Topsis Technique in Self-Government – Case Study of Košice Region

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Abstract. In the last decades, most of the democratic countries have re-allocated tax revenues from collected taxes between the state budget and local government budgets. It is possible to monitor the effort to increase the relative financial autonomy of local governments, to strengthen own revenues of local self-government and to increase the autonomy of decision-making bodies regarding their use. The manuscript focuses on usage of TOPSIS technique as a tool for comprehensive evaluation in self-government in Slovakia. 8 criteria were used and their weight was calculated based Fuller triangle method and 25 experts. Based on this analysis, it is possible to recommend this method for usage not only in public sector, but also in private sector as well. Its use is also conditioned by the appropriate selection of the monitored indicators and their weighting, which significantly determines the overall results.

1 Introduction

Domestic and foreign researchers [1-5] noted that in the innovation economy, the efficiency evaluation based on multiple criteria is a more complicated option, but on the other hand, this evaluation gives more insight into the real state of public sector efficiency. According to [6], the basic advantage of these methods is the fact that they are not in a position to transform non-economic criteria into economic criteria at the cost of delicate, sometimes controversial operations. These methods include: scales and ranges (can be used separately or as a part of another method), methods of weight determination, methods based on partial evaluation of variants, methods based on pairwise comparison of variants.

All multi-criteria evaluation methods work with criteria (indicators) that are non-negative and normalized, i.e. their sum is 1. The method of equal importance is not able to distinguish between the greater or lesser importance of the observed criteria, i.e., all criteria are evaluated equally. Ranking is based on assigning a point value based on certain preferences. The scoring method is similar to the previous method, but works with cardinal variables (preference of individual indicators). The principle of the Fuller's method is to allocate the points to each pair of indicators and then to sum up the points obtained. [7, 8]

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used this method to evaluate municipalities in the Slovak Republic. Saaty's method works much like the previous methods. The only difference is that it also determines the size of this preference. The weighted sum method is particularly suited to determine quantitative criteria, assuming a linear dependence of the utility rate on criteria (indicators). The basic variant method determines the best or desired values and then calculates the utility rate of each alternative. The lexicographic method is based on the assumption that the most important criterion has the greatest influence. In the case of compliance, the second and the criterion after that shall be taken into account. When solving a problem, the AHP method takes into account all the elements that affect the outcome (the links between them and the intensity with which they influence each other). The TOPSIS method chooses the variant that is closest to the pre-set ideal and at the same time the furthest from the basal variant.

2 Methodology

According to [9], TOPSIS enables the decision maker to solve and analyze the problem, to compare alternatives and to rank them on the basis of selected criteria (see also [10-15, 16]).

The identification of individual criteria for TOPSIS calculation was based on personal consultations with government employees of the Financial Control and representatives of municipalities. The common goal was to jointly identify a set of core indicators that best reflect the real status of a particular municipality's economy and that would offer an alternative to the currently valid law-based evaluation.

Table 1. Weights of criteria in two alternatives

critterion	R1	R2	R3	R4	R5	R6	R7	R8
weight – alterative 1	0.161	0.113	0.150	0.123	0.09	0.144	0.106	0.113
weight – alterative 2	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125

After several meetings, the set was minimized into the following group of monitored indicators:

- R1 – total expenditures per capita,
- R2 – share of foreign resources on the total assets of the municipality,
- R3 – total income of the municipality per capita,
- R4 – profit per inhabitant of the municipality,
- R5 – return on assets,
- R6 – current expenditures per inhabitant of the municipality,
- R7 – foreign sources per inhabitant of the municipality,
- R8 – current income per capita of the municipality.

The results of TOPSIS technique are complemented by a set of mathematical and statistical methods, namely Dean Dixon test, Kendall rank coefficient, Kolmogorov-Smirnov test, Kruskal-Wallis test, Levene test, Moran index, Regression model, and Shapiro-Wilk test as well. For detailed results see also [7, 8, 17, 18].

The whole process of statistical analyzes was carried out in MS Excel, Statistica 13.1 and Statgraphics XVII.

3 Application of TOPSIS technique in Košice region

Košice region (KSK) is the second most prosperous region in Slovakia. More than 55 % of its inhabitants live in the cities. The region is dominated by metallurgical, chemical and electrotechnical industry.

