Comparison of Multiple Criteria Decision Making Approaches: Evaluating eGovernment Development

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Abstract

This paper focuses on the comparison of selected multiple criteria decision making (MCDM) methods for the evaluation of eGovernment development. Multiple criteria evaluation of alternatives is regarded as the basis of MCDM problems. The methods are defined as a set of techniques which aim to rank options, from the most preferred to the least preferred, with a view to supporting decision makers in their selection of the most appropriate alternative under uncertain circumstances. The application of the methods in practice therefore has great potential. As interest in the application of selected MCDM methods has grown, it has also come to encompass the issue of eGovernment development in terms of its ability to modernize public administration. The research in this article is based on the results of the following MCDM methods: WSA; TOPSIS; and MAPPAC. These methods are compared in terms of their applicability and reliability for the purpose of evaluating eGovernment development.

Keywords: comparison, eGovernment, MAPPAC, MCDM methods, TOPSIS, WSA

Introduction

Multiple criteria decision making (MCDM) approaches are important as potential tools for analysing complex problems because of their inherent ability to examine various alternatives according to various criteria for the possible selection of the best preferred alternative (Dincer 2011). The application of MCDM methods has great potential, in particular where it is necessary to select an appropriate option from various alternatives. MCDM problems are common in everyday life, they affect the decision making both in the private and public sectors alike (choosing an appropriate option, supporting business decision making, determining strategy or policy). Získal (2002) states that businesses, like state authorities, make similar objective decisions with certain goals in mind. In such cases, the goals are defined, which makes it possible to

utilize MCDM methods to determine the best alternative for future realization. However, in real life, within the business and public decision making context, MCDM problems are more complicated and usually on a large scale (Xu and Yang 2011).

This paper looks at the application of MCDM methods for evaluating eGovernment development. The goal of the presented research is to compare the results of selected MCDM methods, namely the TOPSIS method (Technique for Order Preference by Similarity to Ideal Solution), WSA method (Weighted Sum Approach) and MAPPAC method (Multi-criteria Analysis of Preferences by means of Pair Actions and Criteria comparisons), with the purpose of generating an overall ranking of the examined alternatives on the basis of a synthesis of the different MCDM approaches. The MCDM methods were applied to the area of eGovernment development to demonstrate their potential use and to evaluate the current state of eGovernment in EU countries.

Mohammed and Ibrahim (2013) and Kettani and Moulin (2015) state that in practice, the evaluation of the state of eGovernment is an important factor in the selection of appropriate measures for further progress in the field of eGovernment and for putting forward recommendations for the development of eGovernment in a country. In this research, the state of eGovernment was evaluated on the basis of selected eGovernment indicators as monitored by various international institutions (European Commission, Eurostat and the United Nations). The data published by these international institutions in 2014 makes it possible to conduct a complex evaluation of the state of eGovernment in 2013. More up-to-date information was also available from the European Commission in the form of its "eGovernment Benchmark" studies for 2014 and 2015 (European Commission 2014 and 2015), which were published as part of its European Information Policy. However, other selected eGovernment indicators for 2014 or 2015, as monitored by Eurostat and the UN, have not been published yet, or there is a break in the series. The input data for the conducted research therefore included the results of the "eGovernment Benchmark" study from 2014 (EUROPA 2014), which contained data for 2013, data processed by Eurostat for 2013 (EUROSTAT 2016) and data obtained by the UN in 2013 and published in 2014 (UNPACS 2016). The empirical research involved the application of the TOPSIS, WSA and MAPPAC methods to the results of the selected criteria for the 28 countries of the EU in order to evaluate the state of eGovernment. These methods were used because they represent a suitable tool for the creation of a ranking where a large number of alternatives exist. The empirical part of this paper was processed using SANNA (System for ANalysis of Alternatives) software (see also Jablonský 2009).

MCDM Methods and Potential Applications

MCDM as a discipline has a relatively short history. The development of the MCDM discipline is closely related to the advancement of computer technology. The widespread use of computers and information technologies is generating huge quantities of information, which makes MCDM increasingly important and useful (Xu and Yang 2001).

