere);
b. Socio-cultural, with the selected economic aspects and life style (quality), conditioned by multiannual political and institutional mechanisms.

The selected sets of primary variables, collected mainly from Eurostat database (according to the state as of October 2014). The transformation process required from the authors a proper definition of the reference point (usually the country's population, gross value added or GDP were chosen) and subsequently the definition whether the variable has a character of stimulant or destimulant for the described process, namely the level of technological, economical and socio – political development. Subsequently indicatory variables were normalised to ensure the comparability of their numerical values – a very important feature from the statistical point of view. Taking into account literature recommendations [3] to transform the diagnostic variables, the unitarisation algorithm has been used, described by the formula:

(1) For stimulant

$$x_{ij} := \frac{x_{ij} - \min\limits_{i} x_{ij}}{\max\limits_{i} x_{ij} - \min\limits_{i} x_{ij}}$$

(2) For destimulant

$$x_{ij} := \frac{\max\limits_{i} x_{ij} - x_{ij}}{\max\limits_{i} x_{ij} - \min\limits_{i} x_{ij}}$$

where:

x_{ij} - value (realisation) of j^{th}- variable in i^{th} country,

$max\ x_{ij}$ - maximal value of j^{th}- variable,

x_{ij} - minimal value of j^{th}- variable.

In unitarisation variable interval is in the denominator; thanks to the transformation variables after the unitarisation satisfy the non-negativity condition, i.e. their values are in the range [0,1], but they keep diversified values of standard deviations (similarly to primary variables).

After completing the task of grouping EU countries into similar clusters by the use of Ward's method, we have assessed each variable impact on obtained clustering results.

The influence of each diagnostic variable on the grouping of EU states into three clusters was verified using the F-Test (Fisher – Snedecor); for a given level of statistical significance, checking the significance of the total variance in clusters for agiven variable and total variance between (three) clusters.

It should be emphasized that the distinction is considered to be the better, the smaller sum of variance within the cluster and the greater sum of the variance between clusters. After conducting the F-test it was found that the majority of diagnostic variables had significantly influenced the grouping of EU countries into three clusters.

To select the representative of similar countries belonging to each cluster we have used, in the applied statistical research, the concept of centroid, i.e., geometric center of the objects belonging to each from the clusters. The concept of the centroid is the core of k-means method, in which in the subsequent steps, clusters including increasing number of objects are replaced by the clusters' centroids. Objects close to the centroid are considered as good representatives of the cluster, from the statistical point of view. This information, parallel with the expert's (substantive) analysis and statistical assessment allows more accurate representatives' choice.

3. GROUPING RESULTS

3.1.Clusters' structure

In case of the presented analysis, the grouping process was applied to 24 states, as four EU countries were considered to be outliers. These were:

a) Croatia – significant gaps in data, mainly for 2000 and 2005 but also incomplete for 2012;
b) Cyprus and Malta – specific countries, significantly distanced from other ones, including Mediterranean (such a conclusion was drawn from the preliminary analysis conducted for the set of 27 EU);
c) Luxembourg – it was noticed that the country is very different from other EU countries, creating a separate group (many analyses and statistical evaluations indicate this 'uniqueness' stressing out that one of its reasons is welfare developed by commuters from other countries but living in Luxembourg). This situation distorts all economic indicators, which are used in comparative analyses what may lead to wrong conclusions.

Results of the analysis allowed defining homothetic clusters and selecting their representatives:

a) Highly developed countries (H): Austria; France; UK; Belgium: Netherlands; Denmark; Sweden; Finland; Ireland; Germany (the representative)
b) Medium developed countries (M): Spain, Portugal, Greece; Italy (the representative)
c) 'Catching up' countries (L): Hungary; Slovenia; Czech Republic; Lithuania; Latvia; Estonia; Romania; Bulgaria; Poland (the representative)

Fig. 1 presents results of 24 EU clustering, obtained by MDS[1] method for 2012, for the complete set of 63 diagnostic variables (two subsets: economic and social together). On the figure there have been marked similar clusters obtained by Ward's method. Whereas clusters including only one states (outliers) have been marked with different lines.

