

## **Economic Activity-Based Cluster Analysis of European Union Countries**

Anna Blajer-Gołębiewska \*

*In the case of European Union countries, there is a significant homogeneity between their geographical, historical and political classifications. Moreover, it has been stable for decades. The aim of the research was the identification of stability in classification of European Union economies regarding their economic activities in the 21<sup>st</sup> century. The author put forward a hypothesis that the classification of economies is not stable, however the changes are not very significant. The study reveals that the hypothesis cannot be rejected, and moreover, there are not countries, but groups of countries which change their similarities to each other. There is also a high level of similarity of obtained clusters to geographical, historical and political classifications. Regarding this fact, the geographical, historical and political background of each country should be considered as one of the most important factors in the convergence analysis. In the research two clustering methods were applied: Ward's method and k-means method.*

**Field of Research:** Economics

### **1. Introduction**

In the case of European Union countries, there is a significant homogeneity between their geographical, historical and political classifications. The contemporary division of the European continent groups countries into four main clusters. Moreover, this division has been stable for decades. EU countries are therefore grouped into:

- Western Europe (Austria, Belgium, France, The Netherlands, Ireland, Luxembourg, Germany, and the United Kingdom);
- Scandinavian countries (Denmark, Norway, Sweden) or the Nordic countries (Scandinavian countries with Finland and Estonia);
- Central and Eastern Europe (Bulgaria, the Czech Republic, Estonia, Lithuania, Latvia, Poland, Romania, Slovakia, Hungary);
- Mediterranean countries (Cyprus, Greece, France, Spain, Malta, Portugal, Slovenia, Italy).

Despite being developed over centuries geographical, historical, and political classifications of European countries are not always equivocal. For example, Slovenia may be included in the group of either Central and Eastern Europe countries (which is due to its historical and political past) or the Mediterranean countries (due to its geographical location). Similarly, Estonia is sometimes classified among the countries of Central and Eastern Europe and sometimes as a member of the Nordic countries,

---

\* Dr. Anna Blajer-Gołębiewska, Department of Microeconomics, University of Gdańsk, Poland .  
email : [a.blajer@ug.edu.pl](mailto:a.blajer@ug.edu.pl)

The research was funding from the of National Science Centre (granted on the basis of decision no. DEC-2011/01/B/HS4/04718).

and France is classified as a member of either Western Europe or the Mediterranean countries.

The approach to classification of EU countries undertaken in this article is based on the assumption that there some primary factors (geographical, historical, and political) that formed and constituted the present economic situation in each country. Moreover, there are some indicators that reflect the impact of these factors on economies. One of them is the structure of economic activity in a given country which is therefore considered as a reflection of its geographical, historical, and political background.

The aim of the research is the identification of stability in economic activity-based classification of European Union countries in the 21st century. This paper tests the hypothesis that classification of economies on the basis of their economic activities is not stable, however the changes are not very significant. Moreover, there is a high level of similarity of obtained clusters to geographical, historical and political classifications in each analysed year.

The 5-year gaps were determined due to long-term processes of changes in structures of economic activities. The first analysed year was 2001 (before the biggest enlargement of the European Union), then the 2006 data (just after this enlargement, but before Bulgaria and Romania's accession to the EU, and before the financial crisis) was taken into consideration, and the last analysed year was 2011 (during the recession in Europe, the latest available data). In the research, there were applied Ward's method and k-means method of clustering.

The article proceeds as follows. The next section provides a brief overview of literature on clustering countries and regions on the basis of their economic indicators. In the following section applied data and methodology is presented. In the next sections, there are presented and discussed findings on clustering European Union countries and changes in obtain clusters over time. A final section provides summary and conclusions.

## **2. Literature Review**

In the literature, there is a wide range of studies on economic convergence of the EU economies concerning their structural changes (Laursen, 1998) and sectoral convergence of productivity levels (Muller, 2000).

Convergence was also previously analysed using clustering methods. Boreiko (2003) applied a fuzzy clustering algorithm to estimate the readiness of the Accession Countries of Central and East Europe for EMU or for unilateral euroisation. He used variables which are suggested alternately by the criteria in the Maastricht Treaty and by Optimum Currency Area theory. The first set of variables was used to analyse nominal convergence, and the second set to measure real convergence. Regarding both nominal and real convergence, the leaders are Estonia and Slovenia. Countries, which were preparing for accession then, achieved substantial results only in real convergence, but Poland was excluded from the leading group due to its weaker economic performance.