According to Triantaphyllou (2000) and Zavadskas, Turskis and Kildiene (2014), MCDM is described as a set of methods which enables the evaluation of various alternatives under different decision making criteria. The aim of MCDM is, on the basis of a stated set of alternatives (options) and number of decision making criteria, to provide an overall ranking of alternatives, from the most preferred to the least preferred (Liou and Tzeng 2012).

According to Jablonský and Urban (1998), the multiple criteria evaluation of alternatives is the basis for MCDM problems. As described by Dincer (2011), MCDM methods are both an approach and a set of techniques. MCDM methods provide a systematic procedure to help decision makers choose the most desirable and satisfactory alternative under a given set of circumstances (Yoon and Hwang 1995). Hwang and Yoon (1981), reviewed many methods for the multiple criteria evaluation of alternatives. In general, a MCDM problem is described using a decision matrix. On the assumption that there are *m* alternatives to be assessed based on *n* attributes, a decision matrix ($m \times n$) can be created, whereby each element Y_{ij} is the *j-th* attribute value of the *i-th* alternative.

There are two types of MCDM methods. The first is compensatory, and the second, non-compensatory (Hwang and Yoon 1981). As described by Xu and Yang (2001), non-compensatory methods do not permit trade-offs between attributes. An unfavourable value for one attribute cannot be offset by a favourable value for other attributes. Examples of these methods include the Dominance method, Maxmin method, Maxmax method, Conjunctive constraint method, and the Disjunctive constraint method. In contrast, Yang (2001) states that compensatory methods permit trade-offs between attributes. A slight decline in one attribute is acceptable if it is compensated by an improvement in one or more other attributes. Compensatory methods can be classified into the following 4 subgroups (Hwang and Yoon 1981):

- Scoring Methods (e.g. Simple Additive Weighting method, AHP);
- Compromising Methods (e.g. TOPSIS);
- Concordance Methods (e.g. Linear Assignment Method);
- Evidential Reasoning Approach.

As stated by Jablonský and Urban (1998) and Xu and Yang (2001), the application of the multiple criteria evaluation of alternatives has great potential in practice. The methods are already commonly used for making evaluations in different sectors. For example, Dincer (2011) analysed the economic activity in 2008 of the EU countries and candidate countries. For the purpose of generating alternative rankings, the TOPSIS and WSA methods were applied. Kuncová (2012), in addition to the using the aforementioned methods, also applied the PRIAM method to compare e-commerce in EU countries. Like Dincer (2011), Ardielli (2015) used the TOPSIS and WSA methods to evaluate the state of eGovernment in the Czech Republic. In a similar vein, Ardielli and Halásková (2015) assessed EU countries using the TOPSIS method.

Evaluating eGovernment Development

EGovernment is one of the most important trends in the modernization of public administration across EU countries (Demmke, Hammerschmid and Mayer 2006). The evaluation of the state of eGovernment is a necessity in terms of its impact on the effective implementation of future actions and measures in the field of eGovernment across EU countries. This point is well documented in research into eGovernment conducted by numerous authors. Mohammed and Ibrahim (2013), analysed the existing indexes of eGovernment to demonstrate their common components and attributes with a view to composing a comprehensive framework for the evaluation of eGovernment. Máchová and Lněnička (2015), compare the structure of selected frameworks, identify core criteria and put forward their own framework for the evaluation of eGovernment, one which respects current trends in public administration.