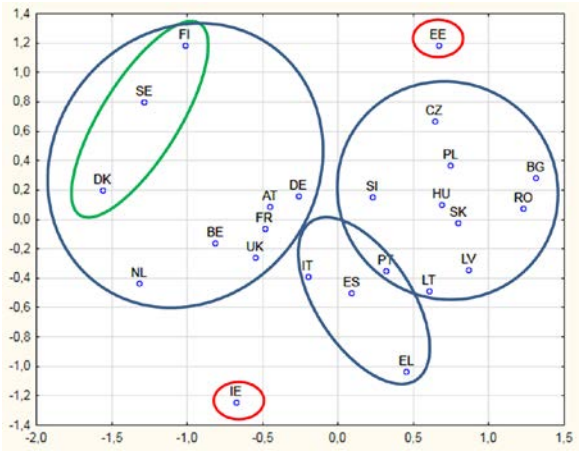

Fig. 1. Results of clustering of 24 EU countries, obtained by MDS method for 2012

In interpreting results of similarity on the map configuration (Fig. 1) it is clear that objects standing out developmentally from other countries are: IE (Ireland)

[1] Multidimensional Scaling method

and EE (Estonia). Ireland is located at a similar distance from the group of Southern and North-West countries, which may cause it joining one or the other cluster. In the case of Estonia, sometimes called a post-socialist Scandinavian country, although formally classified Central and Eastern Europe's country, it is firmly away from others, and thus in some cases can form the cluster with Scandinavian countries.

Results of grouping countries using data from 2012, illustrated in Fig. 1 allow for a relatively clear separation of objects between clusters of most developed countries (H cluster) leading a vertical separation line between Italy (IT) and Germany (DE). The second line between Greece (EL) and the Czech Republic (CZ) moves Slovenia (Sl) into medium-developed countries (M cluster) in 2012. However, other assessments of development similarities of EU countries show that Slovenia is very close to Poland in terms of the development metrics applied. Moreover, k-means verification indicates Slovenia to L cluster membership of the CEE (Central and Eastern Europe).

3.2. Set of techno – economic variables

Separated analyses have been also conducted for the subset of economic and social variables in 3 times frames. The grouping results for the year 2000 and 2012 for economic variables are presented on the Fig.2. It was confirmed, that the period of 13 years allows for assessing economic changes of distinguished countries. The effects of these changes include reshuffles in the structure of economic coherence, visualized by changed clusters' composition. This conclusion is strongly conditioned by the financial crisis of the World and the EURO zone and EU' support programmes directed to NMS'10. Significant structural changes of economic similarities of EU countries were the result of strong economic growth of 'catching up' countries, significant slowdown or even economic recession of medium - and high – developed EU countries. These two processes resulted in the decrease of development gap between EU countries in approx. annual rate of 3,3% in period 2000 – 2012. On dendrograms of Ward's Method (Fig. 2) this effect is mapped by the decrease of development distance measured by the binding distance (on the vertical axis) that allows for the creation of one cluster of all EU countries (in our case this distance in 2000 equaled 7,84 while in 2012 – 5,11 units).