## Blajer-Gołębiewska

Works on classifications of European countries regarding their main economic indicators reveal that grouping of these countries on the basis of economic factors to some extent corresponds with their historical, political and geographical classifications. The research on the basis of a wide array of variables corresponding to the standard of living for EU: security, food, health, housing, education and culture, environment, communication, and transportation was conducted by Warzecha (2009). The results obtained using the Ward's method revealed that in 1995 European countries formed the following groups:

- I. Austria, Belgium, France, Germany, Malta, Italy, Finland, Ireland, Sweden;
- II. Cyprus, Slovenia, Denmark, The Netherlands, the United Kingdom, Greece, Portugal, Spain;
- III. the Czech Republic, Slovakia, Hungary, Estonia, Poland, Romania, Lithuania, Latvia, Bulgaria.

However, a dendrogram plotted for these variables in 2005 indicates the following classification of countries:

- I. Austria, Germany, France, Belgium, Malta;
- II. Cyprus, Spain, Portugal, Italy;
- III. Denmark, The Netherlands, the United Kingdom, Britain, Ireland, Sweden, Estonia, Finland, Slovenia;
- IV. the Czech Republic, Lithuania, Greece, Latvia, Poland, Slovakia, Hungary, Bulgaria;

This study clearly classifies the countries of Central and Eastern Europe for the last class, pointing to their lower standard of living. Moreover, the second group in 2005 accounted for the Mediterranean countries. The Nordic countries were included in the third group, together with other countries in Northern Europe.

According to research conducted by König and Ohr (2012) the heterogeneity of EU members is evident in macroeconomic variables as well as in the level of their economic integration. They developed the EU-Index, which exhibited large heterogeneities between the EU countries with respect not only to overall European economic integration, but also to various sub-indices. By using cluster analysis (particularly the Wards' method), however, they proved that there are relatively homogeneous groups of countries within this heterogeneous community. Moreover, they found that "contemporary European integration is driven by a core group including Germany, Austria, France, The Netherlands, Finland and Belgium" (König and Ohr, 2012).

In the research of well-being, in terms of GDP per capita, life satisfaction, and the Gini index, it was found that countries of Western Europe and Nordic countries are better off. They form two clusters: one for Western Europe countries and the second one for Nordic countries. In the group of economies with worse indicators of well-being there were Mediterranean countries (all in one cluster), and the worst situation was in the case of Central and Eastern Europe (also one cluster). The methodology applied was k-means (Babula, 2013). This research proves that geographical, historical and political classifications imply the level of economic development of EU members in the area of well-being.

## **Blajer-Gołębiewska**

There are also many works on classifications of countries due to the level of human capital. Research of Wronowska (2009) for the 2006 data as well as Balcerzak (2011) for years 2006 and 2008 shows that achieved clusters of countries almost coincide with the geographical, historical and political divisions of Europe.

Most of the works on the subject of clustering on the basis of economic factors, but they focus on regional clustering: analysing one specific country (US: Delgado, Porter and Stern, 2012, Delgado, Porter and Stern, 2012) or urban region (Kloosterman & Lambregts, 2001). There are also studies on determinants explaining differences in European regions development such as social capital (Beugelsdijk and van Schaik, 2005), and socioeconomic diversity of European regions (del Campo and Monteiro, 2006).

However, there is lack of research based on economic activities. As a result, research presented in the article is focused not on social or on the main economic indicators (such as unemployment, economic growth), but on economic activities and their shares in creating value added in European Union economies. Moreover, most of the research based on cluster analysis focuses on a given point in time. As a result, an important aspect of this research is the fact that it aims to identify the stability in classification over time.

Research on clustering of European countries regarding economic activities for the 2011 data (Blajer-Gołębiewska, 2013) showed that regardless of the applied clustering methodology, achieved groups of countries formed on the basis of economic activities are the same. This research is a continuation of the previous works.

### **3. Data and Methodology**

In order to identify stability in classification of European Union economies regarding their economic activities, two groups of indicators were extracted. The first one represented the current state of structure of economic activities, they were shares of economic activities in the value added of analysed countries, and the second group represented possibilities of expanding economic activities due to levels of economic freedom.

In the first group of variables, economic activities were divided into 9 groups, corresponding to the high-level International Standard Industrial Classification of All Economic Activities (ISIC) aggregation into 10 groups, but in this research Financial and insurance activities and Real estate activities were joined as there was no detailed data available for some countries. As a result, the following groups of activities were taken into consideration:

- a. Agriculture, hunting, forestry, fishing,
- b. Mining and quarrying,
- c. Manufacturing,
- d. Construction,
- e. Wholesale and retail trade, transportation and storage, accommodation and food service activities,
- f. Information and communication,
- g. Financial and insurance activities, real estate activities,

## Blajer-Gołębiewska

- h. Professional, scientific, technical, administration and support service activities,
- i. Public administration, defence, education, human health and social work activities.

As mentioned above, the second group of economic activity indicators are economic freedom indicators, which represent possibilities of expanding economic activities. They are indices of: Business Freedom, Trade Freedom, Fiscal Freedom, Government Spending, Monetary Freedom, Investment Freedom, Financial Freedom, Property Rights, Freedom from Corruption, Labour Freedom. These indices are components of the Index of Economic Freedom published by The Wall Street Journal and The Heritage Foundation.