However, eGovernment is not only about important current trends in the modernization of public administration, but also about making international comparisons, as discussed by West (2004) and Bannister (2007). Many organizations monitor eGovernment as part of their activities, but the approaches utilised differ considerably across organizations. One of these organizations is Eurostat. Eurostat processes and evaluates data from the area of eGovernment. Up to and including 2013, the assessment was based on measuring the interaction of citizens and businesses with public administration. The evaluation framework has since changed and now includes policy indicators which assess eGovernment activities on the basis of an individual´s use of websites or user satisfaction of eGovernment websites. The European Commission's approach to the evaluation of eGovernment is based on an evaluation of the effectiveness of its European Information Policy (European Commission 2014 and 2015). At the international level, the UN has developed benchmarks for the evaluation of eGovernment. It has developed a Composite Index of eGovernment and an Index of eParticipation with which to evaluate eGovernment (UNPACS 2016). Unfortunately, the eGovernment data generated by these organizations are not consistent with each other. They monitor different time periods, use different methodologies for collecting, collating and processing data, as well as focus on those sub-areas of eGovernment which correspond to the specific needs and purposes of their own organization.

Materials and Methods

In this paper all EU countries (EU-28) were analysed on the basis of selected eGovernment indicators using the TOPSIS, WSA and MAPPAC methods. The TOPSIS method is based on the selection of the alternative that is closest to the ideal solution and furthest from the baseline solution (see Shih, Shyur and Lee 2007). It arranges the alternatives according to the relative distance from the baseline (hypothetically worst) alternative (Chen and Hwang 1992). The result of this method is an overall ranking of the alternatives. The WSA method is based on the principle of utility maximization. It ranks the alternatives according to their total utility, which takes into account all the selected criteria (Fiala 2008). The MAPPAC method is based on paired comparisons of

the alternatives, whereby each pair of individual criteria results in a decision on which of the two objects is the more important, or whether they are indistinguishable in terms of the selected criteria (Matarazzo 1991). A comparison of the selected methods was carried out on the basis of eGovernment data for 2013 for all 28 EU member states. The final list of alternatives (EU-28 countries) and criteria (9 eGovernment indicators) for the research were sourced from indexes monitored by three international organizations, namely:

- indexes monitored by European Commission: User Centric Government (UCC), Transparent Government (TG), Citizen Mobility (CM), Business Mobility (BM) and Key Enablers (KE);
- indexes monitored by the UN: Online Service Index (OSI), eParticipation Index (EI); and
- indexes monitored by Eurostat: Individuals Using Internet (IUI) and Enterprises Using Internet (EUI).

The research was based on a dataset generated from multiple data sources (see European Commission (2014), UNPACS (2016) and Eurostat (2016)). Due to the fact that the eGovernmet Index, monitored by the United Nations, was not up-to-date, the comparison was made on the basis of a dataset for 2013. All criteria carried equal weight. The TOPSIS, MAPPAC and WSA were used to provide a comprehensive ranking of the alternatives, from the best to the worst. TOPSIS applies the simple concept of maximizing the distance from the nadir solution and minimizing the distance from the ideal solution (Özcan and Çelebi 2011). Under the TOPSIS method, the decision matrix of a MCDM problem is normalised. Calculations are subsequently made of the weighted distances of each alternative from the ideal solution and the nadir solution. The best solution is judged to be that which is relatively close to the ideal solution and far from the nadir solution (Hwang and Yoon 1981). The ideal solution represents that which provides the maximum benefit as determined on the basis of a composite of the best performance values in the matrix. The nadir solution represents that which provides the least benefit, which is a composite of the worst values in the matrix. The proximity of the alternatives to the ideal solution d_i^+ and the nadir solution d_i^- can be obtained using the square root of the squared distances in the imaginary attribute space given in equation (1) (see Thor, Ding and Kamaruddin 2013):

$$d_i^+ = \sqrt{\sum_{j=1}^{r}(w_{ij} - H_j)^2} \qquad (1)$$

where for all $i = 1, 2, \ldots m$; and $j = 1,2, \ldots r$.

Similarly, the separation from the nadir solution d_i^- is given in equation (2):

$$d_i^- = \sqrt{\sum_{j=1}^{r}(w_{ij} - D_j)^2} \qquad (2)$$

where for all $i = 1, 2, \ldots m$; and $j = 1,2, \ldots r$.

The most preferable alternative is the one which is closest to the ideal solution and the farthest from the nadir solution.

