Multicriteria Evaluation of Municipal Management Using TOPSIS Technique: Case Study on Slovak Republic

Roman VAVREK

VSB – Technical University of Ostrava, Ostrava, Czech Republic; roman.vavrek@vsb.cz

Abstract: Effective management of (non)public funds is an area for every economic entity that is subject to more and more control. Currently, municipalities in the Slovak Republic are evaluated by law on the basis of a single criterion. This criterion is indebtedness. The aim of the presented article is to offer an alternative in the form of TOPSIS technique and further statistical processing for a comprehensive evaluation of the management of municipalities in the Slovak Republic. Individual mathematical-statistical methods are applied to the basic set of municipalities of the Slovak Republic of 2,940 municipalities with the purpose of identifying, using 8 indicators, the municipality with the best management. One of the results of the performed analyzes is pointing out the differences resulting from different approaches to determining the importance of the evaluated criteria.

Keywords: TOPSIS technique; municipality; Slovakia, weight of criterion

JEL Classification: B23; E69; H11

1. Introduction

The economic activity of each economic entity is regulated by legislation that defines the scope of its activities. According to Act no. 460/1992 Coll. (Constitution of the Slovak Republic) "territorial self-government consists of a municipality and a higher territorial unit". The basic unit is the municipality, which is enshrined in the Constitution and defined by Act no. 369/1990 Coll. on municipal establishment. The essence of higher units (Act No. 302/2001 Coll.) can be defined in such a way that the area of its scope is formed by the territory of a larger number of basic units (municipalities).

Under the conditions of the Slovak Republic, the management of municipalities is governed by the Act no. 583/2004 Coll. on Budgetary Rules of Territorial Self-Government, which considers its indebtedness as the only evaluation criterion of the municipal management (§ 19): "The municipality is obliged to introduce a recovery regime if the total amount of its obligations after the maturity date exceeds 15% of the actual current income of the municipality of the previous budget year and if it has not paid any recognized obligation within 60 days from its due date." The recovery regime precedes the introduction of forced administration and represents a loss of freedom over the administration of the municipality's own finances. At the same time, the law (§ 17) adds that the municipality can accept repayable sources of financing (i.e. credit, loan) to fulfill its tasks only if:

- „the total amount of the debt of the municipality or higher territorial unit does not exceed 60% of the actual current income of the previous budget year and
- the amount of annual installments of repayable sources of financing, including the payment of revenues, will not exceed 25% of the actual current income of the previous fiscal year."

In the Slovak Republic, there is no framework (including legislation) that would evaluate the complex management and efficiency of municipal management. We consider its absence to be the main research problem of the submitted manuscript. This absence of a municipal management evaluation system formed the starting point for establishing the goal of the presented research, which is to apply verified a multi-criteria decision-making method (Technique for Order of Preference by Similarity to Ideal Solution) to the management of municipalities in individual regions of the Slovak Republic using 8 selected economic criteria.

2. Methodology

A total of 8 criteria were identified for the evaluation of the management of municipalities in the framework of the previous already published research. The identification of individual criteria was based on personal consultations with government auditors of the Financial Control Administration and representatives of municipalities. Their goal was to jointly identify a group of basic criteria that best reflects the real state of management of a specific municipality and that would offer an alternative to the currently valid assessment according to the law. In the first phase, a group of 28 criteria was presented to them, which after several meetings and discussions was minimized to the following group of monitored criteria:

- R1 –total expenditure per capita,
- R2 – share of liabilities in total assets of municipality,
- R3 – total income per inhabitant,
- R4 – profit per inhabitant,
- R5 – return on assets,
- R6 – current expenditures per capita,
- R7 – liabilities per capita,
- R8 – current income per capita.

In our opinion, the given set of criteria meets the requirements set for such a set by Fotr, Dědina, and Hrůzová (2000), i.e. completeness, operability, non-redundancy and minimal scope.

The importance of individual criteria is determined differently, while in the first case the MW (Mean Weight) method is used, which considers all criteria to be equal. In the second case, the weights are determined by an expert sample of 25 experts, which identified the weights of the criteria for ranking the municipalities as follows.