The data on the above-mentioned indicators in 2001, 2006 and 2011 was available for the following EU countries: Austria, Belgium, the Czech Republic, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Ireland, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom.

The next step of the research was the selection of variables from both groups for cluster analysis purposes. In order to ensure comparability of data, they were reviewed and standardized in order to make them have equal importance in determining the structure. Then correlations between variables were examined. According to methodology, all the variables used in the agglomeration should not be highly correlated with each other, because the presence of correlation may cause erroneous results. For this reason, variables strongly correlated with others were removed from the final sample. Another factor to be taken into account was variability in each group of variables. Low variability is unfavourable for the agglomeration methods, because objects do not differ significantly. An example of such a variable was the Trade Freedom index, which had only two different values for analysed countries.

Most of the variables, indicating economic activities in the analysed economies that went through the above-mentioned procedure of data selection, were shares of various economic activities in the value added of analysed countries. The collected data covered most of the EU members in 2001, 2006 and 2011. Selected variables were used in clustering analysis.

In order to identify the stability in classifications of European Union economies with regard to their economic activities clustering methods were applied, particularly: the Ward's and k-means methods. The Ward's method, based on squared Euclidean distance:

$$d(x_i, x_k) = d_{ik} = \sqrt{\sum_{j=1}^p (x_{ij} - x_{kj})^2},$$

is considered to be one of most effective agglomerative hierarchical clustering methods (Ward, 1963; Grabiński, 2003). In order to verify the results obtained by using the Ward's method, k-means method was also applied to the same data. In this method the number of clusters is assumed to be known *a priori* (Bandyopadhyay and Saha, 2007). Then clusters are created by associating every observation with the

## Blajer-Gołębiewska

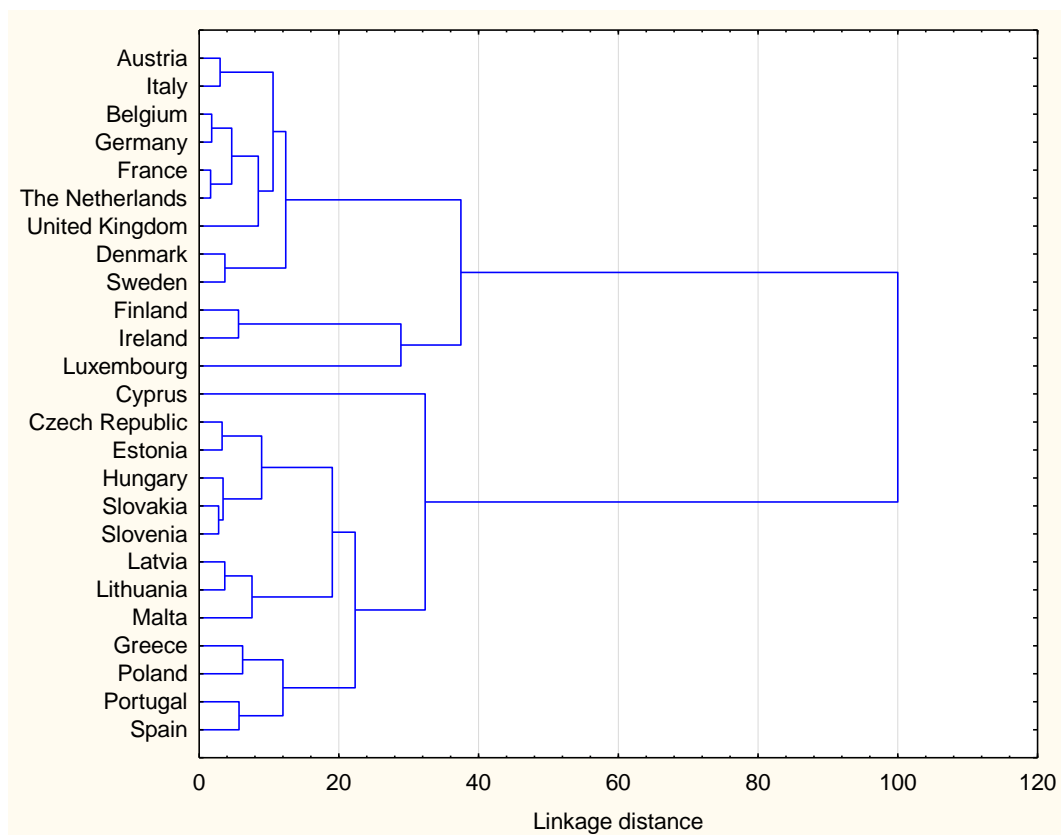
nearest mean called *centroid*. In the next step new *centroids* are calculated. The algorithm is repeated until a convergence criterion is met (MacQueen, 1967).

