Agris on-line Papers in Economics and Informatics

Volume II Number 3, 2010

Analysis of the Method for the Selection of Regions with Concentrated State Aid

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Abstract

The paper deals with the analysis of a method used by the Czech Government and the Ministry for Regional Development to select regions with concentrated state aid. It contains a comparison with several different basic methods of multi-criteria decision-making (MCDM). The analysis focuses on a mathematical algorithm of the established MCDM method and does not consider validity of any selected socioeconomic criteria and their weights. Both the strengths and weaknesses of the used MCDM method are presented.

The paper includes a simple proposal of the modification of the examined method that will prevent incorrect data normalisation used for region's evaluation before revision in 2010. Data used for all calculations were obtained from the Ministry for Regional Development.

Key words

The weighted sum approach, the TOPSIS, multi-criteria decision-making, regions with concentrated state aid, district.

Anotace

Článek je zaměřen na analýzu metody pro výběr regionů se soustředěnou podporou státu využívanou ministerstvem pro místní rozvoj a vládou ČR. Obsahuje srovnání s několika základními metodami vícekriteriálního rozhodování (multi-criteria decision-making (MCDM)). Analýza je zaměřena na matematický algoritmus využívané MCDM metody, předmětem článku není hodnocení správného výběru socioekonomických kriterií nebo jejich vah. Jsou prezentovány silné i slabé stránky zvolené metody.

Článek obsahuje návrh jednoduché úpravy zkoumané metody, která povede k prevenci chybné normalizace dat, která byla používána až do revize v roce 2010. Data použitá pro výpočet byla poskytnuta ministerstvem pro místní rozvoj ČR.

Klíčová slova

Metoda váženého součtu, TOPSIS, vícekriteriální rozhodování, regiony se soustředěnou podporou státu, okres.

Introduction

Regions with concentrated state aid are divided into three subcategories as structurally affected, economically weak and regions with highly excessive unemployment. Law on regional development support 248/2000 [14] sets demand for a balanced state development. These regions are chosen on the basis of expertly selected socioeconomic characteristics and the aid with the purpose of a negative disparity reduction is addressed to them in consequence.

It concerned mainly the support from European funds (e.g. Operational Programme Enterprise and Innovation, priority axis 2 –Development of Firms, is also focused on development in these regions) for the period of 2007 – 2009. The up-date for the period 2010 – 2013 represents, among others, additional national funds – the relief of 50 million Czech Crowns is prepared for the year 2010 [11], [13].

Analysis and comparison of regions is commonly connected with multiple criteria, multiple factor

evaluation. Campo et al. [2] uses multivariate analysis to identify socio-economic clusters of similar European NUTS 2 regions. Žižka et al. [16] applied factor analysis on data for all Czech municipalities and recognised eight factors which have a significant influence on disparities. Athanassopoulos [1] used Data envelope analysis (the DEA, common MCDM method) analysed comparative disadvantage of NUTS 2 and also proposed goal programming production function of social cohesion. Nevima and Ramík evaluated competitiveness of Czech NUTS 3 regions on basis of the MDCM method Analytic hierarchy process [6] and used the DEA for European NUTS 2 regions competitiveness and efficiency evaluation [7]. For detailed comparison of the MCDM methods see e.g. [9] or [15].

The paper deals with the analysis of a method which is used for the evaluation of individual districts and presents the basis for the government decision-making in the selection of regions with concentrated state aid. The paper investigates the method of analysing selected characteristics and the Czech Republic districts arrangement processing. The method is compared with other basic methods for multi-criteria decision making with cardinal information (the Weighted Sum Approach, the TOPSIS). The analysis focuses on computation algorithm and data values normalisation. Whereas, the normalization of data is one of many possible approaches that enable the comparison of indicators with different units of measurement or with same units but with non comparable values intervals. The aim of the paper is the presentation of strengths and weaknesses of the used MCDM and its comparison with other basic MCDM methods.

Material and methods

Currently used method is explained in Annex no. 2 on Regional Development Strategy of the Czech Republic for the Period 2004 – 2006 [8]. However, the described approach does not contain enough information about criteria values normalization. For that reason the used background data were analysed and normalization algorithm was examined. These data were provided on demand by the Ministry for Regional Development of the Czech Republic.

Used method does not focus only on the selection of the best (or worst) variant (for this case variant is district), but it is focused on arrangement of their order. From 2007, for first two subcategories (structurally affected, economically weak) the same criteria are used and the distribution takes place consequently upon order arrangement. Regions with highly excessive unemployment are selected from remaining regions, where the level of unemployment exceeds the Czech Republic average by 25% [10]. Moreover, municipalities with an extended scope of activities are additionally selected in the same manner if they do not fall into already selected districts.