Table 1. Criteria weights assigned by the MW method and the expert group

	R1	R2	R3	R4	R5	R6	R7	R8
MW	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
experts	0.161	0.113	0.150	0.123	0.090	0.144	0.106	0.113

The monitored criteria can be obtained directly from individual municipalities, while the Ministry of Finance of the Slovak Republic also has this data.

The presented research works with a research sample consisting of 2,940 municipalities in the Slovak Republic in 2012, which represents a complete basic set of all municipalities in the Slovak Republic, i.e. research sample no. 2 (Bratislava, Košice were divided into urban districts).

TOPSIS is one of the basic methods of multicriteria decision-making and its primary use is in solving different types of decision-making problems. According to Zavadskas et al. (2016), this method is one of the most widely used, with the AHP, ANP or PROMETHE as possible alternatives. An overview of its applications captures e.g. Tramarico et al. (2015), Ilbahar et al. (2019), who noted an annual increasing number of researches/articles in which the use of not only the TOPSIS technique could be found. The choice of the TOPSIS method for the purposes of our research was based on its previous successful use in solving decision-making problems of a similar nature. Its applications can be found in environmental studies (Rozenthal & Blumberga, 2019; Suharevska & Blumberga, 2019, Siksnelyte et al., 2019), transport (Djordjević & Krmac, 2019), local government (Vavrek & Bečica, 2022), culture (Bečica et al., 2021) and many other areas (see Chang et al., 2010, Behzadian et al., 2012; Luan et al., 2019; Ma et al., 2019; Wu et al., 2019).

The obtained results are subsequently evaluated using a wide range of mathematical and statistical methods including Kendall's rank correlation coefficient, Simple regression model, Levene test, Mann-Whitney test, Kruskal-Wallis test and Dunn test.

All analyzes are processed in MS Office Excel, Statistica and Statgraphics.

3. Results

Individual regions of the Slovak Republic are evaluated as separate analyzes using the TOPSIS technique and criteria mentioned in the previous chapter. This part examines the connection of the achieved result with the size of the statistical unit and individual criteria, the influence of the weights of these monitored indicators and also the geographical classification (into the district or region) on the results.

In the following part, we also deal with the comparison and identification of changes resulting from the change of the compared set (comparison of municipalities in the region versus comparison in the Slovak Republic).

Table 2 captures the correlation between the results in the case of the same and modified weights and individual monitored criteria. The change in weights had no effect on the majority group of pairs (BSK, TSK, TTSK, SR without changes). However, in the case of their occurrence, it was mainly a question of strengthening the correlation. The only correlation confirmed at the level of significance $\alpha = 0.01$ in all regions and the entire republic is the correlation between the result of the TOPSIS technique and criteria R4 and R5, which include the result of management. The difference can be observed especially when comparing the Slovak Republic with individual regions. The intensity in Slovakia confirmed the regional correlations (e.g. R2), or it reduced them. The correlation matrix confirms a statistically significant correlation between the result of the TOPSIS technique and, above all, criteria R2, R4, R5 and R7.

Table 2. Correlation matrix of TOPSIS technique results x criterion

		R1	R2	R3	R4	R5	R6	R7	R8
BSK	E	+M**	-T	+S**	+V**	+V**	+M*	-T	-M**
	M	+M**	-T	+S**	+V**	+V**	+M*	-T	-M**
BBSK	E	-M**	-S**	-T*	+V**	+V**	-M**	-S**	-T**
	M	-M**	-S**	-M**	+V**	+V**	-M**	-S**	-M**
KSK	E	+M**	-M**	+M**	+V**	+V**	+T**	-M**	+M**
	M	+T**	-M**	+M**	+V**	+V**	+T*	-M**	+M**
NSK	E	-M**	-V**	-M**	+S**	+S**	-M**	-V**	-M**
	M	-S**	-V**	-M**	+S**	+S**	-M**	-V**	-M**
PSK	E	-M**	-S**	-T**	+S**	+V**	-M**	-S**	-T**
	M	-M**	-S**	-M**	+S**	+S**	-M**	-S**	-M**
TTSK	E	-S**	-V**	-M**	+S**	+S**	-M**	-V**	-M**
	M	-S**	-V**	-M**	+S**	+S**	-M**	-V**	-M**
ZSK	E	-T	-S**	-T	+V**	+V**	-T	-S**	-T
	M	-T**	-S**	-T	+V**	+V**	-T**	-S**	-T*
SR	E	-T**	-S**	-T*	+V**	+V**	-M**	-M**	-M**
	M	-M**	-S**	-M**	+V**	+V**	-M**	-M**	-M**

