Evaluation of Cohesion in Visegrad Countries in Comparison with Germany and Austria by Multivariate Methods for Disparities Measurement

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***Abstract*—**Measurement of disparities between countries or regions is an important topic of many regional analysis and scientific papers. In European Union (EU), there is no mainstream approach of disparities measuring. There are many opinions and methods of measurement and evaluation of disparities between states or regions at national and European level. The methods differ in structure of using the indicators of disparities and ways of their processing. The main goal of the paper is to classify the Visegrad Four Countries (Czech Republic, Hungary, Poland and Slovakia) to homogeneous units (clusters) in comparison with Germany and Austria according to the similarity of selected indicators of economic, social and territorial development by cluster analysis in reference period 2000-2010 with focus of three milestones years (2000, 2005 and 2010). The paper evaluates the level of economic, social and territorial disparities in evaluated countries in the period 2000-2010 on the basis of selected mathematical and statistical methods leading to construction of synthetic indices of disparities. The theoretical part of the paper defines the concept of disparities in the EU and focuses on selected convenient methods of the disparities measurement and evaluation. The empirical part of the paper deals with the evaluation and comparison of disparities in the Visegrad Four Countries, Germany and Austria by cluster analysis and subsequent through computed values of synthetic sub-indices of disparities and weighted (aggregate) synthetic index of disparities.

***Keywords*—**Cohesion, Cluster analysis, Disparities, Euclidean distance, Multivariate methods, Standardized variable, Weighted synthetic index of disparities

I. Introduction

EUROPEAN Union (EU) is a heterogeneous unit with significant disparities between its Member States and their regions and with unbalanced territorial allocation of economic activities resulting in different living standard. This has a negative impact on balanced development across EU. The support of cohesion and balanced regional development together with increasing level of EU competitiveness belong to the EU key development objectives. Strengthening of cohesion in order to support balanced development of EU countries and regions is being carried out by the EU Cohesion Policy purposing to reduce disparities.

Disparities measurement and evaluation at any level of territorial development is associated with the lack of integrated approaches and methodologies in the EU. More sophisticated methods that can contribute to disparities measurement and evaluation represent *multivariate methods*. Within this paper, the application of multivariate methods (cluster analysis, construction of weighted synthetic index of disparities) are introduced in the topic of disparities in the Visegrad Four (V4) countries, i.e. Czech Republic, Hungary, Poland and Slovakia in comparison with Germany and Austria.

The aim of the paper is to classify V4 countries, Germany and Austria to the optimal number of the homogeneous clusters according to the similarity of the selected economic, social and territorial indicators in the period 2000-2010. The subsequent goal of this paper is to evaluate the level of cohesion in evaluated countries in reference period. For this purpose, the paper will determinate and compute synthetic indices of economic, social and territorial disparities and propose a construction of weighted (aggregate) synthetic index of disparities. The *hypothesis of the paper* is based on the generally accepted concept of Willem Molle, that countries with the lower level of national/regional disparities achieve the higher level of cohesion in the territory, and vice versa [12].

II. Theoretical Background of Disparities in the Context of Cohesion

Disparities in the level of performance are a major obstacle to the balanced and harmonious development of the regions, but also of the territory. Analysis of disparities brings the important information about the key problematic issues in region (and thus in country) on the one side and its development potential on the other side.

A. Concept of Disparities and Cohesion in European Union

There are different approaches to definition of disparities and therefore this term can be understood as a multidimensional problem. According to the horizontal

Manuscript received August 2, 2012.

This work was supported under SGS Project (SP2012/153) of Faculty of Economics, VŠB-Technical University of Ostrava.

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classification, there are three types of the disparities: economic, social and territorial. Economic disparities represent different level of economic convergence of countries and regions that can be measured by economic indicators. Social disparities are related to how people perceive spatially differentiated quality of the life, standard of living or social inequality and they are mostly measured by the indicators of the labour market. Territorial disparities reflect the strong inequalities in the EU competitiveness factors. Territory inequality is expressed by the significant differences in the economic performance, geographical potential and transport and technical infrastructure, capacity for innovations or quality of environment [12].

By Molle [12], the cohesion can be expressed by such level of differences between countries, regions or groups that are politically and socially tolerable. Based on typology of disparities, three dimensions of cohesion are recognized, i.e. economic, social and territorial. Economic cohesion evaluates economic convergence and can be expressed by disparities reducing development levels of countries and regions by economic indicators. Social cohesion tends to achieve objectives in employment and unemployment, education level, social exclusion of different groups and in demographic trends. Territorial cohesion is a supplementary term to economic and social cohesion. This concept develops economic and social cohesion by transferring the basic EU objective, i.e. balanced and sustainable development into territorial context [11].

B. Selected Approaches of Disparities Measurement and Evaluation

The adequate indicators of national or regional disparities can be identified e.g. within the Reports on Economic, Social and Territorial Cohesion published by the European Commission. Other possible indicators appropriate for the evaluation of disparities are the EU Structural indicators or headline indicators for evaluation of achieving the targets of Strategy Europe 2020 [8], [9], [17].

Methods of disparities measurement differ in structure of using the disparities indicators and ways of their processing. In the current regional practice, the methods based on inter-regional comparison or mathematical and statistical methods are often used. Among disparities assessment methods can be namely included interregional comparison method; methods utilizing Geographical information system; variability level (e.g. standard deviation and variation coefficient); multivariate statistical methods (e.g. method of main components and factor, cluster or discrimination analyses); simplistic models; method of real convergence; modified territorial Gini coefficient or method of artificial neuron nets [11], [18].

Within the aim and scope of the paper, the empirical part uses multivariate statistical method such as *cluster analysis*, and other selected mathematical and statistical methods as *methods of standardized variable*, i.e. transformation methods based on the normal distribution function (z-score) and *method of distance from the imaginary point* for partial calculation of synthetic indices of disparities. These methods are convenient to identification level of disparities and thus to evaluation of cohesion [10], [16].