For the current period, municipalities tax incomes from physical entities per an inhabitant, a number of entrepreneurs per one thousand inhabitants, a purchasing power and overall evaluation of unemployment are selected as criteria. These positive criteria are from cost because the aim of the evaluation is to find regions with unfavourable characteristics. The overall evaluation of unemployment consists of two partial indicators – unemployment and the number of applicants per one work place. It is obvious that these criteria are benefit. Besides the purchasing power, all criteria are taken as the average of 2006 – 2008. The purchasing power criterion was quantified by a private company Incoma GfK [10] on the basis of official data and statistical research for years 2005 and 2009. The weights of individual criteria are presented in Table 1. The changes of criteria against all previous periods are given by the cancellation of some surveys by the Czech Statistical Office. For more details see [8] and [10].

Overall unemployment evaluation		Tax income	Number of private	Purchasing
0.4		0.2	0.2	0.2
Unemployment level	Number of applicants per one			
0.8	0.2			

Source: The Strategy of regional development of the Czech Republic [10], Annex no. 2 On the Strategy of Regional Development in the CR: Types and limitations of regions with concentrated state support [8], the Ministry for Regional Development

Table 1. Criteria and their weights.

The originally used MCDM algorithm is similar to common Weighted Sum Approach (the WSA). The difference is in criteria normalization, i.e. in the transfer of values of criteria with different units and weights of these values to comparable ones. The normalization for the Weighted Sum Approach method [3] is based on the following formula:

$$r_{ij} = \frac{y_{ij} - D_j}{H_j - D_j} \quad \textbf{(1)}$$

Whereas Dj presents the lowest (negative ideal) value in criterion j, Hj stands for the highest (ideal) value, yij is the element of criterion matrix **Y** – an original value, which an i-th variant reaches in a j-th criterion, rij ∈⟨0, 1⟩ is a normalised value of the j-th criterion for an i-th variant. Among others, formula (1) has one negative characteristic – it is possible to add a variant that will be assessed as the last one in a line, but it may affect the order of all preceding variants. That means this type of normalisation can be rather susceptible to negative ideal criteria values.

The Ministry reduced this susceptibility using another type of normalization – the ratio of an obtained value to an average in the whole republic [8]. For benefit criteria:

$$r_{ij} = \frac{y_{ij}}{\bar{y}_j} \quad \textbf{(2)}$$

And conversely for cost criteria:

$$r_{ij} = \frac{\bar{y}_j}{y_{ij}} \quad \textbf{(3)}$$

Upon this normalisation, the variants are arranged on the basis of the weighted sum of normalised values obtained in the criteria.

The regional data were also analysed using the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) [3], [5]. The TOPSIS arranges an order of variants on the basis of a distance from an ideal value of criterion Hj and negative ideal value of Dj. During the normalisation, it uses the formula which transfers the columns of the criterion matrix to vectors of a unit distance [3] [5]:

$$r_{ij} = \frac{y_{ij}}{\left(\sum_{i=1}^{p} (y_{ij})^2\right)^{1/2}} \quad \textbf{(4)}$$

Order of variants results from a falling indicator of a relative distance from a negative ideal solution:

$$c_i = \frac{d_i^-}{d_i^+ + d_i^-} \quad \textbf{(5)}$$

where respective variables in the formula present a distance from an ideal solution:

$$d_i^+ = \left(\sum_{j=1}^{k} (w_{ij} - H_j)^2\right)^{1/2} \quad \textbf{(6)}$$

and a distance from a negative ideal solution:

$$d_i^- = \left(\sum_{j=1}^{k} (w_{ij} - D_j)^2\right)^{1/2} \quad \textbf{(7)}$$

The variable wij is a normalised value rij multiplied by a corresponding weight, constant p is the number of variants and constant k is the number of criteria. For the needs of the TOPSIS, Hj and Dj are calculated from the matrix W, which consists of wij.