Note: BSK - Bratislava self-governing region; BBSK - Banská Bystrica self-governing region; NSK - Nitra self-governing region; KSK - Košice self-governing region; PSK - Prešov self-governing region; TSK - Trenčín self-governing region; TTSK - Trnava self-governing region; ZSK - Žilina self-governing region; SR - Slovak republic
Note: E - equal weights defined based on the MW methods; M - modified weights defined based on the expert group.
Note: $|T| \in < 0;0.1)$. $|M| \in <0.1;0.3)$. $|S| \in <0.3;0.5)$. $|V| \in <0.5;1>$
$*\ \alpha = 0.05\ ** \alpha = 0.01$

All five assumptions of the regression analysis were fulfilled in the Banská Bystrica self-governing region, the Prešov self-governing region and the Slovak Republic, within which the match of the regression coefficients was also confirmed.

Table 3. Comparison of regression functions

NUTS 3	same weight (MW methods)	modified weights (experts)
BBSK	$V_E = 0.0839367*ln(PO)$	$V_M = 0.0852169*ln(PO)$.
PSK	$V_E = 0.082366*ln(PO)$	$V_M = 0.08281456*ln(PO)$
SR	$V_E = 0.0881731*ln(PO)$	$V_M = 0.0871478*ln(PO)$

Note: BBSK - Banská Bystrica self-governing region; PSK - Prešov self-governing region; SR - Slovak republic.

Based on the partial results processed in the BSK, BBSK, PSK and SR, we confirm the proven dependence of the results on the size of the statistical unit. In the other regions, the first assumption of normality of the residuals was not fulfilled.

Levene's test confirmed the homoscedasticity of the results in all districts of the Slovak Republic. The Mann-Whitney test in 36.11% of the districts also identified the influence of the change in weights on the result (Figure 1). The changes were manifested primarily in BSK, TSK and PSK.

From the point of view of the difference between districts, the differences were confirmed in 6 out of 8 regions of the SR. Dunn's test (Figure 2) subsequently identified districts in these regions that differed from the others.

Within PSK, NSK and TTSK, the test identified pairs of districts that were statistically significantly different from each other. In the Trenčín self-governing region, the reason for the rejection of the null hypothesis of the Kruskall-Wallis test and the subsequently identified
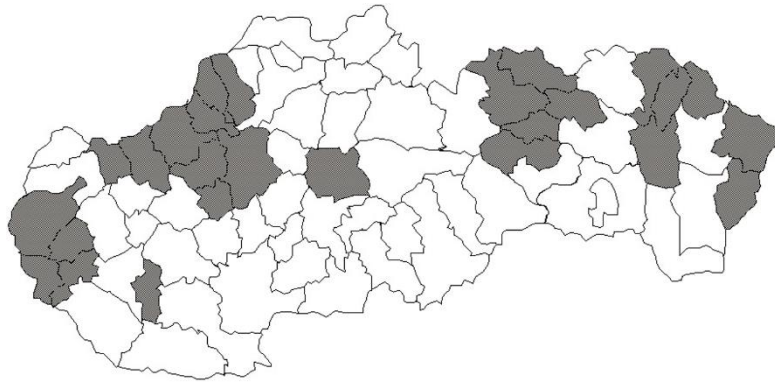
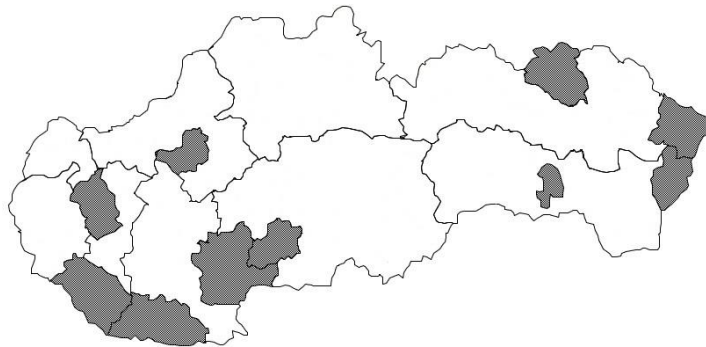Figure 1. Impact of the change in weights in the districts

Figure 2. Districts identified by Dunn's test

Dunn's test was the district of Bánovce nad Bebravou. In the Banská Bystrica self-governing region it was the Krupina district, in the Košice self-governing region the districts of Košice and Sobrance. The Bratislava self-governing region and the Žilina self-governing region were evaluated as homogeneous at the district level in terms of the achieved results.