C. Theoretical Basis of Cluster Analysis

Cluster analysis is a group of multivariate method whose primary purpose is to group objects based on the characteristics they possess. Cluster analysis classifies objects that are very similar to others in the cluster based on a set of selected characteristics. The resulting cluster of objects should exhibit high internal (within-cluster) homogeneity and high external (between-cluster) heterogeneity [7].

There is several clustering procedure how to form the groups of objects. The most popular procedures represent the *hierarchical methods* and *nonhiearchical methods*. Each of procedures follows a different approach to grouping the most similar objects into a cluster and to determining each object's cluster membership [13].

The hierarchical cluster analysis (agglomerative or divisive) is one of the most obvious methods. It uses the dissimilarities such as distances between objects when forming the clusters. The distance is mostly defined as *Euclidean distances* or the *Squared Euclidean distance* suitable for categorical variables, but there are my other specialized measures, e.g. for binary variables. After the determination of the distance measure, the clustering algorithm has to be selected. There are many methods available, the criteria used differ and hence different classification may be obtained for the same data [2]. The most frequently used methods are: nearest neighbour (single linkage), furthest neighbour (complete linkage), average linkage with (between) groups, Ward´s method, centroid method, median method. The last step of the cluster analysis is interpretation of the results. The most important is to select the cluster solution that the best represent the data sample. To define the characteristics of the cluster, it is appropriate to analyse the profile of cluster´s variables.

D. Z-Score Transformation Method

Transformation function in the multidimensional context should satisfy two minimum requirements. First, since the attributes (indicators) are measured in different units, they must be transformed into a common scale for aggregation. Second, the functions should avoid assigning high relative importance to extreme values if the original distribution has extreme values. Transformation of original variables can be used to construct a multidimensional indicator, such as synthetic index of disparities.

The most important and commonly used transformation methods include standardization of variable based on range, on the normal distribution function (z-score) or on distance from the optimal value achieved by the attribute. As the application of classic method of data normalization, we use *Z-score transformation* that provides a way of standardizing data across a wide range of indicators. Data normalized by Z-score transformation can be directly used in the calculation of synthetic indices of economic, social and territorial disparities. Z-score transformation of disparities indicators values used in

the paper is calculated by following equation (1):

$$u_{i,c,t} = \frac{x_{i,c,t} - \overline{x}_t}{\hat{s}_{i,t}}. \quad (1)$$

Where:

$u_{i,c,t}$ standardized value of *i-th* indicator for *c-th* country in time *t*;
$x_{i,c,t}$ value of *i-th* indicator for *c-th* country in time *t*;
i indicator of disparities;
c country; c = {1 = CZ, 2 = HU, 3 = PL, 4 = SK, 5 = DE, 6 = AT};
t time; t = {2000, …, 2010};
$\overline{x}_t$ mean;
$\hat{s}_t$ standard deviation.

Mean ($\overline{x}_t$) is calculated by following equation (2):

$$\overline{x}_t = \frac{\sum_{c=1}^{C} x_{i,c,t}}{C} \quad (2)$$

Where:

$x_{i,c,t}$ value of *i-th* indicator for *c-th* country in time *t*;
C number of countries; C=6;
i indicator of disparities;
c country; c = {1 = CZ, 2 = HU, 3 = PL, 4 = SK, 5 = DE, 6 = AT};
t time; t = {2000, …, 2010}.

Standard deviation ($\hat{s}_t$) is calculated by following equation (3):

$$\hat{s}_{i,t} = \frac{\sum_{c=1}^{C} (x_{i,c,t} - \overline{x}_t)^2}{C-1} \quad (3)$$

Where:

$x_{i,c,t}$ value of *i-th* indicator for *c-th* country in time *t*;
C number of countries; C=6;
i indicator of disparities;
c country; c = {1 = CZ, 2 = HU, 3 = PL, 4 = SK, 5 = DE, 6 = AT};
t time; t = {2000, …, 2010}.

The Z-score standardized value has *mean* ($\overline{x}_t$) equals 0 and *standard deviation* ($\hat{s}_t$) equals 1. Z-scores, however, take decimal values and can be negative.

E. Euclidean Distance Method

Z-score transformation is an example of *linear transformation* and thus it changed scaling uniformly, but it doesn't define the distance between standardized values. There are several convenient methods applicable for calculation of distance from the imaginary point that is usually presents as an optimal value. The most common way of computing distance between objects in a multidimensional space is to compute *Euclidean distances*, an extension of Pythagoras` theorem. The Euclidean distance is the square root of the sum of the squared differences in the variables' values; see e.g. [6]. As optimal value in computing of Euclidean distance in the paper analysis, the *median* is used. Euclidean distance for *i-th* indicator and *c-th* country in time *t* is calculated by following equation (4):

$$E_{i,c,t} = (u_{i,c,t} - \hat{u}_{50i})^2 \quad (4)$$

Where:

E Euclidean distance;
$u_{i,c,t}$ standardized value of *i-th* indicator for *c-th* country in time *t*;
$\hat{u}_{50i}$ median for *i-th* indicator ;
i indicator of disparities;
c country; c = {1 = CZ, 2 = HU, 3 = PL, 4 = SK, 5 = DE, 6 = AT};
t time; t = {2000, …, 2010}.

F. Background of Disparity Analysis

Analysis of economic, social and territorial disparities is based on *24 selected indicators* of disparities. Each dimension of disparities is presented by *8 selected indicators* listed in Annex in Table I. The reference period (2000-2010) is determined by selection of all indicators and their data availability in territorial unit NUTS 0 in *the European Statistical Office* (Eurostat) database [5]. Eurostat served as a basic database of indicators of economic, social and territorial disparities. For elaboration of the practical part of this paper, the software *IBM SPSS Statistics 20* and the table processor *Microsoft Office Excel 2010* has been used.

