MULTICRITERIA EVALUATION OF REGIONAL DISPARITIES IN VISEGRAD FOUR

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Abstract

The economic, social and territorial disparities between regions are major obstacles to the balanced and harmonious development of the territory as a whole. The quantification of regional disparities falls into important spheres of regional policy at the state and European level. In the European Union (EU) there is a general belief that differences should be kept in sustainable limits especially since new member states have joined the EU in the years 2004 and 2007. The admission has been associated with an increase in regional disparities that have negatively affected the EU's competitiveness and cohesion. Visegrad Four countries (V4) belong to the states where regional development of the last decade has been strongly linked to EU funding. The aim of the paper is to evaluate and compare the development of regional disparities in V4 over the period from 2001 to 2011 by utilizing selected multicriteria decision-making methods, namely Analytic Hierarchy Process method (AHP) and VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR). AHP is used to derive the weights of the regional indicators. Subsequently, VIKOR method ranks the NUTS 2 regions according to their socio-economic development in the context of the EU cohesion. Utilization of the multicriteria approach can lead to more precise evaluation of the regional development than one-dimensional ones.

Key words: AHP, evaluation, regional disparities, VIKOR, Visegrad Four

JEL Code: C02, O18, R11

Introduction

The economic, social and territorial disparities in the level of regional performance are a major obstacle to the balanced and harmonious development of the regions, but also of each country as well as a whole EU. Hence, the elimination of disparities with the support of regional development is considered as the primary objective of the EU's development activities. In the European concept, the level of disparities can be regarded as a measure of cohesion. According to Molle (2007), cohesion can be expressed as a level of differences between countries, regions or groups that are politically and socially tolerable. We distinguish

three types of regional disparities: economic, social and territorial, see e.g. Molle (2007), European Commission (2010), Kutscherauer et al. (2010). The level of regional disparities within the EU is evaluated by the selected regional indicators in the Cohesion Reports published by the European Commission every 3 years; see European Commission (2010). Selected indicators for regional disparities evaluation are introduced in table 1.

Tab. 1: Selected indicators for regional disparities evaluation

Subcriteria	*Criteria*	*Abbreviation*
Economic	GDP per capita (PPS)	GDP
	Disposable income of households (PPS)	DI
	Gross domestic expenditure on R&D (GERD) (% of GDP)	GERD
Social	Employment rate (%)	ER
	Unemployment rate (%)	UER
	Persons aged 30-34 with tertiary education attainment (%)	TE
Territorial	Density of motorway (km/1000km^2)	DM
	Density of railway (km/1000km^2)	DR

Source: European Commission (2010), Eurostat (2014), own processing (2014)

To create a suitable methodology that enables to identify the actual level of region's socio-economic development is the most important condition for developing effective regional policy. Therefore, the evaluation of the level of regional disparities in the EU countries are actual and important topics of many discussions and regional research studies, e.g. Campo, Monteiro, Soares (2008), Kutscherauer et al. (2010), Tvrdoň, Skokan (2011). Regional differences in the "new" EU countries (especially in Visegrad Four countries) whose admission in the years 2004 and 2007 increased regional disparities in the EU are analysed by e.g. Melecký, Poledníková (2012), Svatošová, Boháčková, (2012), Staníčková (2012).

The attitude of researchers towards the quantitative evaluation of regional development and disparities is not uniformed. They use several disparity indicators that are processed by different mathematical and statistical methods. From the point of view of low calculation difficulty, a high informative level and the applicability of the results in practice, traffic light method (scaling), method of average (standard) deviation, method of standardized variable, method of distance from the imaginary point are often used for measurement of disparities (Kutscherauer et al., 2010). These methods are often used in an integrated approach based on the calculation of a synthetic index of disparities, see e.g. Kutscherauer et al. (2010), Svatošová, Boháčková (2012). More sophisticated methods that are very useful in the process of regional disparities evaluation are multivariate statistical methods, especially cluster analysis and factor analysis; see e.g. Campo, Monteiro, Soares (2008), Zivadinovic,

Dumicic, Casni (2009). An alternative and not broadly extended approach to regional disparities evaluation represents multicriteria decision-making methods that helps decision maker organize the problems to be solved, and carry out analysis, comparisons and rankings of the alternatives, see e.g. Opricovic, Tzeng (2004), Tzeng, Huang (2011), Dočkalíková, Kashi (2013).

The main aim of the paper is to evaluate and compare the development of regional disparities in V4 over the period from 2001 to 2011 by utilizing selected multicriteria decision-making methods, namely Analytic Hierarchy Process (AHP) and VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR).