Determining the appropriate number of clusters on the basis of a given data set is important in clustering so the analysis began from the Ward's method which allows the determination of the number of clusters which are needed for the k-mean method.

### 4. Findings

For the 2011 and the 2006 data there were also Monetary Freedom, Investment Freedom, Financial Freedom, and Property Rights, but for 2001 Investment Freedom and Property Rights were excluded as they did not meet the criterion for data selection.

**Figure 1: Dendrogram on the basis of the Ward's method (2001)**



Source: Own compilation.

For the 2001 data, classification reflected mostly political division of economies (figure 1). There was high resemblance in economic activities of post-socialist countries (the Czech Republic, Estonia, Hungary, Slovakia, Slovenia, Latvia, Lithuania, and Poland) to Mediterranean countries such as Malta, Greece, Portugal, and Spain (figure 1).

Western countries (Austria, Belgium, Germany, France, the Netherlands and the United Kingdom) were in the first group together with Italy and the Nordic countries (Denmark and Sweden).

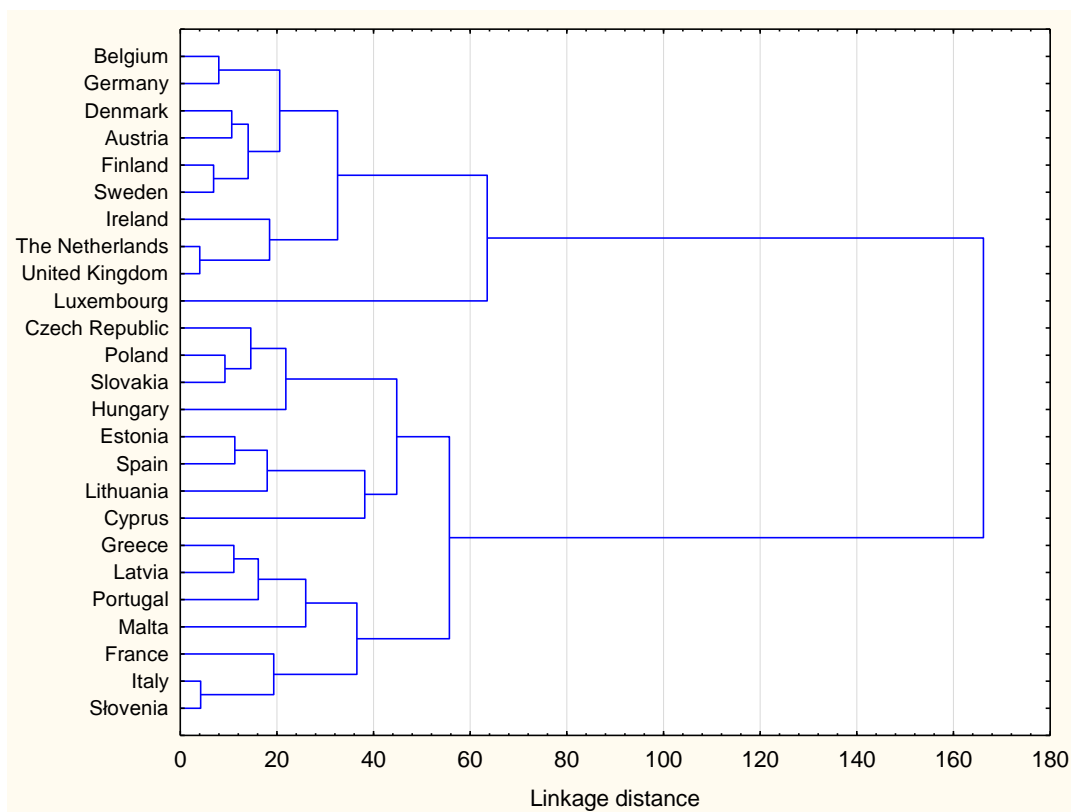
## Blajer-Gołębiewska

Finland, with reference to its economic activities, was the most homogeneous with Ireland, but this group was the most similar to the previous one.

However, there were two outliers: economies which were not significantly similar to the formed groups. They were Luxembourg and Cyprus.

For the same indicators, as used in the analysis of European economies in 2001, there were correlations examined on the basis of the 2006 data. There was no strong correlation between indicators, which allows to conduct the analysis of the 2006 data on the basis of the same indicators as for 2001.

**Figure 2: Dendrogram on the basis of the Ward's method (2006)**



Source: Own compilation.

Analysis of data for 2006 (figure 2) shows that this time the classification based on economic activities in the European economies does not reflect so clearly the geographical, historical and political classification of these countries. The first group that can be extracted consists not only of Western economies (Belgium, Germany, Austria, Ireland, and the UK) but also of the Nordic countries (Denmark, Finland, Sweden, and the Netherlands). This group could be also divided into two subgroups. The Netherlands, Ireland, and the United Kingdom would be in a separate subgroup.

