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MULTICRITERIA ANALYSIS OF REGIONAL DISPARITIES IN THE CONTEXT OF THE EU COHESION

VÍCEKRITERIÁLNÍ ANALÝZA REGIONÁLNÍCH DISPARIT V KONTEXTU SOUDRŽNOSTI EU

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Annotation
The paper deals with an alternative multicriteria approach to quantitative evaluation of regional development in the context of the EU cohesion. The aim of the paper is to evaluate and compare the development of regional disparities in Visegrad Four (V4) countries over the period 2001-2011 by utilizing the selected multicriteria decision-making methods. Applying TOPSIS and AHP methods we get the final ranking of V4 NUTS 2 regions based on the shortest distances to the ideal solution and the farthest from the negative ideal solution. Also, a sensitivity analysis is carried out to study the impact of different weights on the scores of relative closeness to ideal solution (c_i) and regions' ranking. Although some positive changes in disparities trend are observed during the examined period (especially in Poland), disparities have still persisted between NUTS 2 regions with capital cities (Praha, Bratislavský kraj, Mazowieckie, Közép-Magyarország) and more distant regions on the one hand and between Czech regions and Hungarian, Polish and Slovak regions on the other hand. The sensitivity analysis also shows that the importance of criteria influences the final ranking of regions. In the absence of the mainstream to regional disparities evaluation, this paper can be understood as a contribution to the discussion about the quantitative measurement of disparities between regions.

Key words
AHP, regional disparities, TOPSIS

Anotace
Tento článek se věnuje představení alternativního vícekriteriálního přístupu ke kvantitativnímu hodnocení regionálního rozvoje v kontextu soudržnosti EU. Cílem příspěvku je zhodnotit a srovnat vývoj regionálních disparit v zemích Visegrádské čtyřky (V4) v období let 2001-2011 s využitím vybraných vícekriteriálních metod rozhodování. Pomocí metody TOPSIS a AHP získáme konečné pořadí regionů NUTS 2 zemí V4, které je založeno na nejkratší vzdálenosti regionu od ideální hodnoty a nejdelší vzdálenosti od hodnoty bazální. Dále je provedena analýza citlivosti, která sleduje vliv vah kritérií na index relativní vzdálenosti (c_i) a konečné pořadí regionů. Ačkoli lze, během zkoumaného období, pozorovat některé pozitivní změny ve vývoji regionálních disparit (a to zejména v Polsku), významné rozdíly stále přetrvávají mezi regiony hlavních měst (Praha, Bratislavský kraj, Mazowieckie, Közép-Magyarország) a regiony vzdálenějšími na jedné straně a zároveň mezi českými regiony a maďarskými, polskými a slovenskými regiony na straně druhé. Analýza citlivosti rovněž ukazuje, že rozdílné váhy kritérií ovlivňují konečné pořadí regionů. V kontextu neexistence jednotného přístupu k hodnocení regionálních disparit, lze tento článek vnímat jako příspěvek k diskusi o kvantitativním hodnocení regionálních disparit.

Klíčová slova
AHP, regionální disparity, TOPSIS

JEL classification: *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. The quantification of regional disparities falls into important spheres of regional policy at the state and European level. There is a general belief that differences should be kept in the sustainable limits especially since new member states have joined the EU in the years 2004 and 2007. Their admission has been associated with an increase in regional disparities that have negatively affected the EUôs competitiveness and cohesion. The elimination of disparities with the support of regional development is considered as the primary objective of the EUôs 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), 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). The main role in the support of European regional development and its funding plays the EU cohesion policy, see e.g. Molle (2007). To create a suitable methodology that enables to identify the actual level of regionôs 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, at the European and national level e.g. Campo, Monteiro, Soares (2008), Wishlade, Yuill (1997), Viturka, Çítek, Klímová, Tonev (2009), Gineviļius, Podvezko, Mikelis (2004), Kutscherauer et al. (2010), Matloviļ, Klamár, Matloviļová (2008). Regional differences in the ñnewò EU countries, especially in Visegrad Four countries are analysed by e.g., TvrdoŇ, Skokan (2011), Melecký, Poledníková (2012), Svatoňová, Bohálļková, (2012), Tuleja (2010). Visegrad Four countries belong to the central European states where the economic development of the last 10 years has been strongly linked to European funding.

The aim of the paper is to evaluate and compare the development of regional disparities in Visegrad Four (V4) countries over the period 2001-2011 by utilizing the selected multicriteria decision-making (MCDM) methods. The sense of applying the MCDM methods is to rank and describe the changes in the V4 NUTS 2 regions reflecting their socioeconomic development in the context of the EU cohesion.