1 Methodology

Following section discusses the theoretical background of AHP and VIKOR methods. In this paper, AHP is used to derive the weights of the regional indicators. Subsequently, VIKOR method ranks the NUTS 2 regions according to their socio-economic development in the context of the EU cohesion over the period 2001-2011. Finally, a sensitivity analysis is carried out to study the impact of different value *v* on index Q_j and regions' ranking.

1.1 AHP method

Analytic Hierarchy Process is used to derive the criteria weights from paired comparison in four level hierarchic structures. The decision hierarchy structure is created; the goal of the decision is at the top level, subcriteria (group of criteria) at second level followed by the level of criteria (criteria on which subsequent elements depend). The lowest level represents a set of alternatives. Having the hierarchic structure, we compare the comparative weight between the attributes of the decision elements in form of pairwise comparison matrices. The comparisons are taken from fundamental scale that reflects the relative strength of preferences; see Saaty, Vargas (2012).

Let *A* represent an *n x n* pairwise comparison matrix. The diagonal elements in the matrix *A* are self-compared and thus $a_{ij}=1$, where i=j, i, j=1, 2, . . ., n. The values on the left and right sides of the matrix diagonal represent the strength of the relative importance degree of the i-th element compared to the j-th element. Let $a_{ij}=1/a_{ji}$, where $a_{ij}>0$, $i \neq j$. After that, the normalization of the geometric mean method is used to determine the importance of elements. To ensure that the evaluation of the pairwise comparison matrix is reasonable and acceptable, a consistency check is performed. Generally, a consistency ratio (CR) can be used as a

guidance to check for consistence of matrices. If the value of CR is below than the threshold of 0.1, then the evaluation of the criteria importance is considered to be reasonable, see Tzeng, Huang (2011).

1.2 VIKOR method

VIKOR method determines the compromise ranking-list, the compromise solution and the weight stability intervals for preference stability of the compromise solution obtained with the given weights. This method focuses on ranking and selecting from a set of alternatives in the presence of conflicting criteria. It introduces the multicriteria ranking index based on the particular measure of "closeness" to the "ideal" solution (Tzeng, Huang, 2011, p. 71). Assuming that each alternative is evaluated according to each criterion function, the compromise ranking could be performed by comparing the measure of closeness to the ideal alternative. The multicriteria measure for compromise ranking is developed from the *Lp-metric* used as an aggregating function in a compromise programming method. The various J alternatives are denoted as $a_1; a_2; \ldots; a_J$. For alternative a_j, the rating of the ith aspect is denoted by f_{ij}, i.e. f_{ij} is the value of ith criterion function for the alternative a_j; n is the number of criteria. Development of the VIKOR method started with the following form of *Lp-metric*:

$$L_{pj} = \left\{ \sum_{i=1}^{n} \left[w_i (f_i^* - f_{ij}) / (f_i^* - f_i^-) \right]^p \right\}^{1/p}, 1 \le p \le \infty, j = 1, 2, ..., J. \quad (1)$$

Within the VIKOR method, $L_{1,j}$ and $L_{\infty,j}$ are used to formulate ranking measure. The solution obtained by $min_j S_j$ is with a maximum group utility ("majority" rule), and the solution obtained by $min_j R_j$ is with a minimum individual regret of the "opponent". The compromise solution F^c is a feasible solution that is the "closest" to the ideal F^*, and compromise means an agreement established by mutual concessions. The compromise ranking algorithm VIKOR has the following steps (Tzeng, Huang, 2011, p. 72-74).

The first step is to determine the best f_i^* and the worst f_i^- values of all criterion functions, i= 1, 2, . . . , n, that is known as positive and negative ideal solution. If the ith function represents a benefit then (Opricovic, Tzeng, 2004, p. 447-448):

$$f_i^* = \max_j f_{ij}, \; f_i^- = \min_j f_{ij}. \quad (2)$$

Second step is to compute the values S_j and R_j, j=1, 2,..., J, by formula:

$$S_j = \sum_{i=1}^{n} w_i (f_i^* - f_{ij}) / (f_i^* - f_i^-), \quad (3)$$

$$R_j = \max_i \left[w_i (f_i^* - f_{ij}) / (f_i^* - f_i^-) \right] \quad (4)$$

where w_i are the weights of criteria. S_j is a_j with respect to all criteria calculated by the sum of the distance for best value, R_j is a_j with respect to the *i*th criterion, calculated by the maximum distance from the worst value. Third step is to calculate the values Q_j, j= 1, 2, . . . , *J*, by relation:

$$Q_j = v(S_j - S^*)/(S^- - S^*) + (1-v)(R_j - R^*)/(R^- - R^*) \quad (5)$$

where

$$S^* = \min_j S_j,\ S^- = \max_j S_j, \quad (6)$$

$$R^* = \min_j R_j,\ R^- = \max_j R_j. \quad (7)$$

and v is introduced as weight of the strategy of "the majority of criteria" (or "the maximum group utility"), $v=0.5$. Index Q_j is obtained and based on the consideration of both the group utility and the individual regret of the opponent. Next step is to propose as the compromise solution the alternative *(a')* which is ranked the best by the measure *Q* if the two conditions, *acceptance advantage* and *acceptance stability in decision making*, are satisfied, see (Opricovic, Tzeng, 2004). The last step is to rank the alternatives, sorting by the values *S*, *R* and *Q*, in decreasing order. The best alternative *Q(a')* is the best solution with the minimum of Q_j.

Although it is recommended that $v=0.5$ should be used, the final ranking of alternatives can be depended on this value. Therefore sensitivity analysis is carried out to study the impact of different value v on index Q_j and regions' ranking.

2 Evaluation of regional disparities in V4 by MCDM methods

Within AHP hierarchic structure, the goal is to evaluate regional disparities and assess the level of regional development in V4, the alternatives are 35 NUTS 2 regions. These alternatives are evaluated by three types of subcriteria and eight criteria shown in table 1. These selected indicators are most frequently used regional indicators monitored within Cohesion Reports, see European Commission (2010) and are available in Eurostat database.

Tab. 2: Weights of criteria (AHP)

Subcriteria	*Weight*	*Criteria*	*Weight*	*Final weight*
Economic	0.731	GDP	0.637	0.465
		DI	0.258	0.189
		GERD	0.105	0.077
Social	0.188	ER	0.279	0.053
		UER	0.649	0.122
		TE	0.072	0.014

Territorial	0.081	DM	0.750	0.061
		DR	0.250	0.020

Source: own processing (2014)

At first, the weights of subcriteria are calculated with respect to the goal. After that criteria are pairwise compared against the subcriteria importance. The pairwise comparison matrices reflect the author´s preferences. According to final calculated weights of the criteria shown in table 2, indicators GDP per capita, disposable income and unemployment rate have the highest importance in the level of region´s development and disparities evaluation.

Table 3 shows the final ranking of NUTS 2 regions in V4 in years 2001, 2006 and 2011 based on VIKOR method that reflects the weights of criteria calculated by AHP and the value of v=0.5.

Tab. 3: Comparison of regions´ ranking by VIKOR in the years 2001, 2006 and 2011

Year		*2001*		*2006*		*2011*		*Average Qj*	*Average rank*
Code	*Region*	Q_j	*Rank*	Q_j	*Rank*	Q_j	*Rank*		
CZ01	Praha	0.000	**1**	0.000	**1**	0.033	**2**	0.0111	**1**
CZ02	Střední Čechy	0.582	**4**	0.606	**4**	0.665	**5**	0.6176	**5**
CZ03	Jihozápad	0.638	**6**	0.646	**6**	0.701	**7**	0.6615	**6**
CZ04	Severozápad	0.733	**11**	0.770	**13**	0.804	**17**	0.7693	**12**
CZ05	Severovýchod	0.658	**8**	0.697	**8**	0.737	**9**	0.6974	**8**
CZ06	Jihovýchod	0.645	**7**	0.667	**7**	0.676	**6**	0.6627	**7**
CZ07	Střední Morava	0.725	**10**	0.739	**9**	0.753	**13**	0.7390	**9**
CZ08	Moravskoslezsko	0.766	**13**	0.746	**10**	0.731	**8**	0.7479	**11**
HU10	Közép-Magyarország	0.442	**3**	0.418	**3**	0.486	**3**	0.4488	**3**
HU21	Közép-Dunántúl	0.762	**12**	0.775	**14**	0.822	**19**	0.7862	**13**
HU22	Nyugat-Dunántúl	0.719	**9**	0.751	**11**	0.766	**15**	0.7453	**10**
HU23	Dél-Dunántúl	0.889	**20**	0.913	**23**	0.942	**32**	0.9146	**25**
HU31	Észak-Magyarország	0.935	**27**	0.943	**27**	1.000	**35**	0.9592	**32**
HU32	Észak-Alföld	0.928	**26**	0.945	**28**	0.967	**34**	0.9470	**29**
HU33	Dél-Alföld	0.871	**17**	0.908	**22**	0.929	**30**	0.9028	**24**
PL11	Łódzkie	0.910	**23**	0.887	**19**	0.809	**18**	0.8687	**19**
PL12	Mazowieckie	0.608	**5**	0.627	**5**	0.490	**4**	0.5752	**4**
PL21	Małopolskie	0.896	**22**	0.905	**21**	0.841	**20**	0.8806	**20**
PL22	Śląskie	0.842	**14**	0.841	**15**	0.741	**10**	0.8080	**15**
PL31	Lubelskie	0.966	**32**	0.983	**33**	0.929	**29**	0.9594	**33**
PL32	Podkarpackie	0.986	**34**	0.993	**35**	0.946	**33**	0.9751	**35**
PL33	Świętokrzyskie	0.975	**33**	0.970	**32**	0.917	**27**	0.9540	**31**
PL34	Podlaskie	0.945	**29**	0.959	**31**	0.911	**26**	0.9381	**28**
PL41	Wielkopolskie	0.844	**15**	0.843	**16**	0.765	**14**	0.8172	**16**
PL42	Zachodniopomorskie	0.894	**21**	0.927	**26**	0.874	**23**	0.8986	**23**
PL43	Lubuskie	0.943	**28**	0.925	**25**	0.876	**24**	0.9147	**26**
PL51	Dolnośląskie	0.880	**19**	0.863	**17**	0.744	**12**	0.8290	**17**