Based on the Kruskall-Wallis and Dunn tests, we consider the structure of the regions in the SR to be heterogeneous (differences were identified between all regions, with the exception of the pair BSK - TSK).

Significant differences in the change of the research sample can be observed above all when comparing the range of variation and the results of the TOPSIS application. Figure 3 shows the best average rating of municipalities in BSK (in separate assessment in the regions, i.e., left part of figure 3). Outliers occurred primarily in the Košice self-governing region. By combining and evaluating municipalities in one file (SR - right part of figure 3), however, these differences are eliminated, when the median and average between regions are equalized.

A similar trend can be observed in the case of modified weights. The change of the monitored unit caused overlapping of municipalities and equalization of evaluations. Compared to the results with the same weights, we can observe only minimal differences.

The last part of the comparison is the identification of the change in order caused by the merger of the municipalities into a single unit (Figure 3 and Figure 4). Table 4, respectively Table 5, captures the ranking of the municipalities in the Slovak Republic that ranked first in their region. It is clear from both tables that the municipalities from the Prešov self-governing
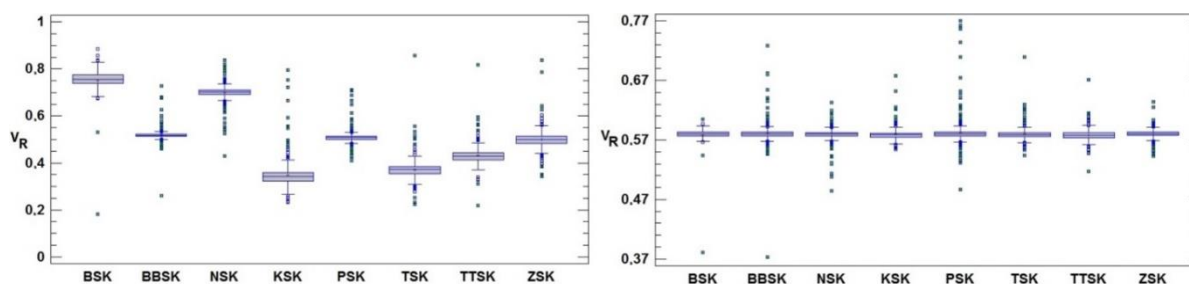
Figure 3. Comparison of the variation range of regions (equal weights based on the MW method);
Note 1: BSK - Bratislava self-governing region; BBSK - Banská Bystrica self-governing region; NSK - Nitra self-governing region; KSK - Košice self-governing region; PSK - Prešov self-governing region; TSK - Trenčín self-governing region; TTSK - Trnava self-governing region; ZSK - Žilina self-governing region;
Note 2: left side - separate evaluation in the regions; right side - joint evaluation in the Slovak republic.
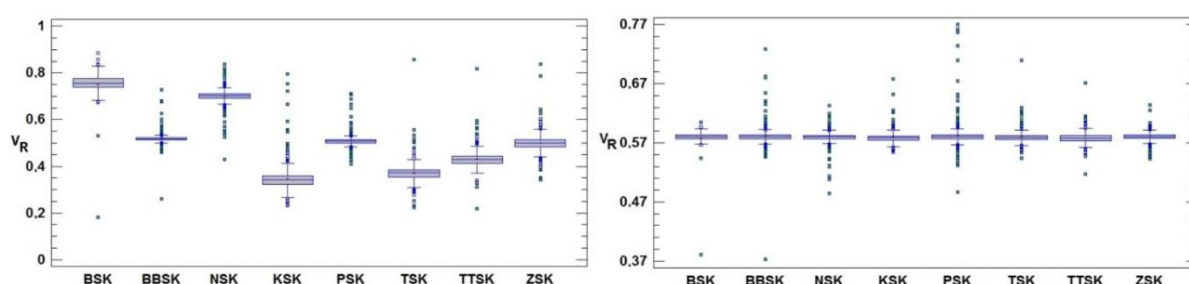