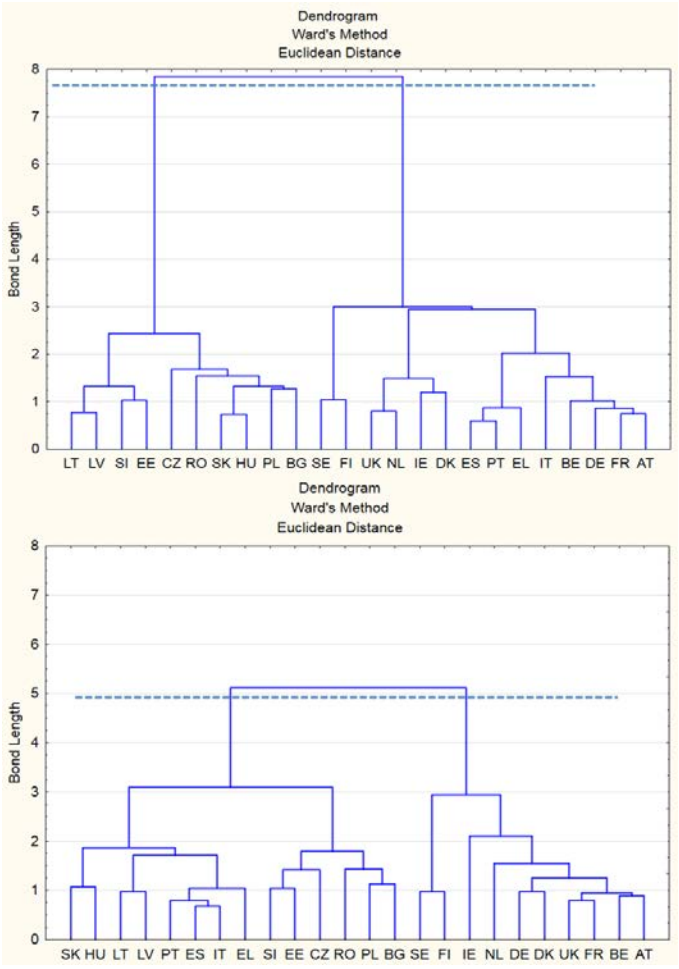

Fig.2. Dendrogram of EU24 countries on economic variables by Ward's method for years a)2000 and b) 2012

3.3. Set of societal variables

The grouping results for 2000 and 2012 for societal variables are presented on Fig.3. Societal changes in the period of 13 years proved to be much more stable, what is confirmed by results of the similarity analysis conducted on the subset characterising societal changes. These results reliably confirm the thesis about greater stability and durability of processes of societal changes over the economic ones – what should serve as a hint in projecting periods of key EU policies implementation. Although no significant changes in EU countries clustering have been observed in terms of three main clusters formation, quite considerable internal variation of clusters Hs and Ls and stabilization of cluster Ms has been observed (note – s –index means societal dimension of clustering). This conclusion concerns results obtained for 2012, which is the most recent year presented of the analysis.

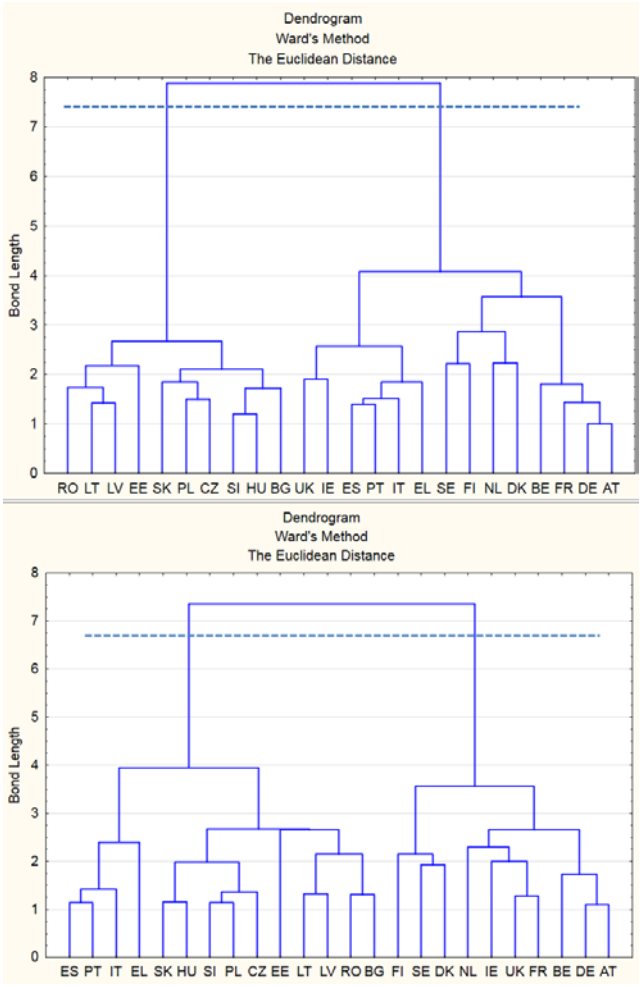

Fig.3. Dendrogram of EU24 countries on societal variables by Ward's method for a)2000 and b) 2012

4. THE MOST DIFFERENTIATING VARIABLES

On the basis of the analysis of variance for years 2000, 2005 and 2012 there have been defined variables significantly differentiating presented clusters of EU countries in those years.

