APPLICATIONS OF TOPSIS TECHNIQUE FOR SELECTING THE MOST EFFICIENT MUNICIPALITY IN THE SELECTED DISTRICT IN THE SLOVAK REPUBLIC

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The purpose of multicriteria decision models is to help decision maker to evaluate each alternative and to rank them in descending order of performance. This study analyses the concept of Multiple Attribute Decision Making for using in local government area. The aim of this paper is to analyse the concept of Multiple Attribute Decision Making for selecting the most efficient municipality in selected district in the Slovak Republic. Achieving this purpose, TOPSIS technique is used as decision making tools.

Keywords: TOPSIS technique, municipality, Prešov district

INTRODUCTION

According to [5] the aim of multicriteria decision is on a base of chosen criteria to select one variant which shows the best characteristics. However to be successful in this aim needs a huge amount of information which might not be available. Each of methods differs in providing ordinal or cardinal information about the order of each particular variant (the importance of particular criteria) and whether they need ordinal or cardinal information for its use about particular variants towards particular criteria (about the preference of those criteria). According to [8] the ordinal (order) variable takes verbal value. Those are presenting categories. They have relative meaning because we can't the difference between those categories. That is why you use cardinal (interval) variable which, according to [10] makes quantification. Moreover it makes quantification of differences between the categories.

According to [11] the first step is choosing of objects contained in analyze folder which is followed by choosing of concrete method of more criterion evaluation. Next step is a choosing of characteristics (indicator) characterizing a concrete object, which are considered to be important (the importance of each indicator) on a base of subjective preferences of each person individually. The obvious part is the identification of character of each indicator (whether it is the indicator of maximation or the one of minimalization).

According to [10] the basic advantage of evaluation on a base of more criteria is the fact, that they do not force reducing non - economic criteria to economic criteria at the expense of precarious or sparing operations.

The method of summary is useful when you need to state quantitative criteria. But it expects linear dependence on behalf of criteria (indicators). The principle of base method is stating of the best values and then you are about calculating of each useful function alternative. The lexicographical method consists of the supposal and it is that the biggest influence has the most important criteria. In the case of congruence you observe the second and the next criteria in an order. The method AHP includes all of the factors that influence the result (connection in between and intension of how much they

influence each other). The method of TOPSIS is based on choosing a variant which is closest to the one which has been chosen before and also the farthest from the base variant.

The municipality in some part of the Slovak republic was chosen for the purpose of this contemplation and the chosen method was the TOPSIS method.

1 TOPSIS TECHNIQUE

According to [7] the main concept behind TOPSIS (Technique for Order Preference by Similarity to Ideal Solution), as a technique for solving the Multiple Attribute Decision Making problems, is that the chosen alternative should have the shortest distance from the Positive Ideal Solution, and also have the farthest distance from the Negative Ideal Solution. Positive Ideal Solution is the solution that maximises the benefit criteria and minimises the cost criteria, while Negative Ideal Solution is the solution, which maximises the cost criteria and minimises the benefit criteria. Furthermore, TOPSIS alleviates the requirement of paired comparisons, and the capacity limitation may not significantly dominate the process. Hence, it is suitable for cases with a large number of attributes and alternatives, and especially handy for objectives with quantitative data.

"It is a rational and relatively simple method where the underlying concept is that the most preferred alternative should not only have the shortest distance from "ideal" solution, but also the longest distance from an "anti-ideal" solution" [12]

The other one characteristic by [4] is: "The basic concepts of TOPSIS are based on the predetermined positive ideal solution and negative ideal solution. The purpose is to find the alternative that is closest to positive ideal solution and farthest from the negative ideal solution. The positive ideal solution is the one with the most benefits and lowest cost of all alternatives, the negative ideal solution is the one with the lowest benefits and highest cost."

Series of stages of TOPSIS technique are described by [7] as follows:

a) construct normalized decision matrix;

b) construct the normalized weighted decision matrix;

c) determine the positive ideal and negative ideal solutions;

d) calculate the separation measures (distance from PIS and NIS for each alternative);

e) calculate the relative closeness to ideal solution;

f) rank the preference order.