Figure 4. Comparison of the variation range of regions (modified weights based on the expert group);
Note 1: BSK - Bratislava self-governing region; BBSK - Banská Bystrica self-governing region; NSK - Nitra self-governing region; KSK - Košice self-governing region; PSK - Prešov self-governing region; TSK - Trenčín self-governing region; TTSK - Trnava self-governing region; ZSK - Žilina self-governing region;
Note 2: left side - separate evaluation in the regions; right side - joint evaluation in the Slovak republic.

region were rated the best in the whole of Slovakia. On the contrary, the largest negative impact was the merger of municipalities in the Bratislava self-governing region, whose municipalities from the top ten fell significantly.

Table 4. Comparison of achieved rank (equal weights based on the MW methods)

| | | ranking in the Slovak Republic | | | | | | | |
		BSK	BBSK	KSK	NSK	PSK	TSK	TTSK	ZSK
ranking in the region	1	69	5	22	10	1	6	12	21
	2	116	9	38	14	2	23	42	28
	3	200	8	37	29	3	25	47	26
	4	151	13	40	36	4	33	55	78
	5	144	18	43	32	7	41	57	101
	6	172	20	45	35	11	39	79	107
	7	367	19	48	52	15	56	85	110
	8	192	31	64	63	16	59	88	109
	9	585	44	70	53	17	84	114	162
	10	318	49	90	60	24	115	199	211
average		1,392.76	1,377.83	1,436.97	1,654.55	1,348.79	1,535.52	1,703.49	1,375.33

Note: BSK - Bratislava self-governing region; BBSK - Banská Bystrica self-governing region; NSK - Nitra self-governing region; KSK - Košice self-governing region; PSK - Prešov self-governing region; TSK - Trenčín self-governing region; TTSK - Trnava self-governing region; ZSK - Žilina self-governing region.

Table 5. Comparison of achieved rank (modified weights based on the expert group)

		ranking in the Slovak Republic							
		BSK	BBSK	KSK	NSK	PSK	TSK	TTSK	ZSK
ranking in the region	1	63	5	27	11	1	7	8	20
	2	122	10	38	14	2	31	25	33
	3	117	9	42	21	3	24	39	32
	4	189	16	43	29	4	26	45	70
	5	154	15	47	30	6	36	54	99
	6	280	18	48	40	12	80	66	111
	7	146	19	49	46	13	59	81	89
	8	171	34	68	57	17	64	77	110
	9	643	41	78	73	23	61	105	141
	10	307	53	83	65	28	84	101	172
average		1,392.76	1,387.81	1,380.68	1,427.97	1,648.69	1,367.01	1,523.5	1,693.45

Note: BSK - Bratislava self-governing region; BBSK - Banská Bystrica self-governing region; NSK - Nitra self-governing region; KSK - Košice self-governing region; PSK - Prešov self-governing region; TSK - Trenčín self-governing region; TTSK - Trnava self-governing region; ZSK - Žilina self-governing region.

Despite the success of individual PSK municipalities, the average ranking of municipalities from this region is not that significant. A minimum difference of 5 places can be observed especially after modifying the weights of the monitored criteria.

In 6 out of 8 regions, by modifying the weights of the criteria, their average ranking within the Slovak Republic improved. Its increase occurred only in the Banská Bystrica self-governing region and the Prešov self-governing region.

4. Discussion and Conclusions

Currently, under the conditions of the Slovak Republic, municipalities are evaluated by law only on the basis of a single criterion, which is indebtedness. The presented article offers a summary of own research in the form of an alternative assessment of municipalities using the TOPSIS technique in combination with selected mathematical and statistical methods. Also on the basis of the above TOPSIS, we consider the technique to be a suitable tool for multi-criteria evaluation, for the application of which, however, it is necessary to have suitable criteria (which may limit its use in some cases). Its use is also conditional on their appropriate selection and, above all, determining their importance, which significantly determine the overall results.

At the same time, we consider the conducted research as a starting point that can serve for further qualitative research or as a basis for the management of municipalities. A suitable extension is the analysis of a longer period of time, allowing to follow the development and trend of the obtained results or the application of other methods of multicriteria analysis. We also consider repeating the same research after 10-year period and comparing the results achieved.