PL52	Opolskie	0.961	**30**	0.949	**29**	0.882	**25**	0.9308	**27**
PL61	Kujawsko-Pomorskie	0.916	**25**	0.922	**24**	0.849	**21**	0.8959	**22**
PL62	Warmińsko-Mazurskie	0.988	**35**	0.985	**34**	0.920	**28**	0.9643	**34**
PL63	Pomorskie	0.876	**18**	0.871	**18**	0.801	**16**	0.8496	**18**
SK01	Bratislavský kraj	0.233	**2**	0.121	**2**	0.000	**1**	0.1179	**2**
SK02	Západné Slovensko	0.857	**16**	0.770	**12**	0.743	**11**	0.7902	**14**
SK03	Stredné Slovensko	0.914	**24**	0.900	**20**	0.852	**22**	0.8890	**21**
SK04	Východné Slovensko	0.962	**31**	0.954	**30**	0.930	**31**	0.9489	**30**

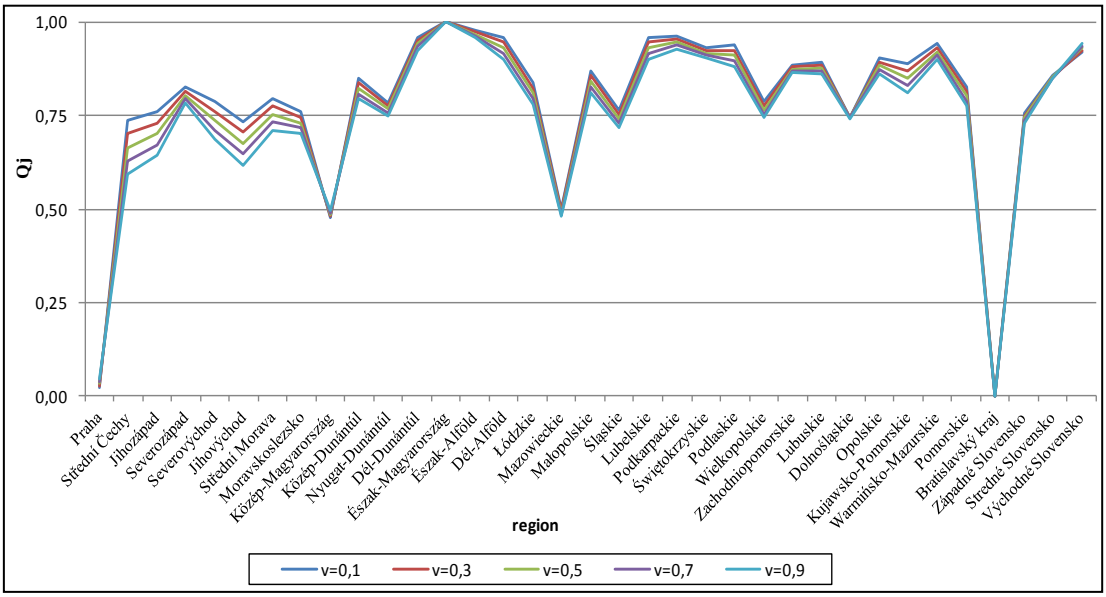
Source: own processing (2014)