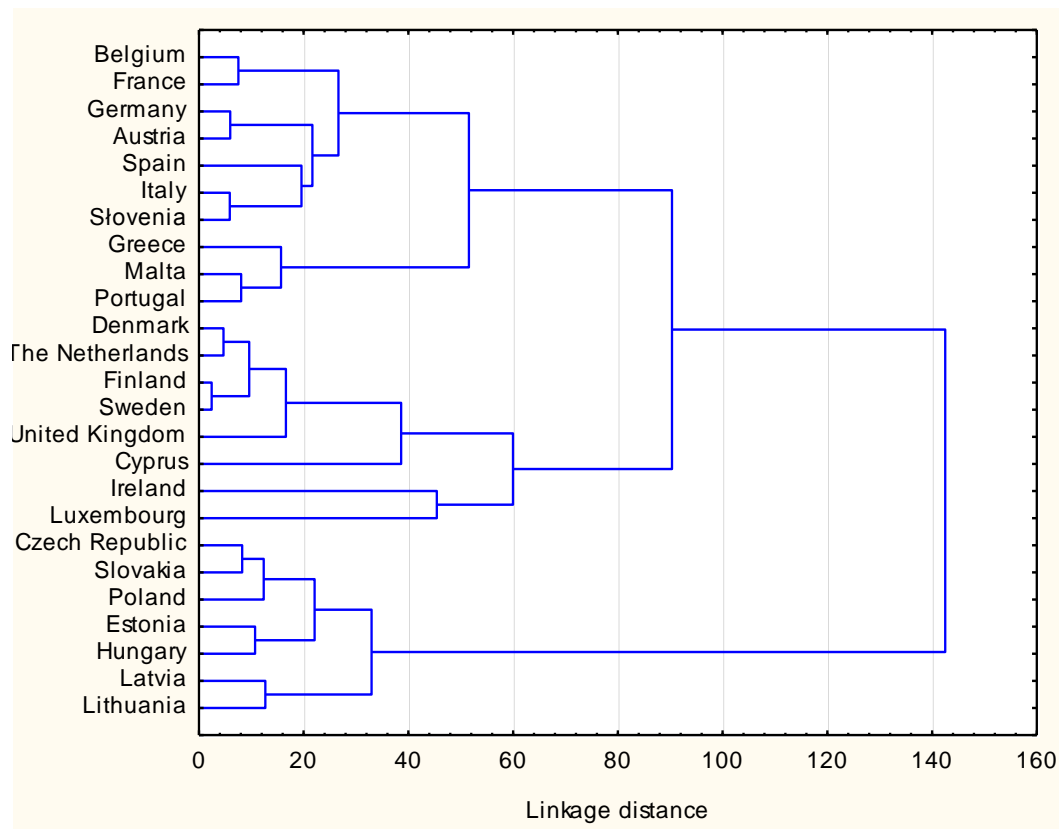
The second of the large groups is really interesting as it includes only Visegrad group countries: the Czech Republic, Poland, Slovakia, and Hungary. Visegrad group was formed as an alliance of four Central European countries in 1991, but as analysis shows these economies are still similar.

## Blajer-Gołąbiewska

There is also a group of countries which generally were not expected to be homogeneous. They are: Estonia, Spain, and Lithuania. Lithuania and Estonia lie in the same region of Europe, but the presence of Spain in this group is rather surprising. The last of large groups is consisted of Mediterranean countries: Greece, Latvia, Portugal, Malta, France, Italy, and Slovenia.

In 2006, there were the same two outliers as in 2001: Cyprus and Luxembourg. Moreover, Cyprus is once again quite close to one of formed groups, i.e. the group in which Estonia, Spain, and Lithuania are.

**Figure 3: Dendrogram on the basis of the Ward's method (2011)**



Source: Own compilation.

Comparing the results obtained for the 2011 data (figure 3) with the 2006 data (figure 2) it can be seen that different clusters were formed (table 1). Analysis of European economies shows that clusters obtained on the basis of the 2011 data covers geographical, historical and political classification (figure 3). As a result, in the first group there are Western Europe countries: such as Belgium, France, Germany, Austria, Spain, Italy, and Slovenia. In the second group, there are Mediterranean countries: Greece, Malta, and Portugal.

Third group includes Northern Europe countries which are the Nordic countries (Denmark, The Netherlands, Finland, and Sweden) and the United Kingdom, the history and geographical location of which is related to the Nordic countries. The last group includes all analysed Central and Eastern Europe countries: the Czech Republic, Slovakia, Poland, Estonia, Hungary, Latvia, and Lithuania (figure 3).