If some criteria are benefit and some are cost, there is a general transforming formula [3]:

$$y'_{ij} = \max_{i=1}^{m} (y_{ij}) - y_{ij} \quad \textbf{(8)}$$

Such transformation is usually being interpreted as savings, or by how much is this variant better in this criterion than the worst one. However, this changes a relative distance to an ideal variant, which may even causes opposite results. Therefore, according to the [4] the use of the following formula is the most convenient:

$$y'_{ij} = 2\bar{y}_j - y_{ij} \quad \textbf{(9)}$$

Results and discussion

For the previous periods, there appeared an error in the overall calculation of unemployment. For the period 2001 – 2009 (originally, it was also for the whole period of 2007 – 2013), this indicator

consisted of the unemployment, long-term unemployment and pressure for work places (i.e. (applicants – job vacancies available)/work force) [8] and [10]. For the sum of this overall indicator, the weighted sum was again employed, using the given weights; however, no normalisation was implied. Thus dimensionless pressure was added up to unemployment with units representing unemployed people. The normalization using (2) and (3) was used only for the result – the overall evaluation of the unemployment necessary for final district arrangement. This caused the deformation of selected weights.

Multiplication of the overall criterion weight and partial criteria weights do not present increase in computation hardness and prevent the mistake that occurred in previous periods. Such an easy modification will transform two calculations into one and still guarantees that the sum of all weights will equal one. Although the normalization for the period of 2010 – 2013 is correct, it would be convenient to cancel a redundant double weighted sum. This will prevent the repetition of the error from the previous period in further periods. The weights for the period of 2010 – 2013 would then correspond to Table 2.

Transformation of the problem into the criterion matrix results into matrix that has 77 variants/rows all districts in the Czech Republic) and for the comparison calculations five criteria/columns – the overall evaluation of unemployment was divided into two criteria with weights based on Table 2.

Although the data were erroneously normalised in the original method, the selection of regions for the previous periods was not affected (only the order changed, but the set of selected regions as a total did not change). For the period 2001 – 2003, the false result was the closest. The difference in value of coefficient identifying an economically weak region between the last economically week and the worst non-economically week was 0.002 (i.e. 0.2% of average coefficient value).

The current method was compared with the WSA, with the normalisation based on the formula (1). To support assumption about the stability of the solution, both approaches were applied to the table without the variant with the lowest obtained criteria values (Prague). The TOPSIS method was calculated twice, with the transformation criteria according to the formula (8) and consequently using the formula (9). The results are presented in Table 3.

Unemployment level	Number of applicants per one work place	Tax income	Number of private entrepreneurs	Purchasing power
0.32	0.08	0.2	0.2	0.2

Table 2. Modified criteria and their weights.

	Original	Original II	WSA	WSA II	TOPSIS	TOPSIS II	Original III
1	Karviná	Karviná	Karviná	Karviná	Karviná	Karviná	Karviná
2	Děčín	Most	Most	Bruntál	Bruntál	Bruntál	Most
3	Bruntál	Bruntál	Bruntál	Most	Most	Most	Bruntál
4	Most	Děčín	Hodonín	Hodonín	Děčín	Děčín	Hodonín
5	Teplice	Teplice	Děčín	Děčín	Teplice	Teplice	Děčín
6	Jeseník	Hodonín	Teplice	Teplice	Hodonín	Hodonín	Chomutov
7	Hodonín	Jeseník	Chomutov	Chomutov	Chomutov	Jeseník	Nový Jičín
8	Přerov	Přerov	Třebíč	Třebíč	Šumperk	Šumperk	Znojmo
9	Nový Jičín	Tachov	Znojmo	Znojmo	Znojmo	Tachov	Šumperk
10	Tachov	Nový Jičín	Šumperk	Šumperk	Tachov	Chomutov	Teplice
11	Třebíč	Šumperk	Přerov	Přerov	Třebíč	Znojmo	Ústí nad Labem

12	Šumperk	Chomutov	Nový Jičín	Nový Jičín	Přerov	Ústí nad Labem	Tachov
13	Znojmo	Znojmo	Tachov	***Svitavy***	Sokolov	***Česká Lípa***	Přerov
14	Chomutov	Třebíč	***Svitavy***	Tachov	Ústí nad Labem	Sokolov	***Česká Lípa***
15	Sokolov	Sokolov	Sokolov	Blansko	Nový Jičín	Přerov	Jeseník
16	Ústí nad Labem	Ústí nad Labem	Blansko	Sokolov	***Svitavy***	Nový Jičín	Sokolov
17	Blansko	***Česká Lípa***	Ústí nad Labem	***Kroměříž***	Blansko	Třebíč	***Svitavy***
		Blansko (18)	Jeseník (21)	Ústí nad Labem	Jeseník (21)	Blansko (21)	Třebíč (19)
				Jeseník (23)			Blansko (23)

Source: Column Original Resolution of Czech government no. 141/2010 on the definition of regions with concentrated state support for years 2010 – 2013 [11] completed with a respective calculation, other columns own calculation.