Conflict of interest: none

References

Bečica, J., Vavrek, R., Galecka, M., & Smolny, K. (2021). Application of Multi-Criteria Analysis on Theatres' Efficiency – Czech and Polish Comparative Case Studies. *HKJU-CCPA*, *21*(3), 423-455. https://doi.org/10.31297/hkju.21.3.5

Behzadian, M., Khanmohammadi Otaghsara, S., Yazdani, M., & Ignatius, J. (2012). A state-of the-art survey of TOPSIS applications. *Expert Systems with Applications*, *39*(17), 13051-13069. https://doi.org/10.1016/j.eswa.2012.05.056

Chang, C. H., Lin, J. J., Lin, J. H., & Chiang, M. C. (2010). Domestic open-end equity mutual fund performance evaluation using extended TOPSIS method with different distance approaches. *Expert Systems with Applications*, *37*(6), 4642-4649. https://doi.org/10.1016/j.eswa.2009.12.044

Djordjević, B., & Krmac, E. (2019). Evaluation of energy-environment efficiency of European transport sectors: Non-radial DEA and TOPSIS approach. *Energies*, *12*(15), 2907. https://doi.org/10.3390/en12152907

Fotr, J., Dědina, J., & Hrůzová, H. (2000). *Manažerské rozhodování*. (2nd ed.). Ekopress.

Ilbahar, E., Cebi, S., & Kahraman, C. (2019). A state-of-the-art review on multi-attribute renewable energy decision making. *Energy Strategy Reviews*, *25*, 18-33. https://doi.org/10.1016/j.esr.2019.04.014

Luan, B., Yin, R., Xu, P., Wang, X., Yang, X., Zhang, L. & Tang, X. (2019). Evaluating Green Stormwater Infrastructure strategies efficiencies in a rapidly urbanizing catchment using SWMM-based TOPSIS. *Journal of Cleaner Production*, *223*, 680-691. https://doi.org/10.1016/j.jclepro.2019.03.028

Ma, L., Long, H., Chen, K., Tu, S., Zhang, Y., & Liao, L. (2019). Green growth efficiency of Chinese cities and its spatio-temporal pattern. *Resources, Conservation and Recycling*, *146*, 441-451. https://doi.org/10.1016/j.resconrec.2019.03.049

Rozentale, L., & Blumberga, D. (2019). Methods to Evaluate Electricity Policy from Climate Perspective. *Environmental and Climate Technologies*, *23*(2), 131-147. https://doi.org/10.2478/rtuect-2019-0060

Siksnelyte, I., Zavadskas, E. K., Bausys, R., & Streimikiene, D. (2019). Implementation of EU energy policy priorities in the Baltic Sea Region countries: Sustainability assessment based on neutrosophic MULTIMOORA method. *Energy Policy*, *125*, 90-102. https://doi.org/10.1016/j.enpol.2018.10.013

Suharevska, K., & Blumberga, D. (2019). Progress in Renewable Energy Technologies: Innovation Potential in Latvia. *Environmental and Climate Technologies*, *23*(2), 47-63. https://doi.org/10.2478/rtuect-2019-0054

Tramarico, C. L., Mizuno, D., Salomon, V. A. P., & Marins, F. A. S. (2015). Analytic hierarchy process and supply chain management: A bibliometric study. *Procedia Computer Science*, *55*, 441-450. https://doi.org/10.1016/j.procs.2015.07.005

Vavrek, R., & Bečica, J. (2022). Similarity of TOPSIS results based on criterion variability: Case study on public economic. *PLOS One*, *17*(8), e0271951. https://doi.org/10.1371/journal.pone.0271951

Wu, Y., Xu, C., Zhang, B., Tao, Y., Li, X., Chu, H., & Liu, F. (2019). Sustainability performance assessment of wind power coupling hydrogen storage projects using a hybrid evaluation technique based on interval type-2 fuzzy set. *Energy*, *179*, 1176-1190. https://doi.org/10.1016/j.energy.2019.04.195

Zavadskas, E. K., Mardani, A., Turskis, Z., Jusoh, A., & Nor, K. M. (2016). Development of TOPSIS Method to solve Complicated Decision-Making Problems – An Overview on Developments from 2000 to 2015. *International Journal of Information Technology and Decision Making, 15*(3), 645-682. https://doi.org/10.1142/S0219622016300019