## Blajer-Gołębiewska

However, there were three outliers: Cyprus, Ireland and Luxembourg. These economies are relatively close to the third group, but their classification in the third group would not be justified. Analysed indicators of economic activities are the most related to the third group in the case of Cyprus. Ireland became an outlier in 2011. In 2006 and 2001, regarding structure of its economic activities, Ireland was not classified as an outlier - it was similar to such countries as the Netherlands and the United Kingdom (figures 1 and 2).

**Table 1: Comparison of clusters achieved on the basis of the Ward's method for years 2011, 2006 and 2001**

2001		2006		2011	
Cluster	Countries	Cluster	Countries	Cluster	Countries
I	Austria, Italy, Belgium, Germany, France, the Netherlands, the United Kingdom, Denmark, Sweden	I	Belgium, Germany, Denmark, Austria, Finland, Sweden, Ireland, the Netherlands, the United Kingdom	I	Belgium, France, Germany, Austria, Spain, Italy, Slovenia
II	Finland, Ireland	II	Luxembourg	II	Greece, Malta, Portugal
III	Luxembourg	III	the Czech Republic, Poland, Slovakia, Hungary	III	Denmark, the Netherlands, Finland, Sweden, the United Kingdom
IV	Cyprus	IV	Estonia, Spain, Lithuania	IV	Cyprus
V	the Czech Republic, Estonia, Hungary, Slovakia, Slovenia, Latvia, Lithuania, Malta, Greece, Poland, Portugal, Spain	V	Cyprus	V	Ireland
		VI	Greece, Latvia, Portugal, Malta	VI	Luxembourg
		VII	France, Italy, Slovenia	VII	the Czech Republic, Slovakia, Poland, Estonia, Hungary, Latvia, Lithuania

Source: Own compilation.

Regarding their economic activities, there were countries which in the analysed period were always together in the same cluster. In the first cluster, there were always Austria, Belgium and Germany (table 1). That means that structures of their economic activities and the level of economic freedom remained similar in the analysed period. The other group of countries, showing a high level of similarity in all analysed years, is formed by the United Kingdom, Sweden, and Denmark. They are close to other European and Nordic countries, so they join other countries from these

## Blajer-Gołąbiewska

groups. In 2001 and 2006 these countries formed one cluster with Austria, Belgium and Germany, but in 2011 they were in a separate group (figures 1-3, table 1).

France, which was in the first group of countries in 2001, occurred to be more like Italy and Slovenia in 2006 regarding structures of their economic activities. However, in 2011 they all (France, Italy and Slovenia) joined the first group (table 1).

In 2001 Italy and Slovenia, regarded as Mediterranean countries, were rather different from other countries in their region due to their economic activities structure (figure 1). There was also a much higher level of investment freedom in the case of Italy. In 2006 they became more homogeneous and they formed one cluster with Estonia (figure 2). But in 2011, as it was mentioned above, they joined the first group (figure 3).

Finland was always close to Northern countries (table 1). In 2001, it was in one group with Ireland (figure 1). In 2006 they both joined the first group together with Denmark, Finland, Sweden, Ireland, and Western Europe countries (figure 2).

As it can be concluded on the basis of the analysis above, regarding their economic activities, Nordic and Western Europe countries were similar in analysed years.

A completely distinctive group of European countries was formed on the basis of Visegrad countries which were grouped in one cluster in each analysed year. In 2001 their group was joined not only by other post-socialist countries (Estonia, Latvia, Lithuania, Slovenia), but also by Mediterranean countries (Malta, Greece, Portugal and Spain). This group split up in 2006.

In order to check the results achieved using hierarchical Ward's method, the other clustering method was applied to the same data. In k-means clustering the number of clusters is assumed to be known a priori, so for each year the number of clusters was adopted from the results obtained using the Ward's method.

In the case of 2011 data, application of k-means method gives the same results as for the Ward's method (tables 1 and 2).

Comparing results of different methods applied to the 2006 data, there is the same composition of the first group achieved by the Ward's method as the fourth group achieved by the k-means methodology (tables 1 and 2). However, two countries have changed their clusters:

1. Latvia which was previously classified in one cluster with Greece, Portugal and Malta, but according to k-means method, its economic activity structure was more similar to Lithuania, Estonia and Spain;
2. Slovenia, which previously formed one cluster together with France and Italy, but according to k-means method, its economic activity structure was more similar to Visegrad countries.