Application of the TOPSIS method involves the following steps:

- design of the criteria matrix;
- transformation of the minimum criteria to maximizing type;
- transformation of the matrix;
- determination of the ideal and basal alternatives (formula 1 and 2); and
- calculation of the relative distance from the ideal alternatives and basal alternatives using formula (3):

$$c_i = \frac{d_i^-}{d_i^+ + d_i^-} \tag{3}$$

where $i = 1,2 \ldots m$.

The alternatives are subsequently sorted in descending order of the c_i values. Those alternatives with the highest values for an indicator are considered to be viable solutions to the problem.

The WSA method is based on a linear utility function. The method generates a complete ranking of the alternatives according to their total utility. This method is based on the construction of a linear utility function on a scale of <0 – 1>. The worst alternative is given a utility value of 0 and the best alternative utility value of 1. The application of the WSA methods involves the following steps:

- design of the criteria matrix;
- transformation of minimum criteria to maximizing type;
- determination of the perfect (the best) and basal (worst) alternatives;
- calculation of the utility value of each alternative;
- calculation of the total utility value of each alternative according to the following formula (4):

$$u(a_i) = \sum_{j=1}^{k} v_j r_{ij} \tag{4}$$

where $u(a_i)$ is the total utility value of the alternative, a_i, r_{ij} are the normalized values from the previous step, v_j is the weight of *j-th* criteria, and k is the number of criteria.

The MAPPAC method encompasses both the criterion matrix and the weights of the criteria. The method splits the alternatives into several preference groups. The MAPPAC method uses a normalized multiple criteria matrix $C = (c_{ij})$, where the *r-th* row corresponds to alternative a_r and the *s-th* row corresponds to alternative a_s. The paired comparison of the alternatives is processed first. On the basis of the results there are two possible relationships between the alternatives, either preference (alternative *a* was rated better than alternative *b*) or indifference (alternative *a* and alternative *b* were assessed in the same way). This method allows for the presence of fuzzy relations, which

allows it to take into account the uncertainty associated with the measurement, or arising from the different nature of the criteria, for the assessment. In the last step, the preferences are aggregated, resulting in a final ranking. The row totals of the aggregated matrix π are calculated according to equation (5):

$$\sigma^l(a_i) = \sum_{j=1}^{p} \pi(a_i, a_j),\ i \in J^l \qquad (5)$$

The alternatives with the highest σ^l values are ranked the highest. The set of alternatives is reduced and a new set of alternatives A^l is created. The set of indexes of alternatives from A^l are subsequently marked as J^l. The procedure is repeated for m steps, where m is the number of indifference classes in the arrangement above.

A similar procedure is followed to generate the values of τ^1, τ^2,..., τ^n, where n is the number of indifference classes in the arrangement below, using equation (6):

$$\tau^t(a_i) = \sum_{j \in J^t} \pi(a_j, a_i),\ i \in J^t,\ t = 1, 2, \dots n. \qquad (6)$$

The overall ranking of the alternatives is achieved by averaging the serial numbers of the alternatives in the arrangements (equations 5 and 6). The best alternative is that which has the lowest overall serial number.

The WSA, TOPSIS and MAPPAC were selected because they have the same input requirements and the decision maker cannot intervene in the course of the calculations. This enables an objective comparison to be made of the resulting ranking of alternatives.

Results

The empirical results of the TOPSIS, MAPPAC and WSA methods are presented below. The input data characterize the extent of on-line services (UCG), government transparency (TG), availability and usage of online services abroad by citizens and businessmen (CM and BM), availability of key enablers (KE), quality of services on governmental websites (OSI), eParticipation (EPI) and the individuals and businessmen which use the internet in relation to public administration (EUI and IUI). The results indicate the level of eGovernment in the 28 member states of the EU in 2013. On the basis of the results, it is possible to determine the ranking of each country, from the best to the worst according to the selected method, in terms of how eGovernment functions. The results are presented in Table 1, 2 and 3.

The R.U.V value describes the relative distance of the alternative from the basal alternative c_i. The assessment of the state of eGovernment in EU countries according to the TOPSIS method put Estonia in first place (c_i = 0.73013), followed by the Nordic countries of Finland and Sweden. The countries at the bottom of the rankings were Croatia, Bulgaria, and the worst Romania (c_i = 0.12061). The percentage difference between the best and the worst country was very significant at 84 %.