The same number of stages of TOPSIS techniques is identified by [1] as [7]. They indicate the little more detail 6 stages:

a) construct the matrix of consequences;

b) construct the matrix of normalized consequences;

c) construct the weighted-normalized matrix with the criteria importance coefficients;

d) define the PIS vector and the NIS vector (the vector for minimal value of alternatives if the criteria is a minimal criteria or the maximal value of alternatives if the criteria is a maximal criteria);

e) calculation of distance between the each alternative and the positive alternative and the calculation of distance between the each alternative and the negative ideal alternative;

f) determination of the index to positive ideal solution.

2 METHODOLOGY

The methods used in this article we can divide into three categories:
a) TOPSIS technique;
b) financial indicators;
c) statics methods used to municipal valuation.

2.1 TOPSIS technique

According to [3], the TOPSIS method is based on choosing of an alternative, which is closest to the ideal variant and at the same time the farthest from the base variant. The supposal is maximal character of criteria.

We tend to [6], who considers the first step of the method making a matrix of criteria and then the summary of standard matrices. We can describe the calculation as following:

a) construct starting criterial matrix (y_{ij}) aconstruction of vectorweights ($v_1, v_2, ..., v_k$),

b) Construct criterial matrix $R = (r_{ij})$ of formula:

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

where $i = 1, 2, ..., n; j = 1, 2, ..., k$;

c) construct the normalized weighted matrix $W = (w_{ij})$ of formula $w_{ij} = v_j r_{ij}$,

where y_j– weight of j-criterion;

d) using the matrix W elements is creating ideal variant ($H_1, H_2,..., H_k$) and baseline variant ($D_1, D_2,..., D_k$), where

$$H_j = max(w_{ij}), \ D_j = min(w_{ij}),$$

where $j = 1, 2, ..., k$;

f) for the calculation of the distance from the ideal option (d_i^+) and baseline option (d_i^-) we use the formula:

$$d_i^+ = \left[\sum_{j=1}^{k} (w_{ij} - H_j)^2 \right]^{1/2}, \ \text{or} \ d_i^- = \left[\sum_{j=1}^{k} (w_{ij} - D_j)^2 \right]^{1/2},$$

where $i = 1, 2, ... n$;

g) the last step is calculating a relative distance from baseline variant:

$$c_i = \frac{d_i^-}{d_i^- + d_i^+},$$

where $i = 1, 2, ... n$.

Values c_i are in the range <0;1>, where 0 represents the basal variant 1 ideal option. The higher the value c_i, the greater the distance from the baseline alternatives.

2.2 Financial indicators

The described method TOPSIS was used for evaluation of economy in villages belonging to Prešov county (the number of municipalities is 91). The

charts consist of chosen villages because of the high number of municipalities in county (just for the illustration of method).

We used for municipal comparison these selected indicators (after consultation with municipalities):

R_1 – total expenditure per capita;

R_2 – borrowed funds to total municipal assets;

R_3 – total income per capita;

R_4– current profit per capita;

R_5 – return on assets;

R_6 – current expenditure per capita;

i– borrowed funds per capita;

R_8 – current income per capita.

The first indicator (R_1) describes only expenditure (cost = expenditure, i.e. is not examined law compliance) for one financial period per capita:

$$R_1 = \frac{C}{PO},$$

where: C – total expenditure; PO – city population.

We can identify the construct of the second indicator (R_2) as follows:

$$R_2 = \frac{CzZ}{A},$$

where: CzZ – borrowed funds; A- assets.

The third indicator (R_3) presents total income per capita:

$$R_3 = \frac{P}{PO},$$

where: P – total income; PO – city population.

Current profit per capita in one financial period is the fourth indicator (R_4) that was calculated:

$$R_4 = \frac{VH}{PO},$$

where: VH – current profit per capita; PO – city population

Return on assets (ROA) presents the fifth indicators (R_5) that is the basic indicator of evaluation of municipal management:

$$R_5 = \frac{VH}{A},$$

where: VH- current profit per capita; A-assets.

Current expenditure per capita is the sixth indicator (R_6) that we can calculate:

$$R_6 = \frac{C_B}{PO},$$

where: C_b – current expenditure; PO – city population.

The seventh indicator (R_7) borrowed funds per capita was calculated:

$$R_7 = \frac{CzZ}{PO},$$

where: CzZ – borrowed funds; PO – city population.
Current income per capita presents the last indicator (R_8):

$$R_8 = \frac{P_B}{PO},$$

where: P_b – current income; PO – city population.