III. Application of Cluster Analysis in the Case of Selected Disparity Indicators in V4, Germany and Austria

A. Basic Framework of Cluster Analysis

The selection of indicators results from the concept of regional disparities evaluation in the EU. For cluster analysis, it was selected 24 indicators that represent the most frequently indicators of economic, social and territorial disparities used in *Reports on Economic, Social and Territorial Cohesion* [3], [4], some of them represent also the *EU Structural indicators*, see e.g. [14].

Because of the *correlation* it was necessary to *remove nine indicators* from the follow up analysis: Disposable income of households, Labor productivity, Gross domestic expenditure on research and development, Employment rate of woman, Unemployment rate of youth, Long-term unemployment, Municipal waste generation and treatment, Density of motorway, Volume of freight transport relative to GDP. The Pearson Correlation Coefficient of these variables achieved the value above 0.8.

The final input matrix for cluster analysis is created by 5 economic indicators, 5 social indicators and 5 territorial indicators in the reference period 2000-2010. Descriptive statistics of used indicators are illustrated in Tables II, III and IV in Annex.

To meet the assumptions of the correct implementation of the multivariate statistical analysis, the attention should be paid to the *characteristic and quality* of *data file*. On the basis of descriptive statistics, the significant differences between V4 countries, Germany and Austria exist within the economic indicators especially EPO, HRTS, ETKI and the territorial indicators GGE and EGRS, in the years 2000, 2005 and 2010. Table II in Appendix shows, that in the year 2000, the number of patent application per million of inhabitants (EPO) ranged from the 1.12 (minimum) to 269 (maximum). This indicator shows the high level of variability according to the *coefficient of variation*. Although the coefficient of variation of EPO and also HRTS, ETKI has decreased in the year 2005 and 2010, the value has exceed 50 % that indicates the heterogeneity of the file, see Table III and Table IV in Appendix. The high level of variability reached the *territorial indicators GGE and EGRS*. The mean is not appropriate measure of the data evaluation and file is heterogeneous. The positive development is recorded in the *social indicators*. In the end of reference period, the average rate of employment has increased and the rate of unemployment has reduced in comparison with the year 2000. According to the coefficient of variation of the social indicators, the file is homogeneous and without outliers.

According to characteristic of the *skewness* in the years 2000 and 2005, the data distribution is mostly *right–skewed*. The characteristic of *kurtosis* mostly implies the leptokurtic distributions.

Within indicators of HRTS, ETKI, GGE and EGRS were detected *the outliers* (Germany, Austria). Nevertheless, outliers have not been removed from the subsequent cluster analysis due to possible disruption of the actual structure of the analyzed file.

B. Empirical Results of Cluster Analysis

The *first step* of cluster analysis is to select the *criterion of similarity* (dissimilarity) of the objects. As a measure of dissimilarity was selected the *Squared Euclidean Distance* which is the most used one and it is basis of the *Ward´s method*. Given the extensive Tables of each year, only Table I and Table II for year 2000 are shown for illustrative purposes. On the basis of the Proximity Matrix in Table I, the highest differences in the year 2000 exist between Slovakia and Germany (55,423). The lowest distance is recorded between Hungary and S1ovakia (11,165). In the year 2005, the distance between Germany and Slovakia reduced on the 49,314 and between Hungary and Slovakia on the 5,334. However, the rate of dissimilarity between Germany and Slovakia was again increased in the 2010 (62,544). The positive development can be seen in the case of differences between Hungary and Slovakia, where the distance was decreased (8,477).

Table I Proximity Matrix (year 2000)

Case	Squared Euclidean Distance					
	1:Czech Republic	2:Hungary	3:Poland	4:Slovakia	5:Germany	6:Austria
1:Czech Republic	,000	19,486	15,304	16,839	35,364	26,239
2:Hungary	19,486	,000	11,223	11,165	44,218	39,769
3:Poland	15,304	11,223	,000	11,659	41,467	40,384
4:Slovakia	16,839	11,165	11,659	,000	55,423	44,251
5:Germany	35,364	44,218	41,467	55,423	,000	37,207
6:Austria	26,239	39,769	40,384	44,251	37,207	,000

Source: Own calculation and elaboration, 2012

Table II *Agglomeration Schedule*, provides the information about the hierarchical clustering process based on *Ward´s method*.

Table II Agglomeration Schedule (year 2000)

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	2	4	5,583	0	0	2
2	2	3	11,349	1	0	3
3	1	2	21,419	0	2	5
4	5	6	40,023	0	0	5
5	1	5	75,000	3	4	0

Source: Own calculation and elaboration, 2012

The column *"Coefficients"* helps us to decide how many clusters are optimal for representation of the data. In this case, the cluster formation should be stop when the increase in the *Coefficients* is large. In this case, the best interpretation of data ensures *four-cluster solution* in the year 2000, as well as in the years 2005 and 2010. *Cluster I* represents only the *Czech Republic*. The separation of this cluster from *Cluster II* including *Hungary, Slovakia and Poland*, implies the visible differences between V4 countries. *Cluster III* represents only *Germany* and *Cluster IV* is created by *Austria*. The significant disparities can be noticed between Germany and Austria on the one side and Visegrad Four countries on the other side. *The four-cluster solution has remained the optimal solution* also in the year 2005 and 2010. In the year 2005, the structure of the clusters is identical to the clusters in the year 2000. The *cluster membership was changed* in the year 2010. *Cluster I* comprises of the *Czech Republic* and *Slovakia*. Cluster II is created by *Hungary and Poland. Cluster III* represents *Germany* and *Cluster IV* is characterized by *Austria*.