Fig. 1. Districts of Košice region

Košice region has a total of 461 municipalities (including 22 city districts of Košice), of which Košice - Bakša was excluded because of unavailability of data. On average, each municipality has 1721 inhabitants. Since Košice was divided into city districts, the largest statistical unit is Košice - Západ with 40695 inhabitants. The majority group consists of small municipalities ($Q_3 = 1175$), while the basic set is considerably skewed ($\alpha = 52.13$). The smallest municipality is Hanková (62 inhabitants) in the Rožňava district.

Fig. 2. The structure of KSK municipalities according to the number of inhabitants and districts PO - population - municipality size in thousands of inhabitants

4 Results of TOPSIS method and statistical processing

The ranking of municipalities achieved by applying the TOPSIS method with the same and modified weights, including the dependence of the individual monitored criteria on the achieved result is outlined in Table 2.

Table 2. Ranking of municipalities based on TOPSIS method - KSK

S	M	D*	Municipality	c_i^{**}	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8
1	1	KS	Janík	0.837	301.20	18.92	583.56	344.88	0.60	301.18	107.99	296.39
2	2	RO	Lúčka	0.821	438.36	6.66	463.95	300.11	0.41	425.82	49.10	463.95
3	3	TV	Malý Kamenec	0.820	599.56	29.25	611.03	396.94	0.41	244.76	280.73	256.23
...	...	...	...	...	...	...	...	...	...	...	...	...
458	458	TV	Trnávka	0.532	163.63	187.98	170.05	-15.41	-0.40	163.62	73.02	163.98
459	459	KE	Košice - Dar. Hrdinov	0.526	33.16	345.15	39.26	5.29	0.12	31.13	146.82	37.77
460	460	SO	Veľké Revišťa	0.431	425.59	5.45	456.47	686.38	-1.25	419.90	29.77	446.10
Correlation of results with individual criteria												

same indicator weights (r_K)	0.105	-0.217	0.165	0.681	0.683	0.093	-0.126	0.149
p-value	0	0	0	0	0	0.003	0	0
modified indicator weights (r_K)	0.085	-0.217	0.156	0.679	0.658	0.072	-0.124	0.131
p-value	0.007	0	0	0	0	0.022	0	0

* district **ci - relative distance from PIS

For the purposes of further analysis, the remote values identified by the Dean Dixon test were removed (Table 3).

Table 3. Remote values - KSK

District	Statistical unit
Gelnica	Gelnica
Košice	Košice - Západ
Košice okolie	Čaňa, Moldava nad Bodvou
Michalovce	Michalovce, Veľké Kapušany
Rožňava	Dobšiná, Rožňava
Sobrance	Sobrance
Spišská Nová Ves	Spišská Nová Ves
Trebišov	Trebišov

The Kolmogorov-Smirnov test did not confirm any match between the distribution functions of the results of the TOPSIS method ($K-S = 0,252$, $p < 0,01$). However, the relationship between both distribution functions was confirmed by the Kendall coefficient ($r_K = 0,938$, $p < 0,01$).

Fig. 3. Comparison of distribution functions of results – KSK WS - distribution function of results of TOPSIS technique with same indicator weights, WM - distribution function of results of TOPSIS technique with modified indicator weights

The Kendall coefficient tests the dependence between the result of the TOPSIS method and the number of inhabitants. This confirmed a weak negative correlation between the monitored variables ($r_K = -0.041$, $p = 0.194$; $r_K^* = -0.042$, $p = 0.180$), however, it was not statistically confirmed.

Table 4. Residue requirements - KSK

Requirement	Test (S)	Test (M)	Interpretation
$\varepsilon_i \sim N(0; \sigma_\varepsilon^2)$	SW = 0.962, $p < 0,01$	SW = 0,960, $p < 0,01$	unfulfilled
$E(\varepsilon_i) = 0$	$E(\varepsilon_i) = 0.015$	$E(\varepsilon_i) = 0,0..15$	fulfilled
$cov(\varepsilon_i \varepsilon_j) = 0$	Moran I = -0.007	Moran I = -0.004	fulfilled
$D(\varepsilon_i) = \sigma_\varepsilon^2$	$L_E = 8/10$	$L_E = 10/10$	fulfilled
outliers	Dean Dixon test	Dean Dixon test	fulfilled

Despite 97,5 % ability to explain the variability of results dependent on the size of the statistical unit, estimates of regression functions $WS = 0.105261 \cdot \ln(PO)$ or $WM = 0,104227 \cdot \ln(PO)$ cannot be seen as indicative due to the non-fulfillment of the residue prerequisites.