Table 3 presents and compares the final value of index Q_j in given years as well as average value of index that reveal the trends of regional disparities. This ranking index is an aggregation of all criteria, the relative importance of the criteria, and a balance between total and individual satisfaction. The highest ranked region is the closest to ideal solution. On the basis of wide range value of index Q_j (interval between 0.0-0.9), the significant socioeconomic differences between regions can be identified. The shortest distance to ideal solution was achieved by regions with capital city - Praha, Bratislavský kraj, Közép-Magyarország, Mazowieckie and region Střední Čechy over all reference period 2001-2011. These regions were ranked at the top five positions according to average Q_j that implies visible differences in the regional development of regions with capital cities and the other regions. These regions had the highest value of the economic indicators (GDP per capita, disposable income of households) and high support of the research and development (the expenditure on R&D is higher than 1 % GDP). These regions are also characterized by high quality structure of labour force (high share of human resources in science and technology and flexible labour market (low level of unemployment and high level of employment). In the year 2011, the shortest distance to ideal solution was achieved by region Bratislavský kraj, following by region Praha. Also region Mazowieckie recorded visible strengthening of socioeconomic development and was ranked at fourth position in the year 2011. This phenomenon can be explain by the dominant position of capital city Warsaw that lies in region Mazowieckie and statistically affects the level of development of whole region. Warsaw had the highest dynamics of economic changes in the country and has been one of the fastest growing of metropolitan regions in the EU over the past few years. Within the EU cohesion policy 2014-2020 region Mazowieckie is a first region that is considered as more developed region. On the other hand, Polish regions Lubelskie, Świętokrzyskie, Warmińsko-Mazurskie, Podkarpackie and Slovak region Východné Slovensko achieved the farthest distances to ideal solution and they were ranked according to average Q_j in the last positions

over all reference period. These regions were considered as less developed compared to the others. In the years 2006 and 2011 the strong weakening of all Hungarian regions development (with exception of Közép-Magyarország) was recorded. Also ranking of Czech regions (with exception of Moravskoslezsko) got worse in the year 2011 in comparison with the year 2006 (especially region Severozápad). On the other hand, the convergence of some Polish regions (Kujawsko-Pomorskie, Łódzkie, Małopolskie, Lubuskie, Warmińsko-Mazurskie, Opolskie Dolnośląskie) and Slovak region Západné Slovensko and Czech region Moravskoslezsko to the ideal solution could be observed.

Figure 1 shows the results of the sensitivity analysis on the example of the year 2011. As can be seen, the impact of different value *v* on index Q_j was various by regions. There was no impact of value *v* different than 0.5 on the ranking of more developed regions Bratislavský kraj and region Praha and less developed regions Észak-Magyarország and Észak-Alföld. There was a small effect of different value *v* on rankings of regions Jihozápad, Severozápad, Jihovýchod, Közép-Magyarország, Közép-Dunántúl, Dél-Dunántúl, Łódzkie, Mazowieckie, Małopolskie, Śląskie, Lubuskie, Opolskie, Pomorskie, Stredné Slovensko. By the rest of regions the change of ranking depending on value *v* was more evident.

Fig. 1: Effect of value *v* on Q_j and ranking of regions (2011)



Source: own processing (2014)

Conclusion

By applying AHP and VIKOR methods we got the final regions' ranking based on the shortest distances to the ideal solution. The results of VIKOR analysis confirmed that NUTS 2 regions with capital city (Praha, Bratislavský kraj, Mazowieckie, Közép-Magyarország) have had significant and different socio-economic positions from the other regions in V4 since the year 2001 and they are considered as more developed over the whole period. In average, Polish regions Lubelskie, Świętokrzyskie, Warmińsko-Mazurskie, Podkarpackie and Slovak region Východné Slovensko were ranked in the last positions. These regions were considered as less developed compared to the others. Although some positive changes in disparities trend were observed during the examined period (especially in Poland), the regional disparities have still persisted between dominant regions with capital city and more distant regions on one hand and between Czech regions and Hungarian, Polish and Slovak regions on the other hand. The sensitivity analysis conducted in year 2011 showed that value *v* had the impact on index Q_j and regions' ranking. However, the effect is various by particular regions. It can be said that regions with capital city Praha, Bratislavský kraj as well as less developed regions Észak-Magyarország and Észak-Alföld were comprehensively developed/underdeveloped regions because different value *v* had a small impact on their ranking.

The advantage of multicriteria evaluation of regional development is that it takes into account the importance and mutual dependence of the decision-making criteria. Due to importance of the criteria we are able to determine the shortest distance to the ideal solution in a more realistic way. Then the final ranking of regions corresponds to the different economic, social and territorial importance of individual criteria. In the absence of the mainstream in methodological approach to regional disparities evaluation, the presented multicriteria evaluation can be considered as a suitable alternative approach.

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