The *graphical representation* of distance between which clusters are combined is *Dendogram*. The gradual clustering of the V4 countries, Germany and Austria and the final optimal number of the determined clusters in the year 2000 is shown in example of dendogram in Fig. 1.

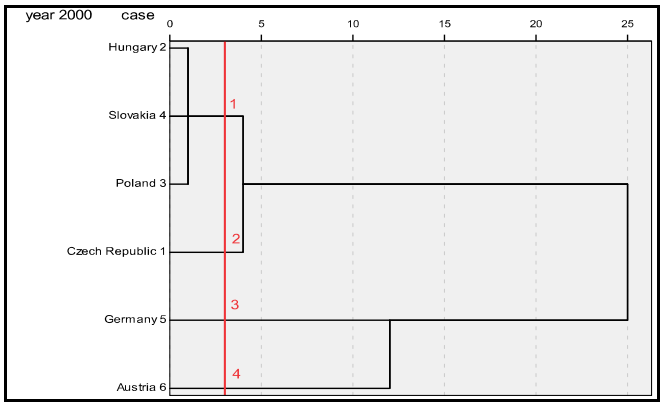

Fig. 1 Dendogram using Ward Linkage (year 2000)
Source: Own calculation and elaboration, 2012

C. *Interpretation of the clusters profile*

To easier interpretation of the determined clusters and comparison of their basic characteristics, it is appropriate to construct the *profile of cluster*. The profile of each cluster is based on the mean value of the standardized indicators (variable).

Cluster I represents only the *Czech Republic* in the year 2000 and 2005. Cluster I is separated from other Visegrad countries that implies the disparities between Czech Republic and Hungary, Poland, Slovakia. Cluster I is characterized by the *higher economic performance* than Cluster II achieves, sufficient development of the labor market and good territorial cohesion. As can be seen in Fig. 2, the Czech Republic recorded the positive development of all indicators in the period 2000-2005. Due to change of the cluster membership in the year 2010, the negative development of the indicators, especially economic and social indicators has been recorded.

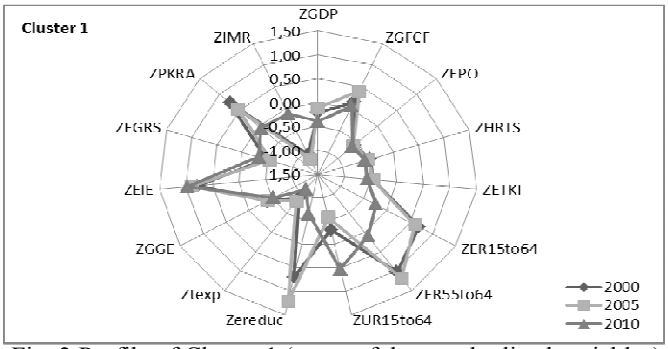

Fig. 2 Profile of Cluster 1 (mean of the standardized variables)
Source: Own calculation and elaboration, 2012

Cluster II including *Hungary, Poland and Slovakia* in the year 2000 and 2005, can be considered as a cluster with *the lowest degree of economic performance*, biggest problems at the labour market and low rate of territorial cohesion. The positive development between years 2000-2005 is noticed in increase in gross fix capital formation, human resources in science and technology, rate of employment and in decrease in energy intensity of economy. Cluster II has remained the worst evaluated cluster also in the year 2010 after the change of cluster membership. Slovakia was combined with the Czech Republic to Cluster I in the year 2010 that can indicates the drop in disparities between countries as illustrated Fig. 3.

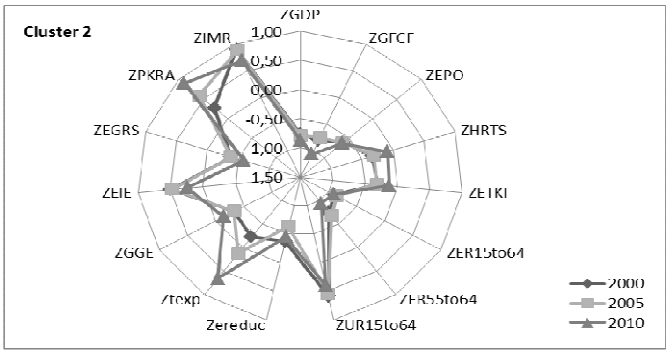

Fig. 3 Profile of Cluster 2 (mean of the standardized variables)
Source: Own calculation and elaboration, 2012

Cluster III including only *Germany* is characterized by a *very good economic prosperity and the innovative capacity* that has risen since the year 2000. The disparities in the innovation area are visible for the all reference period, especially between Germany and Cluster I and Cluster II. As it is noticed in Fig. 4, Cluster 3 also achieves the high level of social cohesion that is defined by the increase in rate of employment and decline in rate of unemployment in the reference period. Cluster III had the biggest problems in the area of environment. Compared to Cluster 4, Germany featured the highest level of greenhouse gas emission and energy intensity and on the other hand the lowest rate of electricity generated from renewable sources in the year 2000. In the end of the period the positive development of environmental indicators was recorded.