## Blajer-Gołębiewska

**Table 2: Results of k-mean clustering**

2001		2006		2011	
Economies in a cluster	distance to the nearest centroid	Economies in a cluster	distance to the nearest centroid	Economies in a cluster	distance to the nearest centroid
CLUSTER I		CLUSTER I		CLUSTER I	
Luxembourg	-	Italy	0.570341	Cyprus	-
CLUSTER II		Portugal	0.700106	CLUSTER II	
Belgium	0.405010	Greece	0.741959	Austria	0.510492
Netherlands	0.416502	France	0.765126	Belgium	0.547190
France	0.494035	Malta	0.835543	Italy	0.586550
Germany	0.505946	CLUSTER II		Slovenia	0.658805
Italy	0.576168	Cyprus	-	Germany	0.687091
Sweden	0.663761	CLUSTER III		France	0.806261
Denmark	0.696813	Slovenia	0.591842	Spain	0.811891
Austria	0.697100	Slovakia	0.594161	CLUSTER III	
UK	0.795461	Poland	0.616148	Luxembourg	-
CLUSTER III		Czech Rep.	0.648769	CLUSTER IV	
Cyprus	-	Hungary	0.752528	Sweden	0.327551
CLUSTER IV		CLUSTER IV		Netherlands	0.403350
Greece	0.588782	Sweden	0.480115	Finland	0.444528
Spain	0.624814	Netherlands	0.540430	Denmark	0.498478
Portugal	0.650328	Belgium	0.613587	UK	0.688931
Poland	0.709499	Finland	0.654431	CLUSTER V	
CLUSTER V		Austria	0.681997	Slovakia	0.591369
Czech Rep.	0.521527	Denmark	0.699017	Czech Rep.	0.669367
Estonia	0.570470	UK	0.727596	Estonia	0.683295
Hungary	0.619155	Germany	0.740084	Hungary	0.684021
Slovenia	0.662942	Ireland	0.871006	Poland	0.716462
Slovakia	0.672924	CLUSTER V		Lithuania	0.749117
Lithuania	0.708716	Estonia	0.512607	Latvia	0.856325
Finland	0.719579	Latvia	0.634199	CLUSTER VI	
Malta	0.796403	Lithuania	0.643757	Ireland	-
Latvia	0.861243	Spain	0.708808	CLUSTER VII	
Ireland	1.157232	CLUSTER VI		Portugal	0.485509
		Luxembourg	-	Malta	0.488946
				Greece	0.611034

Source: Own compilation.

The first group, formed on the basis of the Ward's method, applied on the 2001 data (table 1), is exactly the same as the second group achieved by k-means (table 2). Economies grouped in the fourth cluster using k-means method could be a relatively highly homogeneous subgroup of the last group formed by the Ward's method. The fifth group made by k-means contains not only the next subgroup of the last group formed by the Ward's method, but also Finland and Ireland (the second group regarding the Ward's method). Cyprus and Luxembourg were outliers regardless of the method applied and the analysed year.

Concluding, classification of economies on the basis of their economic activities is stable regardless of the selected clustering method only in 2011. In 2001 and 2006 classification are similar, but not exactly the same.

### 5. Summary and Conclusions

The research showed that artificial changes in division of Europe are not stable. Structure of countries in accordance to their economic activities has a tendency to change towards the geographical, historical and political classification based on the old division into Western Europe, Nordic countries, Central and Eastern Europe and Mediterranean countries which was created centuries or even millennia ago. Development of economic activities of analysed countries is therefore strongly related to their cultures. Slovenia which was one of Mediterranean countries, even after years of socialist impact on their economy is now becoming more and more homogeneous with Austria, Italy and France, and more distant from Central and Eastern Countries.

Generally, it can be noticed that there are rather not countries, but groups of countries which change their similarities to each other. These are groups of economies of which internal resemblance due to their economic activities remains significant in each of analysed years, but similarity to other groups may change:

- Austria with Germany and Belgium;
- the United Kingdom with Denmark and Sweden;
- Visegrad Group: Poland with Slovakia, the Czech Republic and Hungary;
- Portugal with Malta and Greece;
- Italy with France and Slovenia (for the 2006 and the 2011 data);
- Finland with Ireland (for the 2001 and the 2011 data);
- Estonia with Lithuania, Latvia and Spain (Latvia left this group only in 2006, and Spain left it in 2011).

There are also two permanent outliers: Cyprus and Luxembourg.

Concluding, the hypothesis of the article cannot be rejected. On the basis of research conducted, it can be stated that classification of economies due to their economic activities is not stable, however changes are not very significant (because of existence of above-mentioned groups) and there is a high level of similarity of obtained clusters to geographical, historical and political classifications in each of the analysed years. For the 2001 data classification reflected mostly political division of economies: post-socialists with Mediterranean countries, and Nordic with Western countries. Classification on the basis of the 2011 data almost perfectly reflects the old division into Western Europe, Nordic countries, Central and Eastern Europe and Mediterranean countries.

Results of the study show that there is a wide array of problems which may be analysed using clustering methods. Similar analysis may be applied for instance to socio-political activities.