2.3 Used statistics methods

In addition to demonstrations and applications TOPSIS techniques such as multi-criteria evaluation of the effectiveness of the algorithm municipalities, we focus in the next section to analyze the results of multicriteria algorithms.

Municipalities have scored TOPSIS technique quantified of municipality with lowest score were the best. We investigate whether the success factor has a significant effect size of municipality. This leads us to the assumption that the largest of municipality can both realize economies of scale, and have more qualified personnel infrastructure to effectively ensure all processes at of municipality level.

For analysis, we took off in addition to MS excel even further, specialized statistical programs (SPSS and Systat).

Appropriate coefficient to measure context was chosen Kendall-Stuartovo tau-c:

$$\tau_c = \frac{n_c - n_d}{n^2(k\text{-}1)/2k},$$

where: n_c – number of concordant pairs (i.e. if $x_i > x_j$ and $y_i > y_j$ or $x_i < x_j$ and $y_i < y_j$ for each sample consisting of n-observations of two variables Y and Y);

n_d- number of disconcordant pairs (i.e. if $x_i > x_j$ and $y_i < y_j$ or $x_i < x_j$ and $y_i > y_j$);

k – smaller value of m, n.

Both of these coefficients take values from -1 to 1. High value indicates a high degree of value dependence.

The significance testing of coefficients is based on the calculation of p-values. The significance factor is accepted if the calculated p-value is less than 0.05.

3 RESULTS

Since the method TOPSIS is choosing an alternative which is closest to the ideal variant and at the same time the farthest from the base variant we need to use the character of maximum of spotted indicators. Because of this reason were the indicators R_1, R_2, R_6, R_7 multiplied by coefficient -1.

The first step of the TOPSIS method is making a criterion matrix.

Table 1 - Criterion matrix in 2012

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8
Abranovce	-0.078	-0.010	0.127	-0.004	-0.008	-0.109	-0.007	0.104
Bajerov	-0.181	-0.307	0.190	0.007	0.012	-0.254	-0.251	0.247
Bertotovce	-0.170	-0.185	0.120	-0.024	-0.012	-0.120	-0.531	0.113
Brestov	-0.056	-0.066	0.058	0.000	0.000	-0.079	-0.033	0.076
Bretejovce	-0.049	-0.025	0.058	0.013	0.056	-0.068	-0.008	0.065
Source: own calculations								

The criterion matrice (table 1) creates a base for making a standard matrice. This matrice is considering the importance of each particular criterion (indicator), which was for each of those indicators the same, means 0. 125.

Table 2 -Normalized weighted matrix in 2012

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8
Abranovce	-0.010	-0.001	0.016	0.000	-0.001	-0.014	-0.001	0.013
Bajerov	-0.023	-0.038	0.024	0.001	0.001	-0.032	-0.031	0.031
Bertotovce	-0.021	-0.023	0.015	-0.003	-0.002	-0.015	-0.066	0.014
Brestov	-0.007	-0.008	0.007	0.000	0.000	-0.010	-0.004	0.009
Bretejovce	-0.006	-0.003	0.007	0.002	0.007	-0.009	-0.001	0.008
Source: own calculations								

With the help of elements of standard matrices (table 2) it was created the ideal and baseline variant and then calculated the relative distance from the baseline variant.

Table 3- The relative distance from baseline variant in 2012

Municipality	RD
Abranovce	0.382
Bajerov	0.279
Bertotovce	0.232
Brestov	0.369
Bretejovce	0.396
Source: own calculations	

On a base of the relative distance from baseline variant the municipalities were given points and they were arranged in the order for the certain year.

Table 4 -The individual score of municipalities in 2012

No	Municipality	Score
1.	Geraltov	1
2.	Gregorovce	2
3.	Janov	3
	…	…
89.	Bajerov	89
90.	Rokycany	90
91.	Bertotovce	91
Source: Own calculations		

The municipality with very little points was classified as the best by the TOPSIS method in the particular section (the years 2010-2012).