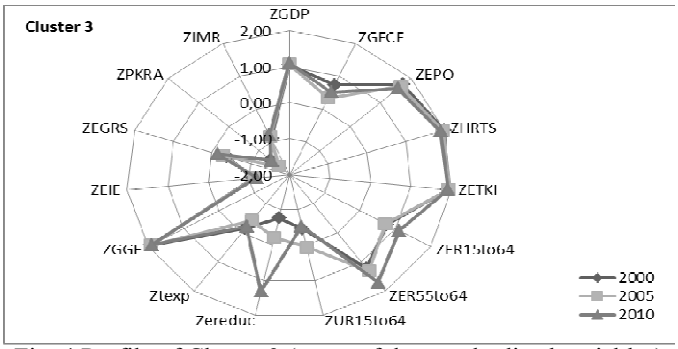

Fig. 4 Profile of Cluster 3 (mean of the standardized variables)
Source: Own calculation and elaboration, 2012

Cluster IV represents only *Austria*, is distinguished by the *high level of the living standard* which is characterized by the highest value of GDP per head (in PPS) in comparison with the other three analysed clusters. Cluster 4 achieves the best results also in the indicators of GFCF and EPO. As the Fig. 5 shows, the mean value of the standardized GDP, GFCF, EPO slightly increased in the year 2005 and 2010 in comparison with the year 2010. Cluster 4 is characteristic by the highest level of social cohesion in the comparison with other cluster.

According to Fig. 5, in the end of the reference period the rate of employment has increased and the rate of unemployment has reduced. The positive development during ten years has been recorded in territorial cohesion, when the security on roads has increased (number of people killed in the road accident has reduced in 2010) and the infant mortality has reduced. Although the energy intensity has reduced since the year 2000, the electricity generated from renewable sources has decreased and greenhouse gas emissions have risen.

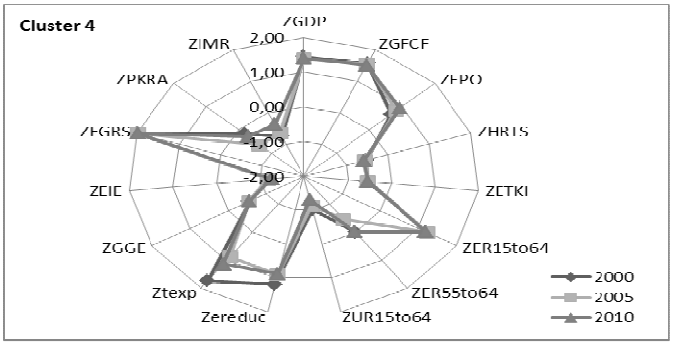

Fig. 5 Profile of Cluster 4 (mean of the standardized variables)
Source: Own calculation and elaboration, 2012

IV. Cohesion Evaluation in Visegrad Countries, Germany and Austria by Synthetic Indices of Disparities

A. Analysis Background of Indices of Disparities

By construction of synthetic indices of disparities for evaluation of cohesion, it is used all *24 selected indicators* of disparities. Each dimension of disparities is presented by *8 selected indicators* listed in Annex in Table I. The construction of indices has been inspired by approaches of Farrugia and Gallina [6] that proposed construction of index of territorial disparities and also by Bárcena, et al. [1] that evaluated social cohesion in Latin America by construction of index of social cohesion.

B. Synthetic Indices of Disparities

Synthetic indices are compute as partial simple sub-indices for each individual dimension of disparities. Synthetic indices of each country *c*, for each dimension of disparities *d*, in time *t* are calculated by following equation (5):

$$ID_{c,d,t} = \frac{\sum_{i=1}^{I} E_{i,c,t}}{I}. \quad (5)$$

Where:

ID index (sub-index) of disparities;
E Euclidean distance;
c country; c = {1 = CZ, 2 = HU, 3 = PL, 4 = SK, 5 = DE, 6 = AT};
d dimension of disparities; d = {economic, social, territorial};
i indicator of disparities;
t time; t= {2000;…,2010};
I number of indicators *i* per one dimension of disparities; I = 8.

Following Tables (Table III, Table IV and Table V) show calculated values of synthetic indices of economic, social and territorial disparities as well as the rank of explored countries. In all V4 countries as well as in referenced advanced EU countries as Austria and Germany, *positive development trend of economic, social and territorial disparities has been recorded in reference period 2000-2010*. The rate of disparities in Austria and Germany is rather smaller than in V4 countries according to computed values of synthetic indices. Results in all dimensions of disparities indicate that computed standardized values of synthetic indices converge to disparities indices *optimal value* (i.e. to 0) more at the end of reference period (2010) than at the beginning of reference period (2000). It can be said that *smaller value of calculated difference (distance), marks the lower rate of disparities and therefore the higher level of cohesion*.

In Table III, on-going computed volumes and total ranks of evaluated countries in terms of synthetic index of *economic disparities* are illustrated. The best results, traditionally economic powerful countries have reached (Germany, Austria). Economic disparities in V4 countries are, according to values of this synthetic index, higher than in Germany and Austria. Increasing trend of economic disparities has been recognized in Hungary, Poland and Germany, throughout period 2000-2010. Vice versa, the Czech Republic, Slovakia and Austria have illustrated decreasing rate of economic disparities in referred period.

The on-going computed volumes and total ranks of evaluated countries in terms of synthetic index of *social disparities* are illustrated in Table IV. The best results have been reached in Austria and Germany. Social disparities in V4 countries are, according to values of this synthetic index, also higher than in Germany and Austria. Decreasing trend of social disparities has been recognized only in Germany and Austria during referred period. V4 countries show increasing rate of social disparities throughout period 2000-2010.

In Table V, on-going computed volumes and total ranks of evaluated countries according to values of synthetic index of *territorial disparities* are shown. The best results, Austria and Germany have reached. Territorial disparities in V4 countries are, according to values of this synthetic index, higher than in Austria and Germany. Only in Slovakia and Austria, increasing trend of territorial disparities has been recognized, in referred period. Vice versa, the Czech Republic, Hungary, Poland and Germany have illustrated decreasing rate of territorial disparities throughout period 2000-2010.