Table 3: District order 2010 – 2013.

The column Original illustrates structurally affected and economically weak regions, i.e. the first two categories of regions with the concentrated state aid, as they are currently used. Column Original II illustrates first 17 variants upon the removal of Prague. The WSA presents the Weighted Sum Approach with the normalisation based on the formula (1). The WSA II illustrates the order of variants upon the removal of Prague. The order in the column TOPSIS is given by the application of the algorithm and the cost criteria transformation based on the formula (8). The formula (9) was used for the column TOPSIS II.

Eight highlighted districts are those that were originally not on the position till the seventeenth bar. Additionally, regions with concentrated state aid, which other approaches transferred to more remote positions (position eighteen and higher), are at the end of the table and their order is in the brackets following their names.

All districts, which by using other methods enter the seventeenth bar, are districts presently selected for the category of Regions with highly excessive unemployment. Only Blansko dropped to lower position and simultaneously does not enter the highly excessive unemployment category and not even as an administration district of municipality with an extended activity.

In contrast to a previous period, the order of districts in the period 2010 – 2013 is much more stable. Also, the higher stability of used normalisation when omitting the Prague was not confirmed. The average absolute change in the order from Original to Original II is the same as an average absolute change from the WSA to the WSA II (d = 1.11). A maximum change is 7 and stands for a presupposed more stable normalisation based on formula (2) and (3). The average absolute change in the order is much higher for switch from Original to WSA (d = 4.47) and also to the TOPSIS II with corrected transformation (9) (d = 4.16). The maximum change is 19 for the WSA and 20 for the TOPSIS II. Nevertheless, the TOPSIS II gives same set of supported districts as the Original II.

The most obvious difference in results is position of Jeseník district. This district is originally placed on

the sixth position and falls to the position twenty-Column Original III is applied to test whether it is functional to use the criterion "number of applicants per a work place" with a weight 0.08 which is 2.5 times smaller than the second smallest weight. It is obvious that this criterion will relatively high correlate with unemployment (correlation coefficient r = 0.699). A distinct change in the order in this column unambiguously suggests the importance of this criterion irrespective of a low weight.

For the period 2007 – 2009 (table 4), there was confirmed a high susceptibility to negative ideal values for the WSA and the WSA II (e.g. Ostrava-City dropped from position 23 to position 40, while one when using the WSA. This is caused by mentioned susceptibility of formula (1). E.g. the tax

income criterion is mainly distributed in only 30% of data interval, which is the same for the

normalised data by (1). The formula (2) gives

nearly a bell shape distribution with fatter tails that must provide different results, see graph 1.

for the original method this district was selected on the position 13. In contrast, for the normalisation based on the formula (2) and (3) the stability of the solution was confirmed. See table 4 for more details. On the whole, a higher stability for a current period (independent of the used method) signals a sharper boundary for the denotation of problem regions. Column wOriginal illustrates structurally affected and economically weak regions with wrong (but used) normalisation of unemployment criterion. Column Original represents these regions after correction of algorithm. Although the order was distorted, the resulting set of regions was unaffected.

Conclusions

With regard to the intention to compare all districts, it is convenient to apply algorithm that will not be susceptible to extreme negative ideal values. Therefore the application of other than classical normalisation of criteria values (1) for the WSA appears to be the right choice. It was proved that normalisation would significantly distort results in previous periods. The TOPSIS method as a representative of alternative methods results in almost the same districts on first 17 positions as the method used by Ministry for the period 2010 – 2013 and absolutely same districts for the period 2007 – 2009.

There is a plenty of MCDM (see e.g. [9] or [15]). The calculation algorithms presented in this article belongs among the simplest ones. The use of any other method than the used one will very probably cause different order. The advantage of herein presented methods is, besides relatively simple calculations, also an easy interpretation of results and easy comprehension of the whole procedure. For this decision-making situation the method selected by the ministry is sufficient enough.

New evaluation caused not only the update of regions with concentrated state aid, but also, within this up-date, it caused the correction of the applied method. However, the definition of partial criteria without the denotation of weights multiplication seems to be an open path back to the original error. Till now, the erroneously applied normalisation has had no impact on the overall correctness of results. The output of the generally correctly defined algorithm can be degraded because of processional error. It would be also convenient to introduce some computation control procedures at Ministry for Regional Development to avoid more of such errors.