Table 5 - The overall score of municipalities 2010 – 2012

No	Municipality	Score	City population
1.	Janov	6	304
2.	Široké	31	2408
3.	Záborské	31	584
…	…	…	
104.	Šarišské Bohdanovce	244	695
105.	Chmiňany	266	874
106.	Bertotovce	271	485
Source: Own calculations			

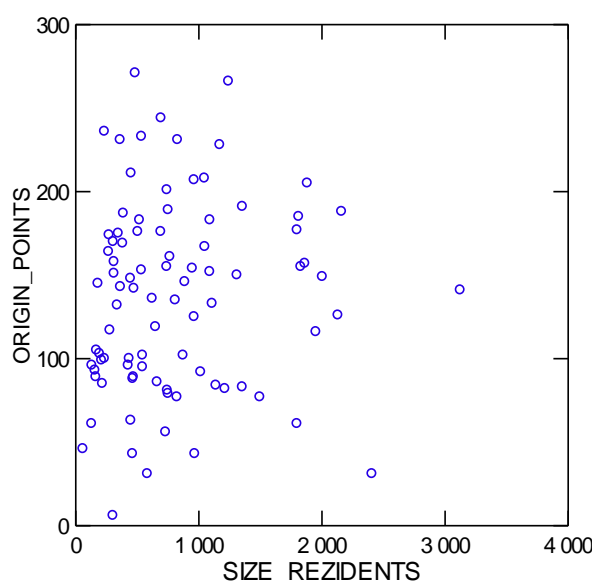Figure 1 shows the results obtained by municipalities re population.

Figure 1 - Scatter plot of parameters the city population and the score
(for better ilustration, the city with a population over 5000 is eliminated)
Source: own calculations

The distribution of the monitored parameters indicates that it is not possible to image by a single regression function. Kendall correlation coefficient more closely monitors a correlation between monitored parameters. Simultaneously, coefficient Kendall-Stuartovo tau-c presents correlation between the score and a municipal size (city population).

Table 6 - Correlation matrix of municipal size and score

Kendall's tau_b		Size	Score
Municipal size	Correlation coefficient	1.000	0.120
	Sig. (2-tailed)	.	.092
	N	91	91
Score	Correlation coefficient	.120	1.000
	Sig. (2-tailed)	0.092	.
	N	91	91
Source: own calculations			

Reliability calculated parameter does not allow drawing conclusions about the existence of links between those phenomena. Even when a statistical confidence level of the correlation coefficient would indicate to statistical inconsistency of the phenomena.

3.1 Graphical representation of the results
In the spotted Prešov district was made the ideal variant, means the best values of indicators, which were reached in each of the municipalities in the same year. Following graphical image is describing the year 2012 – the ideal variant with the comparison of results from the best municipality to the worst municipality for the particular year.
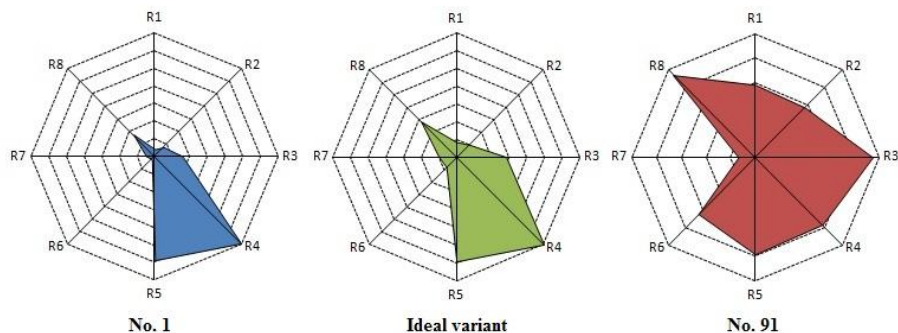
Figure 2 - Illustration of results in 2012.
Source: own calculations