Table 1: Results of eGovernment evaluation of EU countries using TOPSIS method (2013)

Rank	Country	R.U.V	Rank	Country	R.U.V
1	Estonia	0.73013	**15**	Belgium	0.48378
2	Finland	0.71536	**16**	Luxembourg	0.45683
3	Sweden	0.65817	**17**	Germany	0.44439
4	Malta	0.65637	**18**	Slovenia	0.43254
5	Denmark	0.63536	**19**	Cyprus	0.39826
6	The Netherlands	0.61149	**20**	Italy	0.39460
7	France	0.59456	**21**	Poland	0.34856
8	Austria	0.59062	**22**	Greece	0.28150
9	Latvia	0.58488	**23**	Slovakia	0.27202
10	Portugal	0.56566	**24**	Czech Republic	0.25731
11	Spain	0.53813	**25**	Hungary	0.24677
12	United Kingdom	0.52095	**26**	Croatia	0.23673
13	Ireland	0.51587	**27**	Bulgaria	0.23231
14	Lithuania	0.49228	**28**	Romania	0.12061

Source: European Commission (2014), UNPACS (2016) and Eurostat (2016), own calculations

The evaluation according to the WSA method (see Table 2) puts Estonia in first place (utility value = 0.76420), very closely followed by Finland (utility value = 0.75017) and Malta a distant third (utility value = 0.72445). The three countries ranked the worst were Bulgaria, Hungary and Romania. It is noteworthy that the utility value for Romania (0.08234) is significantly lower than for Hungary (0.23937), ranked second worst. The utility value is an indication of how bad Romania faired in the surveyed period with respect to eGovernment.

Table 2: Results of eGovernment evaluation of EU countries using WSA method (2013)

Rank	Country	Utility	Rank	Country	Utility
1	Estonia	0.76420	**15**	Belgium	0.51378
2	Finland	0.75017	**16**	Luxembourg	0.48088
3	Malta	0.72445	**17**	Germany	0.46898
4	The Netherlands	0.69854	**18**	Italy	0.45661
5	Sweden	0.67785	**19**	Slovenia	0.44506
6	France	0.66747	**20**	Poland	0.39806
7	Denmark	0.66503	**21**	Cyprus	0.39759
8	Portugal	0.64115	**22**	Czech Republic	0.29504
9	Austria	0.63607	**23**	Slovakia	0.29252
10	Latvia	0.61455	**24**	Croatia	0.27933
11	Spain	0.60944	**25**	Greece	0.27515
12	United Kingdom	0.60877	**26**	Bulgaria	0.24091
13	Ireland	0.59662	**27**	Hungary	0.23937
14	Lithuania	0.57342	**28**	Romania	0.08234

Source: European Commission (2014), UNPACS (2016) and Eurostat (2016), own calculations

The output of the MAPPAC method provides a list of rankings according to preferential classes. In Table 3, it is possible to see the alternatives in the ranking according to the average serial numbers from the top and bottom. It is evident from the results that the first two alternatives (Estonia, Finland) are also single element indifference classes. Their rank is therefore clearly given. They were simultaneously ranked in the same position from the top and from the bottom. The average serial numbers for France and Sweden were the same, so they are ranked the same. They belong to one class of indifference. For third place, there was a sorting match. From the top, the Netherlands was ranked third, whereas from the bottom Malta was ranked third. The worst three countries with regards to eGovernment were, once again, Hungary, Bulgaria and Romania (all were ranked in the same position from the top and from the bottom).