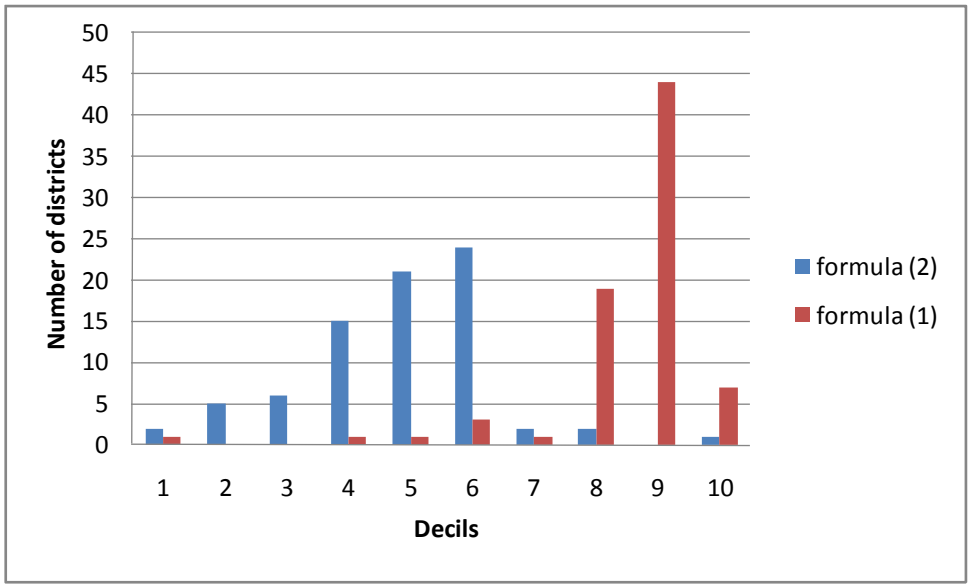

Figure 1: Tax income dostribution after normalization.

	wOriginal	Original	Original II	WSA	WSA II	TOPSIS	TOPSIS II
1	Most	Most	Most	Karviná	Karviná	Most	Most
2	Karviná	Karviná	Karviná	Most	Most	Karviná	Karviná
3	Bruntál	Teplice	Teplice	Bruntál	Bruntál	Teplice	Teplice
4	Teplice	Bruntál	Bruntál	Teplice	Frýdek-Místek	Bruntál	Bruntál
5	Louny	Chomutov	Louny	Chomutov	Třebíč	Chomutov	Chomutov
6	Chomutov	Louny	Chomutov	Louny	Louny	Louny	Louny
7	Jeseník	Jeseník	Jeseník	Frýdek-Místek	Hodonín	Ostrava-město	Jeseník
8	Hodonín	Hodonín	Hodonín	Hodonín	Teplice	Hodonín	Hodonín
9	Frýdek-	Frýdek-Místek	Frýdek-Místek	Třebíč	Chomutov	Frýdek-Místek	Děčín
10	Děčín	Ostrava-město	Děčín	Nový Jičín	Nový Jičín	Děčín	Frýdek-Místek
11	Nový Jičín	Děčín	Ostrava-město	Znojmo	Znojmo	Nový Jičín	Ostrava-město
12	Třebíč	Nový Jičín	Nový Jičín	Svitavy	Svitavy	Třebíč	Ústí nad Labem
13	Ostrava-	Třebíč	Třebíč	Přerov	Přerov	Znojmo	Nový Jičín
14	Znojmo	Znojmo	Znojmo	Děčín	Šumperk	Přerov	Třebíč
15	Přerov	Přerov	Přerov	Jeseník	Opava	Svitavy	Přerov
16	Svitavy	Ústí nad Labem	Ústí nad Labem	Šumperk	Jeseník	Ústí nad Labem	Znojmo
17	Šumperk	Svitavy	Svitavy	Opava	Děčín	Jeseník	Sokolov
18	Ústí nad	Šumperk	Šumperk	Sokolov	***Vyškov***	Šumperk	Šumperk
19	Sokolov	Sokolov	Sokolov	***Kroměříž***	***Kroměříž***	Sokolov	Litoměřice
20	Litoměřice	Litoměřice	Litoměřice	Ústí nad Labem	***Blansko***	Opava	Svitavy
21	Opava	Opava	Opava	***Vyškov***	***Žďár nad***	***Kroměříž***	Opava
…	…	…	…	Ostrava-město	Sokolov (22)	Litoměřice (23)	…
				Litoměřice (29)	Ústí nad Labem		
					Litoměřice (32)		
					Ostrava-město		

Table 4. District order 2007 – 2009.

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