The rest of this paper is organized as follows. The approaches of regional disparities evaluation in the context of the EU cohesion are discussed in Section 1. In Section 2, the theoretical background of the methods Technique for Order Preferences by Similarity to an Ideal Solution (TOPSIS) and Analytic Hierarchy Process (AHP) are introduced. In Section 3, the empirical results of regional disparities evaluation in V4 in the year 2001 and 2011 are presented. In the last Section, the conclusions and remarks are provided.

1. Regional disparities evaluation in the context of the EU cohesion

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. Tuleja (2010), Svatoňová, Bohálļková (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), Poledníková, Lelková (2012), Horká (2013). 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), Dai, Zhang (2011), Kashi (2013).

2. Methodology

Differences in the level of socio-economic development of V4 regions and their ranking are determined by TOPSIS method. AHP method is used to derive the weights of the regional indicators. The multicriteria evaluation of regional development takes into account the importance of the decision-making criteria. Therefore the sensitivity analysis is carried out to study the impact of the weights of criteria calculated by AHP and weights of criteria equal to one, on the scores of relative closeness to the ideal solution (ci) and regions´ranking.

2.1 The method TOPSIS

TOPSIS method is based on the determination of the best alternative that comes from the concept of the compromise solution. The compromise solution can be regarded as choosing the best alternative nearest to the ideal solution (with the shortest Euclidean distance) and farthest from the negative ideal solution. TOPSIS is always used for multi-attribute decision making, by ranking the alternatives according to the closeness between the alternative and the ideal alternative (Dai, Zhang, 2011). The procedure of TOPSIS method includes the following steps. The first step is to construct a decision matrix. The decision matrix consists of a set of alternatives, A={Ai | i=1,é , n}, and a set of criteria (attributes), C={Cj | j=1,é , m}, where Y = {yij | i=1,é , n; j=1,é , m} denotes the set of performance ratings and w={wj | j=1,é , m} is the set of weights for criteria. Procedure that converts all the criteria so that all of them were either minimization or maximization is often implemented before the execution of TOPSIS method. Second step is to calculate the normalized decision matrix according to formula:

$$r_{ij} = \frac{y_{ij}}{\sqrt{\sum_{i=1}^{n} y_{ij}^2}}, \quad (1)$$

where i=1,...,n; j=1,...,m. With regard to the defined weight of criteria, the third step of TOPSIS method is to calculate weighted normalized decision matrix expressed as vij=wj . rij, where i=1,...,n; j=1,...,m. The following step includes the determination of the positive ideal solution (Hj) and the negative ideal solution that are derived as Hj=max(vij) and Dj=min(vij). Subsequently, the separation from the ideal (di+) and the negative ideal solutions (di-) between alternatives is calculated. The separation values can be measured using the Euclidean distance, which is given as:

$$d_i^+ = \sqrt{\sum_{j=1}^{k} \left(v_{ij} - H_j\right)^2}, \quad (2)$$

$$d_i^- = \sqrt{\sum_{j=1}^{k} \left(v_{ij} - D_j\right)^2}, \quad (3)$$

Last step includes the calculation of the relative closeness to the ideal solution and rank the alternatives in descending order. The relative closeness of the i-th alternative Ai is expressed as:

$$c_i = \frac{d_i^-}{d_i^- + d_i^+}. \quad (4)$$

2.2 The method AHP

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 following table 1.

Tab. 1: Saaty´s fundamental scale

Intensity of importance	Definition
1	equal importance
3	moderate importance
5	strong importance
7	very strong importance
9	extreme importance

Source: Saaty, Vargas (2012), own processing (2014)

Let A represent an n x n pairwise comparison matrix. The diagonal elements in the matrix A are self-compared and thus aij=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 aij=1/aji, where aij>0, i Í 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).

3. Application of MCDM methods and empirical results

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 2. 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: Selected indicators for regional disparities evaluation in V4

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)

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 3, indicators GDP per capita, disposable income and unemployment rate have the highest importance in the level of region´s development and disparities evaluation.

Tab. 3: 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)

Table 4 shows the final ranking of NUTS 2 regions in V4 in years 2001 and 2011 based on TOPSIS method that reflects the weights (w) of criteria calculated by AHP. Table 4 presents and compares the scores of relative closeness to ideal solution (c_i) and the ranks of regions of those two years, which could reveal the trends of regional disparities. On the basis of wide range value of the relative closeness that regions achieved (interval between 0.8-0.04), the significant socioeconomic differences between regions can be identified.