The best municipality in Prešov district according to TOPSIS method was Geraltov (0, 843) for the year 2012. And the worst one was Bertotovce (0,232). As you can see the results of both municipalities differ from the ideal (fictive) variant while the deviations are shown in the Figure 3.
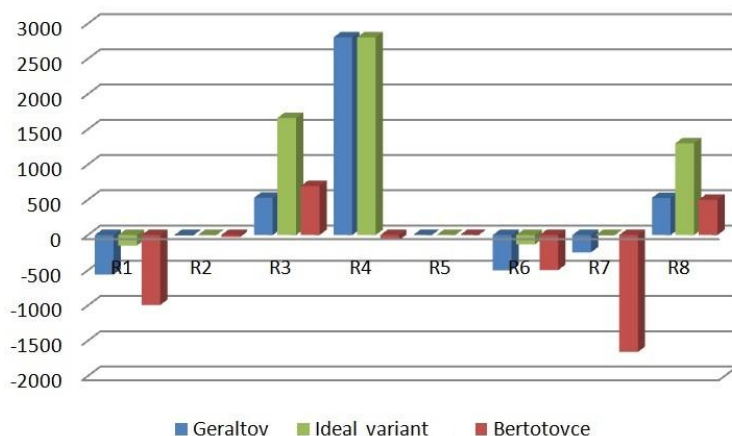

Figure 3 - Indicator comparison of selected municipalities in 2012.
Source: own calculations

REFERENCES
1. Bondor C. I. Correlated Criteria in Decision Models: Recurrent Application of TOPSIS Method / C. I. Bondor, A. Muresan // Applied Medical Informatics [online]. -2012. [cit. 2013.10.12] : available on the internet:<http://search.proquest.com/docview/934310759?accountid=14716>.
2. Fabuš M. 2011. Využitie matematicko-štatistických metód v ŠVOC / M. Fabuš // K rozvoju študentskej vedeckej odbornej činnosti na Ústave ekonomie a manažmentu na VŠEMvs. Bratislava : vysoká škola ekonomie a manažmentu verejnej správy v Bratislave, 2011. -P. 9-14; ISBN 9-788097-049591.
3. Jablonský J. Operační výzkum: Kvantitativní modely pro ekonomické rozhodování / J. Jablonský; 2. vyd. -Praha : Professional Publishing, 2002.- 323 p.; ISBN 80-86419-23-1.
4. Ling-Feng H. Performence evaluation for university electronic libraries in Taiwan / H. Ling-Feng, Ch. Jiung-Bin, W. Mu-Chen // The Electronic Library [online].- 2010 [cit.

2013.10.13]. - Available on the internet <http://search.proquest.com/docview/ 218233243?accountid=14716>.

5. Lištiak P. Konkurencieschopnosť slovenského hospodárstva vo vzťahu k energetike v období finančnej krízy / P. Lištiak // Management Challenges in the 21st Century [online]. -2012 [cit. 2013.10.12]/ - Available on the internet: <http://www.cutn.sk/Library/proceedings/ mch_2012/editovane_prispevky/Li%C5%A1tiak.pdf>.

6. Minařík P. Porovnání investičníchinstrumentů – vicekriteriální rozhodování / P. Minařík // Matematikav ekonomické praxi.- Jihlava : VŠP Jihlava, 2010. - P. 121-132; ISBN 978-80-87035-34-4.

7. TOPSIS and AHP techniques for selecting the most efficient marine container yard gantry crane / A. S. Nooramin et al. // Operational Research Society of India [online]. -2012 [cit. 2013.10.12]. - Available on the internet : <http://www.pulib.sk:2088/pqcentral/docview/1017942897/141115FE11FDBD1D61/1?accountid =14716>.

8. Pancáková V. Štatistické metódy pre ekonómov / V. Pancáková. - Bratislava : Ekonóm, 2009. - 411 p. ; ISBN 978-80-8078-284-9.

9. Rektořík J. Ekonomika a řízení odvětví veřejného sektoru / J. Rektořík, A Kol. // Praha : Ekopress, 2007.- 309 s.; ISBN 978-80-86929-29-3.

10. Rimarčík M. Štatistika pre prax.; 1. vyd. / M. Rimarčík. - 2007. - 200 p. ; ISBN 978-80-969813-1-1.

11. Šebo, J. Meranie konkurencieschopnosti viackritériálnym hodnotením / J. Šebo, M. Šebová // Journal of Competitiveness [online]. – 2010, No1 [cit. 2013.10.12]. - Available on the internet: <http://www.cjournal.cz/index.php?hid=clanek&bid=archiv&cid=23&cp=>.

12. Yilmaz B. Multi-criteria decision making for water ressource management: a case study of the Gediz River Basin, Turkey / B. Yilmaz, N. B. Harmancioglu // Water S.A. [online].- 2010 [cit. 2013.10.13].- Available on the internet:<http://search.proquest.com/docview/814875563? accountid=14716>.

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