The importance of this study is the fact that in the obtained classification of UE countries on the basis of their economic activity, there is a high level of similarity to geographical, historical and political classifications. As a result, the geographical, historical and political background of each country should be considered as one of the most important factors in the convergence analysis.

### References

- Babula, E 2013, 'Komplementarność pomiędzy miernikami dobrobytu oraz klasyfikacja krajów według poziomu dobrobytu', in T Kamińska and E Babula (ed.), *Uwarunkowania dobrobytu w sferze realnej*, Wydawnictwo Uniwersytetu Gdańskiego, Gdańsk, pp. 51-54.
- Balcerzak, AP 2011, 'Taksonomiczna analiza jakości kapitału ludzkiego w Unii Europejskiej w latach 2002-2008', *Prace naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, no. 176: Taksonomia 18, *Klasyfikacja i analiza danych – teoria i zastosowania*, pp. 456-467.
- Bandyopadhyay, S & Saha, S 2007, 'GAPS: A Clustering Method Using a New Point Symmetry Based Distance Measure', *Pattern Recognition*, vol. 40, pp. 3430-3451.
- Beugelsdijk, S & van Schaik, T 2005, 'Social Capital and Growth in European Regions: An Empirical Test', *European Journal of Political Economy*, no. 21, pp. 301-24.
- Blajer-Gołębiewska, A 2013, 'Ekonomiczne uzasadnienie klasyfikacji gospodarek Unii Europejskiej', *Przegląd Zachodniopomorski*, vol. 3, no. 2, pp. 53-66.
- Boreiko, D 2003, 'EMU and Accession Countries: Fuzzy Cluster Analysis of Membership', *International Journal of Finance and Economics*, vol. 8, pp. 309-325.
- del Campo, C & Monteiro, CMF, *The Socioeconomic Diversity of European Regions*, Center for European Studies, CES Working Paper Series 131, 2006.
- Delgado, M, Porter, ME & Stern S 2012, *Clusters, Convergence, and Economic Performance*, NBER Working Paper no. 18250, viewed 25 September 2013, <<http://www.nber.org/papers/w18250>>.
- Delgado M, Porter ME & Stern S 2010, 'Clusters and entrepreneurship', *Journal of Economic Geography*, vol. 10, no. 4, pp. 495-518.
- Gatnar, E 1998, *Symboliczne metody klasyfikacji danych*, PWN, Warszawa.
- Gabiński, T 2003, *Analiza taksonomiczna krajów Europy w ujęciu regionalnym*, Wydawnictwo Akademii Ekonomicznej w Krakowie, Kraków.
- Kloosterman, RC & Lambregts, B 2001, 'Clustering of Economic Activities in Polycentric Urban Regions: The Case of the Randstad', *Urban Studies*, no. 38, pp. 717-732.
- König, J & Ohr, R 2012, *Homogeneous Groups Within a Heterogeneous Community – Evidence from an Index Measuring European Economic Integration*, Center for European Governance and Economic Development Research, Discussion Paper, no. 138.
- Laursen, K 1998, *How Structural Change Differs, and Why Matters (for Economic Growth)*, IKE-Group/DRUID, Department of Business Studies, Aalborg University, pp. 1-14.
- Lopez Bazo E, Vayá, E, Mora A.J & Surinach J 1999, 'Regional economic dynamics and convergence in the European Union', *The Annals of Regional Science*, vol. 33, pp. 343-370.
- MacQueen, JB 1967, *Some Methods for classification and Analysis of Multivariate Observations*, Proceedings of 5-th Berkeley Symposium on Mathematical Statistics and Probability, Berkeley, University of California Press, pp. 281-297, viewed 28 April 2013 <<http://www-m9.ma.tum.de/foswiki/pub/WS2010/CombOptSem/kMeans.pdf>>.
- Muller, G 2000, *A Glimpse on Sectoral Convergence of Productivity Levels*, Halle Institute for Economic Research Discussion Paper, no. 133.

## **Blajer-Gołębiewska**

- Ward JH Jr. 1963, 'Hierarchical Grouping to Optimize an Objective Function', *Journal of the American Statistical Association*, vol. 58, no. 301, pp. 236- 244.
- Warzecha, K 2009, 'Poziom życia ludności Polski i pozostałych krajów Unii Europejskiej – analiza taksonomiczna', in Pangsy-Kania S. & G. Szczodrowski (ed.), *Gospodarka polska po 20 latach transformacji*, Instytut Wiedzy i Innowacji, Warszawa, pp. 19-32.
- Wronowska, G 2009, 'Kapitał ludzki w krajach Unii Europejskiej – analiza porównawcza', in Kopycińska D. (ed.), *Kapitał ludzki jako czynnik przewagi konkurencyjnej*, Wydawnictwo Katedry Mikroekonomii Uniwersytetu Szczecińskiego, Szczecin, pp. 32-46.