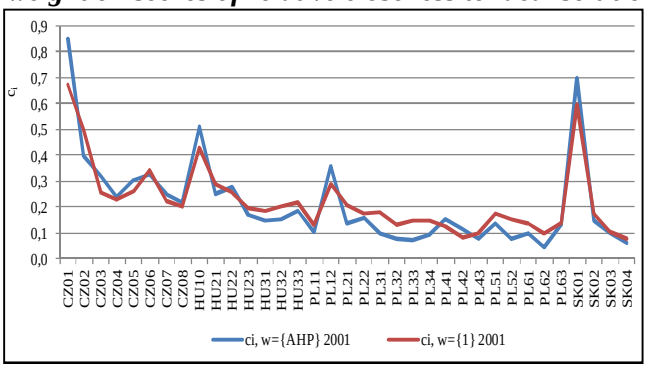
Tab. 4: Comparison of regions´ ranking by TOPSIS in the years 2001 and 2011

Weight of criteria		w =calculated by AHP				w=1			
Year		2001		2011		2001		2011	
Code	Region	c_i	Rank	c_i	Rank	c_i	Rank	c_i	Rank
CZ01	Praha	0.853	1	0.805	2	0.6750	1	0.6304	1
CZ02	Střední Čechy	0.399	4	0.292	6	0.4973	3	0.3205	6
CZ03	Jihozápad	0.321	7	0.268	7	0.2582	9	0.2767	8
CZ04	Severozápad	0.243	12	0.189	18	0.2278	11	0.2206	16
CZ05	Severovýchod	0.307	8	0.242	11	0.2637	8	0.2734	9
CZ06	Jihovýchod	0.325	6	0.294	5	0.3406	5	0.3412	5
CZ07	Střední Morava	0.252	10	0.229	15	0.2243	12	0.2415	13
CZ08	Moravskoslezsko	0.219	13	0.246	8	0.2016	15	0.2579	11
HU10	Közép-Magyarország	0.508	3	0.485	3	0.4276	4	0.4238	4
HU21	Közép-Dunántúl	0.251	11	0.184	19	0.2879	7	0.2428	12
HU22	Nyugat-Dunántúl	0.277	9	0.231	14	0.2542	10	0.2351	14
HU23	Dél-Dunántúl	0.167	15	0.104	30	0.1991	17	0.1847	25
HU31	Észak-Magyarország	0.149	19	0.053	35	0.1847	18	0.1181	33
HU32	Észak-Alföld	0.153	18	0.086	33	0.2007	16	0.1586	31
HU33	Dél-Alföld	0.185	14	0.124	27	0.2209	13	0.1991	21
PL11	Łódzkie	0.103	25	0.182	20	0.1338	28	0.2007	20
PL12	Mazowieckie	0.361	5	0.450	4	0.2899	6	0.3035	7
PL21	Małopolskie	0.137	21	0.168	21	0.2089	14	0.2270	15
PL22	Śląskie	0.159	16	0.238	12	0.1773	20	0.2714	10
PL31	Lubelskie	0.100	26	0.114	29	0.1808	19	0.1912	23
PL32	Podkarpackie	0.078	31	0.100	31	0.1331	29	0.1816	26
PL33	Świętokrzyskie	0.071	33	0.099	32	0.1456	25	0.1696	29
PL34	Podlaskie	0.095	29	0.126	26	0.1498	24	0.1874	24
PL41	Wielkopolskie	0.155	17	0.221	16	0.1241	30	0.2073	19
PL42	Zachodniopomorskie	0.114	24	0.135	25	0.0859	34	0.1548	32
PL43	Lubuskie	0.078	30	0.146	22	0.1005	32	0.1742	28
PL51	Dolnośląskie	0,137	22	0.242	10	0.1736	22	0.2127	18
PL52	Opolskie	0.077	32	0.141	23	0.1540	23	0.1929	22
PL61	Kujawsko-Pomorskie	0.099	27	0.244	9	0.1349	27	0.4719	3
PL62	Warmińsko-Mazurskie	0.044	35	0.123	28	0.0983	33	0.1690	30
PL63	Pomorskie	0.131	23	0.196	17	0.1349	26	0.2165	17
SK01	Bratislavský kraj	0.699	2	0.867	1	0.5994	2	0.5231	2
SK02	Západné Slovensko	0.148	20	0.236	13	0.1767	21	0.1748	27
SK03	Stredné Slovensko	0.098	28	0.141	24	0.1048	31	0.1133	34
SK04	Východné Slovensko	0.060	34	0.085	34	0.0766	35	0.1001	35

Source: own processing (2014)