Table III Synthetic Index of Economic Disparities

Country/Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Index of Economic Disparities										
Czech Republic	3,88	3,82	3,87	3,76	3,77	3,74	3,68	3,57	3,76	3,77	3,51
Hungary	4,90	4,79	4,62	4,60	4,62	4,71	4,88	5,21	5,17	5,12	5,67
Poland	4,56	4,89	4,97	4,97	4,91	5,09	5,13	5,04	5,05	4,78	4,87
Slovakia	5,22	5,08	5,09	5,20	5,20	4,96	4,85	4,71	4,57	4,86	4,44
Germany	0,13	0,14	0,19	0,20	0,24	0,23	0,20	0,20	0,19	0,22	0,31
Austria	1,66	1,65	1,62	1,62	1,62	1,62	1,61	1,62	1,62	1,61	1,56
	Total Average Rank					*Total Absolute Rank*					
Czech Republic	3,00					3					
Hungary	4,91					4					
Poland	5,00					5					
Slovakia	5,09					6					
Germany	1,27					1					
Austria	1,73					2					

Source: Own calculation and elaboration, 2012

Table IV Synthetic Index of Social Disparities

Country/Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Index of Social Disparities										
Czech Republic	0,92	0,94	0,91	0,84	0,98	0,84	0,82	0,80	1,01	1,14	1,31
Hungary	2,95	2,45	2,11	1,66	1,33	1,60	2,29	3,10	4,32	4,17	3,64
Poland	3,43	4,11	4,71	5,38	5,14	5,40	4,74	3,69	2,59	2,15	2,20
Slovakia	4,81	4,52	4,28	3,93	4,18	4,06	4,14	4,51	4,21	4,89	5,39
Germany	0,78	0,83	0,82	0,94	0,79	0,88	0,87	0,83	0,83	0,60	0,41
Austria	0,28	0,34	0,36	0,44	0,75	0,40	0,33	0,26	0,21	0,24	0,23
	Total Average Rank					*Total Absolute Rank*					
Czech Republic	2,64					3					
Hungary	4,36					4					
Poland	5,27					5					
Slovakia	5,36					6					
Germany	2,36					2					
Austria	1,00					1					

Source: Own calculation and elaboration, 2012

Table V Synthetic Index of Territorial Disparities

Country/Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Index of Territorial Disparities										
Czech Republic	3,34	2,95	3,00	3,17	3,23	3,76	3,18	3,75	3,56	3,45	3,12
Hungary	3,12	3,36	3,39	3,38	3,10	2,74	2,89	2,90	2,68	2,74	2,95
Poland	4,60	4,17	4,02	3,91	4,07	3,86	3,95	3,66	3,86	4,11	3,49
Slovakia	3,72	3,52	3,73	3,77	3,86	3,81	4,16	3,81	3,84	3,40	4,00
Germany	1,79	1,60	1,61	1,53	1,50	1,50	1,50	1,48	1,47	1,51	1,13
Austria	0,49	0,55	0,40	0,39	0,40	0,47	0,46	0,53	0,72	1,73	1,46
	Total Average Rank					*Total Absolute Rank*					
Czech Republic	3,91					4					
Hungary	3,36					3					
Poland	5,73					6					
Slovakia	5,00					5					
Germany	1,73					2					
Austria	1,27					1					

Source: Own calculation and elaboration, 2012

C. Weighted synthetic index of disparities

The construction of weighted index of disparities has been met with problems related to the *weighting*; see e.g. [11], [15]. We can aggregate data by using equal or differential weight given to all free dimensions of disparities. On the background of descriptive statistics and variability of selected sample of indicators, we have used *differential weights* for each dimension, however, some research may prove equal weighting; see e.g. [3]. Weights used in construction of weighted synthetic index presented in equation (7) are calculated by equation (6) and reflect the *ratio* between highest and lowest scores of each synthetic sub-index of disparities.

$$w_d = \frac{\sum_{t=1}^{T} \frac{\underset{c}{MAX}\ ID_{c,d,t}}{\underset{c}{MIN}\ ID_{c,d,t}}}{T}. \quad (6)$$

Where:

$\underset{c}{MAX}\ ID_{c,d,t}$ maximum value of index of disparities of country *c* for dimension *d* in time *t*;

$\underset{c}{MIN}\ ID_{c,d,t}$ minimum value of index of disparities of country *c* for dimension *d* in time *t*;

ID index (sub-index) of disparities;

w_d weight per dimension of disparities;

d dimension of disparities; d = {economic, social, territorial};

t time; t = {2000;…,2010};

T T = 11.

Weighted synthetic index is calculated from the partial sub-indices of disparities for country *c*, for dimension *d* in time *t* by following equation (7) on condition (8):

$$IDW_{c,d,t} = \sum_{d=1}^{3} ID_{c,t,d} \cdot \frac{w_d}{\sum_{d=1}^{3} w_d}, \quad (7)$$

on condition: $\sum_{d=1}^{3} \frac{w_d}{\sum w_d} = 1.$ (8)

Where:

IDW weighted synthetic index of disparities of country *c* for dimension *d* in time *t*;

ID index (sub-index) of disparities of country *c* for dimension *d* in time *t*;

w_d weight per dimension of disparities;

$\frac{w_d}{\sum_{d=1}^{3} w_d}$ relative weight per dimension of disparities d in relation to other dimensions of disparities in period *t,*

d dimension of disparities; d = {economic, social, territorial};

c country; c = {1, …, 6; 1 = CZ, 2 = HU, 3 = PL, 4 = SK, 5 = DE, 6 = AT};

t time; t = {2000;…,2010}.

Table VI shows total ranks of V4 countries, Austria and Germany within weighted synthetic index of disparities over the period 2000-2010. The overall evaluation of individual countries shows that the best results, in terms of the lower rate of disparities and therefore the higher level of cohesion, *Austria* and *Germany* have reached and these countries are ranked in *first* and *second place* during the whole period. In *third place*, there is *the Czech Republic*, which has recorded the best position of all V4 countries in the volumes of weighted synthetic index of disparities. *Hungary* and *Poland* are ranked in *fourth* and *fifth place.* These countries have thus recorded lower level of cohesion than the Czech Republic. *Slovakia* is ranked in *last – sixth place* and it is country with the highest rate of disparities and therefore the lowest level of cohesion.