Variables most significantly influencing the differentiation and development of EU countries are variables expressing wealth accumulated over a long period (Wealth/cap) and generating current incomes (GVA/cap; Median income /cap). It is also worth noting the influence of the 'government's debt' variable (destimulant), which has the highest values for highly-developed countries (H cluster). This debt is only slightly lower (approx. 10%) in the case of M cluster countries (medium-developed countries). However this variable strongly differentiates these two clusters from the cluster grouping new Member States (NMS'10), with the biggest difference in variable indicating an accumulated wealth of countries belonging to different clusters. This diversity is almost 8-fold between clusters H - L and almost 5-fold between M - L. **This information cannot be ignored in making new commitments forming new barriers to the development of EU countries**. In those cases the principle of subsidiarity and equal distribution of development load should be applied, taking into account objectively existing significant prosperity differences in the EU.

4.1. Emission transfers

The next Fig. 4 illustrates changes of the so-called transfers of emissions in kg C/cap, which were also found to differentiate significantly the EU24 countries. According to GCP methodology (Global Carbon Project [4]), these transfers are determined from the import - export balance of goods and services for each country. Knowledge of types of goods and services and their averaged emission permit, in accordance with the GCP methodology, allows to determine annual transfers emission contained in the 'surplus' amount of import over export of certain goods.

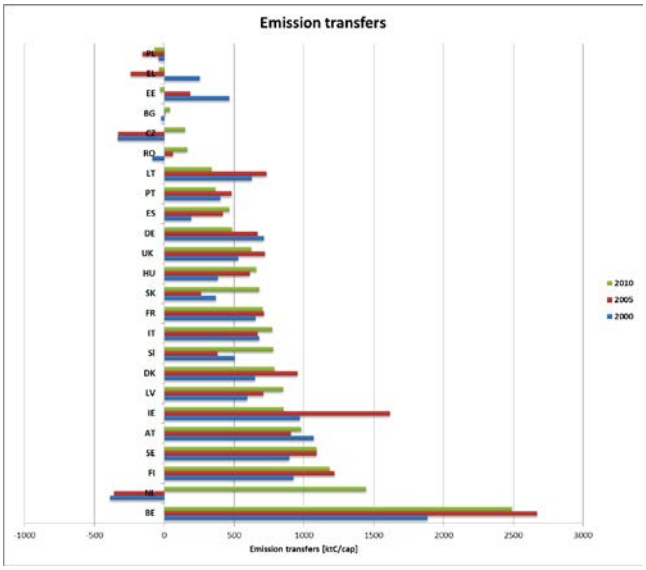

Fig. 4. Annual emissions of carbon transfers (kgC/cap) in the analysed EU countries' 24, [4]

Annual emissions transfers of carbon (C) for years 2000, 2005 and 2010 indicate that the highest emissions are associated with the consumption of goods from the surplus of imports over exports of goods and services. Fig.4 shows that for almost all these years the surplus of imported goods generated the surplus of (transfer) emissions from these goods (goods and services) to importer countries. In particular, major importers of emissions are: Belgium, Scandinavian countries and other highly developed countries forming H cluster as well as medium-developed countries (M cluster). The only exceptions to this rule are: Poland - negative emissions from imports in all analysed years and the Czech Republic and the Netherlands having negative emissions in 2000 and 2005, and

strongly positive in 2010. The explanation of this phenomenon requires a separate analysis, which goes beyond the scope of the study focused on MILESECURE-2050 modelling targets.