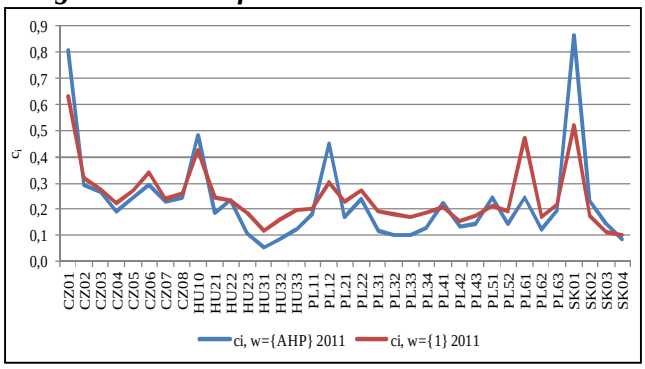
The shortest relative closeness to ideal solution is achieved by regions with capital city - Praha, Bratislavský kraj, Közép-Magyarország, Mazowieckie and region Střední Čechy. Regions Praha, Bratislavský kraj, Közép-Magyarország are ranked on the top positions and their ranking has not significantly changed till year 2011. These regions achieved the highest level of socio-economic development (especially region Praha) that implies the visible differences among regions of capital cities and the rest of V4 regions. In the year 2011, the shortest relative closeness 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. 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 Warmińsko-Mazurskie, świętokrzyskie and Slovak region Východné Slovensko can be considered as less developed compared to others. Their distances from ideal solution are the farthest and they are ranked in the last positions in the year 2001. In the year 2011 the strong weakening of all Hungarian regions development (with exception of Közép-Magyarország) was recorded. The regions Észak-Magyarország, Észak-Alföld and also Slovak region Východné Slovensko have the farthest distances from the ideal solution and they are ranked in the last positions. For the rest of regions the greater or lesser changes in disparities trend are observed during the examined period. In the year 2011, the convergence of some Polish, Czech and Slovak regions to the ideal solution is recorded (e.g. Warmińsko-Mazurskie, Kujawsko-Pomorskie, Łódzkie, Śląskie, Opolskie Dolnośląskie, Moravskoslezsko, Jihovýchod, Západné Slovensko). On the contrary, Czech regions Střední Čechy, Severozápad, Severovýchod, Střední Morava recorded visible weakening of development and their ranking got worse in the year 2011. Nevertheless, Czech regions are mostly ordered in the first half of the overall ranking. It indicates that disparities in the level of regional development have still persisted between Czech Republic on the one hand and Poland, Hungary and Slovakia on the other hand in the period 2001-2011.

Fig.1: Effect of criteria weight on scores of relative closeness to ideal solution (2001)



Source: own processing (2014)

Fig. 2: Effect of criteria weight on scores of relative closeness to ideal solution (2011)



Source: own processing (2014)

Figure 1 and figure 2 show the effect of different weights of criteria (weights of criteria calculated by AHP and weights of criteria equal to one) on the scores of relative closeness to ideal solution (c_i). As both figures and table 4 indicate, weights of criteria have an influence on the final ranking of regions. There are differences in the ranking of regions that are considered as more developed regions, as well as less developed and average developed regions according to ranking reflecting different weights of criteria. It can be said that regions with capital city Praha, Bratislavský kraj are comprehensively developed regions because different weights of criteria had a small impact on their ranking. On the other hand, for example region Mazowieckie achieved the worse position that can imply the higher sensitivity of different criteria importance (especially GDP per capita).

Conclusion

By applying TOPSIS and AHP methods we get the final regions ranking based on the shortest distances to the ideal solution and the farthest from the negative ideal solution. TOPSIS also takes into account the relative importance of the criteria. The results of TOPSIS analysis confirm that NUTS 2 regions with capital cities (Praha, Bratislavský kraj, Mazowieckie, Közép-Magyarország) have had significant and different socio-economic positions from the other regions in V4 in year 2001 as well as in the year 2011. On the contrary, in comparison with the year 2001, the level of regional development in Hungary strongly decreased and Hungarian regions together with Slovak region Východné Slovensko were ranked in the last positions (with exception of region Közép- Magyarország) in the year 2011. These regions should focus on the higher expenditure on research and development which are major drivers of the economic growth and it also supports the future competitiveness that results in the higher GDP. The public investments in the infrastructure (transport, communication, energy), spending on the education and active labour market, including an effective utilization of subsidies from European funds, play key roles in regionsô development. Although some positive changes in disparities trend are observed during the examined period (especially in Poland), the regional disparities have still persisted between dominant regions with capital cities and more distant regions on the one hand and between Czech regions and Hungarian, Polish and Slovak regions on the other hand.

The advantage of TOPSIS and AHP methods is that they are simple, easy to use and understand. Because when making concept of suitable evaluation tools of regional development it is necessary to suggest not only difficult but also simple methods which enable quick evaluation of regional disparities by accessible tools. In comparison with the one-dimensional evaluation, multicriteria evaluation of regional development 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 rank of regions corresponds to the different economic, social and territorial importance of individual criteria. The sensitivity analysis shows that the importance of criteria influences the final ranking of regions (the final ranking of regions reflecting the weights of criteria calculated by AHP differs from the final ranking of regions reflecting the criteria with weights equal to one).
In the absence of the mainstream in methodological approach to regional development evaluation, the presented multicriteria evaluation can be considered as a suitable alternative of more traditional approaches.

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