Table 3: Results of eGovernment evaluation of EU countries using MAPPAC method (2013)

Class	Country	Rank from top	Rank from bottom	Class	Country	Rank from top	Rank from bottom
1	Estonia	1	1	**12**	Belgium	15	15
2	Finland	2	2	**13**	Luxembourg	16	16
3	The Netherlands	3	4	**14**	Slovenia	18	17
4	France	5	5	**15**	Germany	17	19
	Sweden	4	6	**16**	Italy	19	18
5	Malta	10	3	**17**	Cyprus	20	20
6	Denmark	6	8	**18**	Poland	21	21
7	Portugal	8	7	**19**	Czech Republic	22	23
8	Austria	7	9	**20**	Greece	24	22
9	Latvia	9	13	**21**	Croatia	23	25
	United Kingdom	11	11	**22**	Slovakia	25	24
10	Spain	14	10	**23**	Hungary	26	26
	Ireland	12	12	**24**	Bulgaria	27	27
11	Lithuania	13	14	**25**	Romania	28	28

Source: European Commission (2014), UNPACS (2016) and Eurostat (2016), own calculations

To obtain an overall ranking for the EU countries based on the consolidated results of the three selected MCDM methods, it was necessary to determine the final overall arrangement of the alternatives. To achieve this, the results obtained using the MAPPAC methods required minor adjustments with regards to the evaluation order. Those alternatives in the same indifference class were therefore rated on the basis of their average serial number. The next step was to calculate the average ranking of the alternatives, which is equal to the arithmetical average of the individual rankings according to the individual MCDM methods. The results are presented in Table 4.

The synthesis of the results from the selected MCDM methods acknowledge that the highest ranking countries in the EU with respect to eGovernment are Estonia, Finland

and Sweden. This result fully corresponds with the final rankings under the TOPSIS method. In joint fourth position were Malta and the Netherlands. Malta ranked fourth and third under the TOPSIS and WSA methods respectively, whilst the Netherlands ranked fourth and third under the WSA and MAPPAC methods respectively. The countries ranked the worst with regards to the state of eGovernment were Hungary, Bulgaria and Romania (the same result as under the MAPPAC and WSA methods) and Croatia (under the TOPSIS method).

Table 4: Final ranking of EU countries according to the selected MCDM methods (2013)

Rank	Country	TOPSIS	WSA	MAPPAC	Rank	Country	TOPSIS	WSA	MAPPAC
1	Estonia	1	1	1	**15**	Belgium	15	15	15
2	Finland	2	2	2	**16**	Luxembourg	16	16	16
3	Sweden	3	5	4	**17**	Germany	17	17	18
4,5	Malta	4	3	6,5	**18**	Slovenia	18	19	17,5
4,5	The Netherlands	6	4	3,5	**19**	Italy	20	18	18,5
6	France	7	6	4	**20**	Cyprus	19	21	20
7	Denmark	5	7	7	**21**	Poland	21	20	21
8	Portugal	10	8	7,5	**22**	Czech Republic	24	22	22,5
9	Austria	8	9	9	**23**	Greece	22	25	23
10	Latvia	9	10	10	**24**	Slovakia	23	23	24,5
11	Spain	11	11	12	**25**	Croatia	26	24	24
11	United Kingdom	12	12	10	**26**	Hungary	25	27	26
13	Ireland	13	13	12	**27**	Bulgaria	27	26	27
14	Lithuania	14	14	13,5	**28**	Romania	28	28	28

Source: European Commission (2014), UNPACS (2016) and Eurostat (2016), own calculations

The Czech Republic, within the context of the evaluation of eGovernment, achieved the highly unsatisfactory position of 22nd in the overall ranking. Under the MAPPAC method, the result was only slightly better (19th position). However, under the TOPSIS method the result was even worse (24th position). In the country there are clearly very serious shortcomings in the implementation of digital public services. A policy that promotes the use of electronic services in public administration is therefore required because eGovernment is a useful tool for cost reductions in public administration. Moreover, eGovernment and eServices are of huge benefit to residents in the form of time savings. This area therefore remains a major future challenge for the Czech Republic.