The next graph (Fig. 5) shows transfers of CO_2 emissions/cap in relation to the accumulated wealth in the EU country per person (2012).

In this arrangement the division into 3 clusters is also visible, although Italy definitely joined the group of developed countries. Fig.5 shows which countries 'import' emission together with importing goods from abroad (countries located above the regression line), and which ones to a greater extent produce it nationally, which are mostly countries with highly developed industry (DE, UK, IT, FR, CZ, PL), or those that were able to change lifestyle to a more sustainable one (SE, DK, AT). Of course while interpreting results it should be noted that statistics from 2012 are still affected by the financial crisis and the euro zone crisis, which is particularly evident in the case of Greece (EL).

The graph also reveals that a large group of significantly 'poor' countries (group L, with wealth dozen times lower than in group H + Italy) has significantly lower emission transfers. This covers 50% of NMS'10 with relatively low level of industry development.

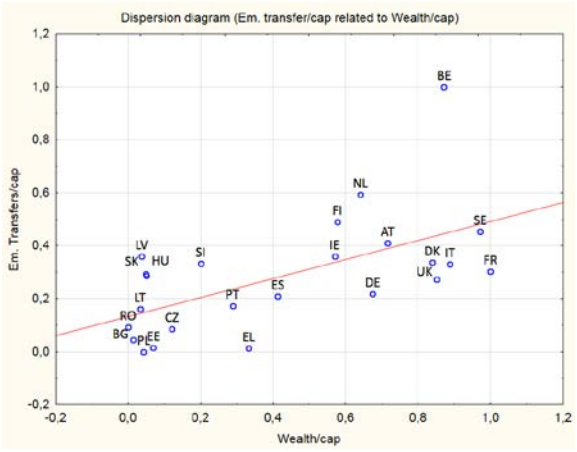

Fig. 5. Graphical presentation of functional dependence and dispersion of two variables: Em.transfers / cap and function of accumulated wealth / cap (data for 2012)

The issue of emission transfers should be analysed separately, especially in the context of current discussions about climate policy mechanisms, which in the present form do not encourage to changes in lifestyle, including the reduction of excessive consumption and are considered a potential source of 'carbon leakage' outside the EU. However, the emission returns to the EU, together with the import of goods and services.

4.2. Gross value added

Fig. 6 shows the change in gross value added per capita over the years. Such regularity is visible - countries that joined the EU after 2004 have significantly lower values of GVA / cap, but they experienced a significantly higher relative growth of macrocategory since 2000. Financial statements are expressed in current prices in EUR or USD, using calculations by official exchange rates.

The analysis of changes presented on Fig.6 confirms the development correctness according to which new member states ('catching up') develop economically much faster than 'old' EU'15 countries, which is due to changes in gross value added per capita (GVA / cap). This variable has been selected intentionally from a set of candidate variables and represents the development of countries in place of the commonly used size of GDP/cap;

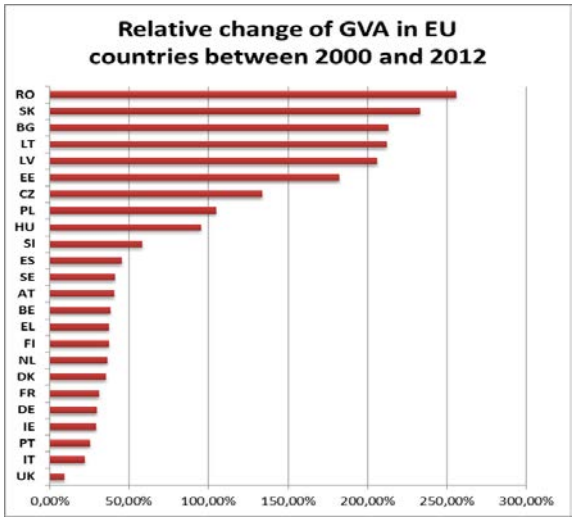

Fig. 6. Relative increase in the value of GVA / cap of EU countries recorded in the period 2000 – 2012, Eurostat

4.3. Wealth per capita

Fig. 7 shows that during current negotiations of climate commitments often the mistake was made by relying only on a significantly lower gross domestic product per capita (GDP/cap), forgetting the other important factor of significantly greater disproportion of richer part of the EU compared to new countries, including Poland. Fig. 7 shows that the accumulated wealth of 'old' EU countries is 2-3 times higher than the corresponding level of GDP/cap.