5 Districts of Košice region

Change in the weights of the monitored indicators did not change the variance of results in the regions, however, what changed was the median in all districts except Spišská Nová Ves and Trebišov. As the normality of the results was not confirmed in any of the districts, the one-factor variance analysis was not used.

Table 5. Selected characteristics of regions - KSK

District	Normality	Homoscedasticity	Identical medians
Gelnica	no	yes	no
Košice	no	yes	no
Košice okolie	no	yes	no
Michalovce	no	yes	no
Rožňava	no	yes	no
Sobrance	no	yes	yes
Spišská Nová Ves	no	yes	yes
Trebišov	no	yes	no

Fig. 4. Average evaluation of municipalities' management in districts of KSK

By comparing the average rating in the districts (Figure 4), we can observe their minimum differences. The best-rated municipalities were found in the Sobrance district. With minimal differences, the worst-rated municipalities were found in the Košice district. Due to the change in monitored weights the evaluation of each district worsened by 0,97 %.

The Kruskal-Wallis test in both cases confirmed the statistically significant difference between medians in individual districts ($KW = 23,94$, $p < 0,01$; $KW = 20,35$, $p < 0,01$). The Levene test confirmed their homoscedasticity.

6 Conclusions

We consider the TOPSIS method to be a suitable multi-criterion assessment tool for the use of which it is necessary to have financial indicators (which in some cases may limit its use).

Its use is also conditioned by the appropriate selection of the monitored indicators and their weighting, which significantly determines the overall results. Based on a number of statistical analyzes in KSK we state that:

- a) the evaluation of the municipality depends primarily on the result of the management, which also determines the return on assets,
- b) the change in the weight, although retaining the variance, changed the median; the average result of the TOPSIS method in individual districts decreased by 0,97 %,
- c) from the point of view of the evaluation of municipalities the KSK's territory cannot be considered homogeneous.

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References

1. M. Petrova, *Electronic management in the public sector of Bulgaria (on the example of the regional administrations)* 330 (2019)
2. M. Petrova, *Informatization of public administration in Bulgaria. Ed. FABER.* (Veliko Tarnovo) 428 (2013)
3. M. Petrova, *The research of e-Government of the Bulgarian Public Sector Organizations. Business Competences: Monograph*, (2012)
4. M. Petrova, Proceeding of the V International Scientific Conference "Innovations in Technology and Education", 102 (2012)
5. M. Petrova, F. Filipov, *Improvement of administrative service in Yambol municipal administration, book "E-Justice, e-government and information security"*, (PSIT-Garant Ltd, Publisher „Znak'94", Veliko Tarnovo, 2011),
6. J. Rektorík, *Ekonomika a řízení odvětví veřejného sektoru*, (Prague: Ekopress, 2007)
7. R. Vavrek, Scientific papers of the University of Pardubice, **24:39**, 236 (2017)
8. R. Vavrek, P. Adamišin, R. Kotulič, Polish Journal of Management Studies, **16:2**, 290 (2017)
9. H. S. Shih, H. J. Shyur, E. S. Lee, Mathematical and computer modelling. **45:7-8** 801 (2007)
10. S. Aouadni, A. Rebai, Z. Turskis, Studies in Informatics and Control. **26:3**, 353 (2017)
11. P. W. Bhutia, R. Phipon, Journal of Engineering, **2:10**, 43 (2012)
12. A. Kandakoglu, M. Celik, I. Akgun, Mathematical and Computer Modelling, **49:3-4**, 586 (2009)
13. A. S. Milani, A. Shanian, C. El-Lahham, Mathematical and Computer Modelling. **48:11-12**, 1765 (2008)
14. M. Noryani, S. M. Sapuan, M. T. Mastura, Journal of Mechanical Engineering and Sciences. **12:1**, 3330 (2018)
15. S. Opricovic, G. H. Tzeng, Computer-Aided Civil and Infrastructure Engineering. **17:3**, 211 (2002)
16. E. K. Zavadskas, A. Mardani, Z. Turskis, A. Jusoh, K. Nor, International Journal of Information Technology & Decision Making, **15** (2016)
17. R. Vavrek, R. Kotulič, P. Adamišin, Lex localis - Journal of Local Self-Government, **13:2**, 249 (2015)
18. R. Vavrek, R. Kotulič, P. Adamišin, Journal of Applied Economic Sciences, **9:3**, 505 (2014)