Discussion

It is evident that despite all the differences the three selected MCDM methods gave the EU countries relatively similar rankings. The best placed countries according to the evaluations of all three selected methods were Estonia and Finland. In a similar vein, all

three methods ranked Romania last. The proposed computing algorithm for each of the selected methods varies according to the operating concept. The WSA method is based on the principle of the weighted average. The TOPSIS method presents the idea of distance-based decision making. The MAPPAC method belongs to a group of methods that make assessments based on a preferential matrix (Thor, Ding and Kamaruddin 2013). Each of these methods require cardinal information about criteria and enable the arrangement of alternatives. Under the WSA method, the criteria are sorted according to the decreasing value of the utility function, whereas under the TOPSIS method they are sorted by the distance from the basal alternatives. The TOPSIS method takes into account the range of values of the criterion, and unlike the WSA method, does not favour extreme values. The results are therefore sometimes slightly different. The advantage of the MAPPAC method is that it does not require the matrix to be normalized, which avoids any impact on the results from utilising the technique. Despite the differences in the operating concepts, these MCDM methods have great potential for increasing the effectiveness of the evaluation of eGovernment.

When evaluating the applicability and relevance of the used methods (TOPSIS, MAPPAC and WSA), the TOPSIS method provides the most objective evaluation of eGovernment. The reason for this is that the method is relatively simple and is able to reflect the large scale of eGovernment data with its different units and criteria. (This is not the case with the WSA method, which always exalts extreme values before average values, or with the MAPPAC method, which fails to give unambiguous results.). It is the directness of the TOPSIS algorithm, which creates no complications in the calculations, that enables it to be applied to large-scale datasets. On the basis of the final ranking, it is possible to compare the final score of each alternative and determine the ideal solution, which makes the decision making process more flexible. In contrast, the only output from the MAPPAC method is a ranking of the alternatives. The TOPSIS method is also favoured by other authors for the same reasons stated above (Ekmekcioglu, Kaya and Kahraman 2010; Thor, Ding and Kamaruddin 2013; Kuncová and Doucek 2013).

The synthesis of the applied MCDM methods for the ranking process also produced successful results that closely reflected those obtained under the TOPSIS, MAPPAC and WSA methods separately. The obtained results are consistent with those of other authors (see Schwab 2013; European Commission 2015; UNPACS 2016; Kuncová and Doucek 2013). According to the DESI Index (see Europa 2015), the highest ranking countries in terms of digital public services were Estonia, Denmark and Finland, with the lowest ranked being Romania and Bulgaria. The Czech Republic came in on the 24th position.

On the basis of the comparison of the outputs of the applied MSDM methods, the TOPSIS method is regarded as the most useful tool for assessing a government´s macroeconomic themes. However, it can also be applied at the microeconomic level e.g. for the management of a company (Olson 2004) or as an evaluation tool for procurement (San Cristóbal 2012). Finally, for verification purposes, the results of any MCDM method

should always be checked against those of another MCDM method e.g. AHP, PRIAM, or any other.

Conclusion

In general, there is no single solution for the multiple criteria evaluation of alternatives. Any resultant solution is influenced by the selection of scales and the applied methodology. To verify the results, it is necessary to apply at least one additional MCDM method. The methods for the multiple criteria evaluation of alternatives can be used at many different levels because of their general character and the independence of the decision making content. There are numerous methods for the multiple criteria evaluation of alternatives, each based on different principles. In this research, three selected MCDM methods, namely TOPSIS, WSA and MAPPAC, were applied to eGovernment data. The results of the applied methods contributed to the assessment of eGovernment development in the EU member states.

Any dissimilarities in the comparison of the results from the different methods can be attributed to the fact that each of the methods is based on a different principle: maximizing benefits (WSA); distance from the ideal alternative (TOPSIS); and the use of the preferential function (MAPPAC). The different methods were chosen deliberately. The final ranking therefore reflected the different approaches and ensured objectivity.

The TOPSIS method exhibited the highest potential for the evaluation of eGovernment development; it provides accurate results with minimal effort.

This paper points out that methods for the multiple criteria evaluation of alternatives can be applied to the exploration and evaluation of eGovernment development. A synthesis of the outcomes of the different MCDM methods further clarified the position of the EU member states in terms of eGovernment development.

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