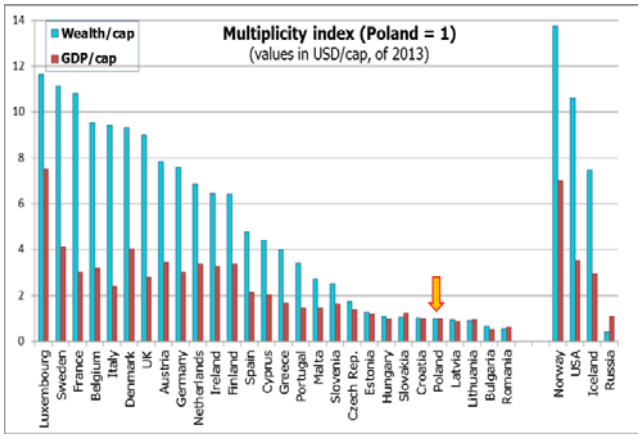

Fig. 7. Changes between 2000 and 2012 on accumulated wealth level in EU countries [5]

Authors conclude that in entering into new commitments which burden households of EU countries there should be taken into account not only the differences resulting from the GDP/cap, but at least in the same proportion - differences resulting from the accumulated wealth. This accumulated wealth creates additional development and competitive advantage. It creates more possibilities to manoeuvre the structure load distributed in a different way either to consumers (households) or specific business sectors (the sphere of production). We think one should consider this type of argument in the course of the negotiation process, including new climate commitments of EU countries, with designing load balancing mechanisms, and thus development opportunities.

5. CONCLUSIONS

The comparison of cluster analysis results leads to the following observations:

(1) Developmental differences within EU member states have been gradually reduced, although the similarity of countries grouped in three clusters does not change. None of the new Member States (L cluster) has joined the group of more developed countries taking as a criterion of similarity the value change (increase) of all 63 diagnostic variables used in the conducted analysis. In addition, there were no changes in the composition of countries between H (highly developed) and M (medium-developed) clusters. In summary, throughout the period 2000-2012 the traditional division of countries into 3 clusters has remained:
   a) West and North of Europe (H)
   b) South of Europe (M)
   c) Central and East Europe (L).

(2) On the basis of changes in metrics of similarity (development distance measured by Euclidean distance) in countries or similar clusters the following changes can be observed:

– Improving the coherence of EU Member states encompassing all three clusters of similar countries in the period 2000-2012 was followed by a rate of approx. 1.4% / a, based on a large set of 63 diagnostic variables;

– In each of the three clusters (H, M and L) grouping high-developed countries, medium-developed and catching up ones, there were almost no changes of similarities - the designated distance between the outermost 'sub-clusters' in each cluster, e.g. In H cluster there were groups: {SE + FI} of {NL, DK, AND IE, UK, FR, BE, DE, AT}, and the in L cluster - group of states {LT + LV} of {EE, RO, BG, SK, HU, Sl, PL, CZ};

– In M cluster {IT, ES, PT, EL} in the period 2000-2012 there has been some slight reduction of internal cohesion, mainly due to the deep crisis in Greece;

– The only major change recorded in 2000, 2005 and 2012 is a greater rapprochement between M and L clusters, as in 2012 for the first time countries of M and L (new member states) clusters and not with H cluster, as it occurred in 2000 and 2005. It may indicate potential mistakes in development policy of the countries belonging M cluster.

(3) According to expert estimates from Credit Suisse bank [5] between 2005 – 2012 in several EU countries there has been a noticeable decrease in accumulated wealth, particularly in Greece, Ireland, the UK and Spain (see. Fig. 7). On the contrary, the most significant increase in wealth occurred in all Nordic countries (SE, FI, DK) and in France, Austria, Germany and Italy, and among the new Member States in the Czech Republic, Estonia and Latvia.