Table VI Weighted Synthetic Index of Disparities

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average Rank	Total Rank
CZ	3,06	2,97	3,00	2,94	2,99	3,02	2,89	2,91	3,04	3,06	2,90	3,0	**3**
HU	4,15	3,99	3,81	3,68	3,57	3,64	3,93	4,33	4,58	4,53	4,75	4,1	**4**
PL	4,28	4,58	4,76	4,91	4,84	4,99	4,86	4,50	4,26	4,02	3,99	4,5	**5**
SK	4,89	4,70	4,68	4,67	4,75	4,56	4,57	4,53	4,37	4,65	4,61	4,6	**6**
DE	0,54	0,53	0,56	0,59	0,56	0,58	0,56	0,55	0,54	0,51	0,46	0,5	**1**
AT	1,14	1,16	1,13	1,14	1,22	1,15	1,12	1,12	1,13	1,29	1,21	1,2	**2**

Source: Own calculation and elaboration, 2012

V. Conclusion

The measurement of disparities and evaluation of cohesion within this paper analysis was performed through cluster analysis and construction of simple and weighted synthetic indices. Cluster analysis is a technique for the classifying a large number of information into meaningful subgroups, called clusters. The clustering allows us to identify homogenous groups of objects and to determine what in our sample belongs to which group. On the basis of Ward's method applying the Squared Euclidean Distance, the *optimal four-cluster solution has been determined* in the study of V4, Germany and Austria disparities in the reference period 2000-2010. The four cluster solution indicates the disparities between V4 countries on the one hand and Germany and Austria as more developed states on the other hand. These socio-economic disparities have persisted since the year 2000.

Simple and weighted synthetic indices are calculated from standardized values of disparities indicators computed by Z-score transformation and Euclidean distance. The main advantage of these methods consists namely in their ability to summarize the different units of measure under the one synthetic characteristic (index), which is the dimensionless figure. The analysis showed that, for the most part, there was a consensus in the development trends of V4 countries in terms of attainment level of development potential to advanced countries as Austria and Germany, depending on the level of existing disparities. Selected statistical methods showed that since the year 2000 positive economic, social and territorial development was monitored in countries of Visegrad Four, Germany and Austria and thus level of cohesion recorded increasing trend thanks to decreasing volume of national disparities. In spite of narrowing rate of economic, social and territorial disparities and convergence process in level of cohesion, the significant national disparities between V4 countries and Austria and Germany remain. The performed analysis also showed that economic disparities between V4 countries, Germany and Austria achieved higher rate of variability than social and territorial disparities.

Appendix

Table I Selected Indicators of Economic, Social and Territorial Disparities

Dimension of Disparities	Indicators
Economic disparities	GDP per head (GDP); Disposable income (DI); Labor productivity (LP); Gross fixed capital formation (GFCF); Total intramural R&D expenditure (GERD); Patent applications to the European Patent Office (EPO); Human Resources in Science and Technology – Core (HRTS); Employment in technology and knowledge-intensive sectors (ETKI)
Social disparities	Employment (ER15to64); Employment rate of older workers (ER55to64); Employment rate of woman (ERw15to64); Unemployment rate (UR15to64); Unemployment rate of youth (URy15to24); Long-term unemployment (LtUR); Employment rates by highest level of education attained- first and second stage of tertiary education (EReduc); Total public expenditure on education (Texp)
Territorial disparities	Greenhouse Gas Emissions (GGE); Energy intensity of the economy (EIE); Electricity generated from renewable sources (EGRS); Municipal waste generation and treatment (MWGT); Density of motorways (DM); People killed in road accidents (PKRA); Infant mortality rates (IMR); Volume of freight transport relative to GDP (VFT)

Source: [5]; own calculation and elaboration, 2012

Table II Descriptive statistics (year 2000)

Indicator	Mean	Median	Std. Deviation	Variance	Minimum	Maximum	Range	Coefficient of variation	Skewness	Kurtosis	Percentiles		
											25	50	75
GDP	15000,00	11900,00	7000,00	49000000,00	9200,00	25100,00	15900,00	46,67	0,85	-1,60	9425,00	11900,00	23075,00
GFCF	3666,67	3200,00	1557,78	2426666,67	2200,00	6100,00	3900,00	42,48	0,76	-0,90	2425,00	3200,00	5125,00
EPO	73,06	9,14	111,71	12478,54	1,12	269,00	267,88	152,89	1,44	0,90	1,84	9,14	178,18
HRTS	1471,83	450,50	2209,46	4881731,77	189,00	5875,00	5686,00	150,12	2,22	4,98	300,75	450,50	2614,75
ETKI	10829,63	4238,51	13233,16	175116481,58	2083,05	36273,97	34190,92	122,19	1,93	3,60	3277,91	4238,51	19919,18
ER15to64	60,90	60,60	5,73	32,83	55,10	67,90	12,80	9,41	0,12	-2,85	55,70	60,60	65,95
ER55to64	29,18	29,10	6,74	45,49	21,50	37,40	15,90	23,11	0,04	-1,80	21,80	29,10	36,43
UR15to64	10,63	8,40	5,81	33,81	4,70	19,10	14,40	54,68	0,79	-1,37	6,13	8,40	17,23
Ereduc	84,10	84,35	1,43	2,05	82,00	85,80	3,80	1,70	-0,43	-1,13	82,75	84,35	85,28
Texp	4,57	4,44	0,67	0,46	3,93	5,74	1,81	14,77	1,14	1,15	3,96	4,44	5,10
GGE	297550,00	113948,00	385451,08	148572534152,80	49203,00	1042071,00	992868,00	129,54	1,96	3,78	69828,00	113948,00	552588,00
EIE	461,60	487,93	268,51	72098,35	140,67	815,40	674,73	58,17	-0,08	-1,43	160,12	487,93	707,15
EGRS	16,74	4,86	27,73	769,18	0,63	72,18	71,55	165,73	2,24	5,12	1,42	4,86	30,20
PKRA	126,33	120,50	25,58	654,27	91,00	165,00	74,00	20,25	0,33	0,18	109,75	120,50	150,00
IMR	6,53	6,45	2,34	5,46	4,10	9,20	5,10	35,77	0,05	-2,97	4,33	6,45	8,75