(4) Using wealth estimates of countries in the world by Credit Suisse, it can compare with annual estimates of changes in GDP/cap. Results presented in Fig.7 show that the accumulated wealth of 'old' EU countries is 2-3 times higher than that corresponding to wealth level of GDP / cap. what should be taken into account in negotiation process, including new climate commitments of EU countries, with designing load balancing mechanisms, and thus more adequate and fair development opportunities.

(5) The results of the EU states clustering presented in the authors' working document [1] were applied in SMET (Socio Metric Energy Transition) macro-modelling performance (exercises) made under WP4 tasks, and will be taken into account

in MILESECURE-2050 final conclusions and recommendation formulation (under WP4 and WP5 key deliverables).

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ANALIZA I OCENA PODOBIEŃSTWA PROCESÓW ROZWOJU PAŃSTW UE W LATACH 2000-2012 – WYBRANE ZAGADNIENIA SPOŁECZNE I GOSPODARCZE

Słowa kluczowe: społeczna transformacja energetyczna, różnice rozwojowe państw UE, analiza skupień, społeczeństwo niskowęglowe

Streszczenie. W artykule przedstawiono wyniki grupowania państw UE w bardziej jednorodne skupienia, uwzględniające ich większe podobieństwo społeczno-kulturowe oraz gospodarczo- energetyczne odnotowane w latach 2000, 2005 i 2012. W tym celu zastosowano bardziej zaawansowane metody statystyczne różnicujące obserwowane zmiany w rozwoju państw UE w analizowanym okresie. Wydzielenie kilku grup krajów o podobnym stopniu rozwoju pozwoliło wytypować ich reprezentantów - z wykorzystaniem kilku metod statystycznych. Wyniki analizy dyskryminacyjnej uzupełniono o prezentację zmian tych zmiennych, które w zasadniczy sposób wpływały na odnotowane zmiany. Ocena taka pozwala lepiej ocenić rzeczywiste tempa zmian kształtujących relacje gospodarcze oraz (razem lub osobno) społeczno-kulturowe – odnotowane w okresie przekształceń (2000-2012). Dobry przykład wykorzystania wyników badania może stanowić np. projekcje transformacji rozwojowej w polityce klimatycznej, energetycznej czy innej - pozostającej w istotnie silnym związku z otoczeniem społeczno-gospodarczym. W artykule potwierdzono znaczące zróżnicowanie rozwojowe państw UE za pomocą zaawansowanych metod analityczno-badawczych.

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Zygmunt Parczewski, dr inż. – absolwent AGH, adiunkt w Instytucie Energetyki- w Zespole Ekspertów oraz konsultant w spółce Badania Systemowe 'EnergSys'; zajmuje się m.in. zagadnieniami zaawansowanego modelowania rozwoju energetyki, ochrony środowiska i klimatu, z uwzględnieniem wpływu na gospodarkę kraju; wielowymiarowym wpływem polityki efektywności energetycznej na proces transformacji energetycznej w Polsce i krajach EU; autor monografii: „Efektywność energetyczna w wybranych krajach UE, USA oraz w Polsce (trendy zmian, mechanizmy i instrumenty polityki); zygmunt.parczewski@ien.com.pl

Adam Umer, mgr ekonomii – absolwent Uniwersytetu Warszawskiego; konsultant w spółce Badania Systemowe 'EnergSys'; zajmuje się zaawansowanym modelowaniem procesów rozwoju makroekonomicznego różnych szczebli gospodarki, ze szczególnym uwzględnieniem ich interakcji z energetyką i ochroną środowiska, w tym wpływem polityki klimatycznej; w badaniach użytkuje m.in. modele równowagi ogólnej; ponadto rozwija badania na modelami popytu na paliwa i energię oraz modelowaniem wpływu zmian cen na zmiany strukturalne i konkurencyjne – w skali kraju i/lub dużych organizmów gospodarczych; aumer@energsys.com.pl