Source: Own calculation and elaboration, 2012

Table III Descriptive statistics (year 2005)

Indicator	Mean	Median	Std. Deviation	Variance	Minimum	Maximum	Range	Coefficient of variation	Skewness	Kurtosis	Percentiles		
											25	50	75
GDP	18533,33	16000,00	6975,86	48662666,67	11500,00	28200,00	16700,00	37,64	0,67	-1,73	13000,00	16000,00	26550,00
GFCF	4033,33	4050,00	1403,80	1970666,67	2100,00	6200,00	4100,00	34,81	0,28	0,36	2925,00	4050,00	5000,00
EPO	84,29	11,98	122,37	14975,43	3,24	288,48	285,24	145,18	1,27	-0,09	5,17	11,98	210,32
HRST	1757,00	557,50	2445,73	5981578,40	267,00	6550,00	6283,00	139,20	2,08	4,31	411,75	557,50	3250,00
ETKI	10892,87	4329,38	13286,74	176537407,19	2214,68	36597,32	34382,64	121,98	1,97	3,83	3417,39	4329,38	19700,45
ER15to64	61,05	61,25	6,12	37,48	52,80	68,60	15,80	10,03	-0,13	-1,82	55,88	61,25	66,28
ER55to64	35,38	32,40	7,70	59,36	27,20	45,50	18,30	21,77	0,69	-1,73	29,53	32,40	44,75
UR15to64	11,00	9,65	5,18	26,85	5,20	18,00	12,80	70,04	0,46	-1,77	6,70	9,65	16,73
Ereduc	83,07	83,00	1,26	1,58	81,10	84,60	3,50	1,51	-0,41	-0,03	82,15	83,00	84,30
Texp	4,84	5,00	0,72	0,52	3,85	5,48	1,63	14,93	-0,36	-2,23	4,16	5,00	5,47
GGE	292495,00	118797,50	367474,13	135037233177,20	50087,00	999776,00	949689,00	125,63	1,93	3,65	72143,00	118797,50	540956,75
EIE	414,37	437,65	220,55	48640,89	153,69	681,63	527,94	53,22	-0,19	-1,73	160,55	437,65	629,99
EGRS	16,05	7,24	21,24	451,34	2,64	58,14	55,50	132,36	2,15	4,77	4,00	7,24	26,98
PKRA	111,17	119,50	28,10	789,77	65,00	143,00	78,00	25,28	-0,88	0,25	86,00	119,50	131,00
IMR	5,22	5,20	1,57	2,47	3,40	7,20	3,80	30,15	0,08	-2,44	3,78	5,20	6,60

Source: Own calculation and elaboration, 2012

Table IV Descriptive statistics (year 2010)

Indicator	Mean	Median	Std. Deviation	Minimum	Maximum	Range	Coefficient of variation	Skewness	Kurtosis	Percentiles		
										25	50	75
GDP	21350,00	18700,00	6741,44	15300,00	30800,00	15500,00	31,58	0,80	-1,68	15675,00	18700,00	29300,00
GFCF	4316,67	4400,00	1324,26	2800,00	6300,00	3500,00	30,68	0,31	-0,78	2950,00	4400,00	5325,00
EPO	92,6300	19,8600	125,55981	6,00	292,11	286,11	135,55	1,141	-,795	7,4775	19,8600	230,5125
HRST	2100,50	684,00	2749,68	348,00	7333,00	6985,00	130,91	1,86	3,23	481,50	684,00	4104,25
ETKI	11619,63	4479,06	14173,28	2316,49	38742,34	36425,85	121,98	1,90	3,43	3415,05	4479,06	21625,27
ER15to64	63,55	62,15	6,82	55,40	71,70	16,30	10,73	0,24	-2,07	57,95	62,15	71,25
ER55to64	42,58	41,45	8,82	34,00	57,70	23,70	20,71	1,02	0,97	34,30	41,45	49,30
UR15to64	9,07	8,55	3,48	4,50	14,40	9,90	38,37	0,39	-0,11	6,53	8,55	12,00
Ereduc	81,88	81,85	3,65	77,80	86,70	8,90	4,46	0,11	-1,73	77,95	81,85	85,50
Texp	4,66	4,77	0,68	3,63	5,43	1,80	14,63	-0,52	-0,99	4,04	4,77	5,24
GGE	282442,84	112584,00	355105,35	46468,67	960227,67	913759,00	125,73	1,87	3,35	65442,17	112584,00	533326,42
EIE	354,87	396,83	172,86	138,40	530,76	392,36	48,71	-0,51	-1,88	147,56	396,83	519,54
EGRS	18,3567	10,2750	22,42531	4,53	62,87	58,34	122,16	2,163	4,867	5,2950	10,2750	28,1975
PKRA	71,17	70,00	18,68	45,00	102,00	57,00	26,25	0,51	1,66	59,25	70,00	82,50
IMR	4,33	4,45	1,18	2,70	5,70	3,00	27,25	-0,27	-1,76	3,23	4,45	5,40

Source: Own calculation and elaboration, 2012

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