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EVALUATION OF ISOLATED SOCIO-ECONOMICAL PROCESSES BY A MULTI-CRITERIA DECISION AID METHOD ESP

Romualdas Ginevičius[1], Valentinas Podvezko[2], Askoldas Podviezko[3]

Vilnius Gediminas Technical University, Faculty of Business Management,
Saulėtekio ave. 11, LT-10223 Vilnius, Lithuania
Email: [1]romualdas.ginevicius@vgtu.lt; [2]valentinas.podvezko@vgtu.lt; [3]askoldas@gmail.com

Abstract. Problems of evaluation by multicriteria decision aid methods (MCDA) imply creating rankings of several objects or alternatives in accordance with their conformity to the objectives of the research or choosing the best alternative among the ones available. Comparison of technological or investment projects, socio-economic development levels of different regions of a country or countries, and similar problems could serve as examples. Mentioned approach can be used only in such cases, when other alternatives are available for making comparisons, which is not always the case: processes could be unique and comparisons could not therefore be made. In the paper particularities and scope of the ESP (Evaluation of a Single Process) multicriteria evaluation method and algorithms of evaluation are described. Evaluation of a few single objects based on this method is given.

Keywords: MCDA, ESP (evaluation of a single process).

Jel classification: C44, C61, D81, D82, G21, O22

1. Introduction

The task of choosing the best alternative from several possible alternatives of activity is often appearing in practice. Comparison of technological or investment projects, socio-economic development levels of different regions of a country or countries, and similar problems could serve as examples. Multicriteria decision-aid methods are often used for solving mentioned problems, increasingly in the last decades (Figueira *et al*. 2005; Hwang, Yoon 1981; Ginevicius 2011; Ginevicius, Podvezko 2007, 2008, 2009; Zavadskas, Turskis 2011; Zavadskas *et al.* 2006; Ginevicius *et al.* 2010a; Brauers *et al*. 2010; Podvezko 2009; Podvezko, Podviezko 2010a,b; Podvezko *et al.* 2010; Maskeliunaite *et al.* 2009; Brauers, Zavadskas 2011; Antucheviciene *et al*. 2011).

The process is characterised by a set of criteria R_i (i=1, 2, … , m), where m is the number of criteria used. As a basis of quantitative evaluation by using MCDA methods serve the decision matrix $\mathbf{R}=\|r_{ij}\|$ and the vector of importance of criteria $\mathbf{\Omega}=\|\omega_i\|$. The matrix $\mathbf{R}=\|r_{ij}\|$ is filled with either statistical data or experts' quantitative estimations of values of criteria R_i chosen for the alternatives under evaluation A_j (j=1, 2, … , n), where n – is the number of alternatives. The vector of importance of criteria $\mathbf{\Omega}=\|\omega_i\|$ consists of weights ω_i of criteria R_i, which usually are supposed to make the unity in total: $\sum_{i=1}^{m}\omega_i=1$.

Before the MCDA methods are employed, every criterion must be identified either as a maximising or a minimising one. Maximising criteria take the better values the bigger are their values relative to their influence on the result of evaluation. As an example could serve profit of an enterprise. Vice versa, the minimising criteria take the better values the smaller are their values relative to their influence on the result of evaluation. Again, as an example could serve a criterion representing cost-efficiency of an enterprise.

MCDA methods are applied, wherever there are several analogous alternatives, which must be ranked in accordance with their significance in respect with the aim of the research or where the best alternative among the available ones must be identified.

So, in fact the task of evaluation by MCDA methods is to rank the alternatives of a process in respect with priority. The task is carried out by applying multidimensional types of normalisation, in accordance to which normalised values are calculated by dividing value of the *i-th* criterion by the sum of values of this criterion by all alternatives. Therefore, the normalised value of the *i-th* criterion for the *j-th* alternative depends on the whole scope of alternatives. Nevertheless, often a task of computing of a multicriteria value of an isolated alternative could appear. The latter approach allows evaluating the alternative without its relations with other alternatives or objects. This also makes it possible to gauge influence of various factors on the object. The approach brings forth new scientific and practical area of research.

This new approach on multicriteria evaluation was proposed by one of the authors of this paper (Ginevicius 2008). The name of the method ESP (Evaluation of a Single Process) was given. The method was used in evaluation of marketing activity of a firm (Ginevicius A. 2011). In the paper particularities and scope of the ESP multicriteria evaluation method and algorithms of evaluation are described. Evaluation of a few single objects based on this method is given.

2. The case of the uniform scale for all criteria

Cumulative criteria derived by evaluation of alternatives by MCDA methods comprise normalised (dimensionless) values of criteria of responses of alternatives and their weights into a single magnitude, which expresses the result of the evaluation. For example, in the simplest and most common method *SAW* (Simple Additive Weighting) (Hwang, Yoon 1981; Podvezko 2011) the following cumulative criterion is used:

$$S_j = \sum_{i=1}^{m} \omega_i \tilde{r}_{ij} , \qquad (1)$$

where ω_i is weight of the *i-th* criterion, $\tilde{r}_{ij}$ is normalised value of the *i-th* criterion for the *j-th* alternative, $i = 1,...,m$; $j = 1,...,n$; m – the number of criteria, n – the number of alternatives under comparison.

The normalisation of every criterion is carried out by spanning through the whole range of alternatives. As an example could serve the “classic” normalisation, realised by the following formula:

$$\tilde{r}_{ij} = \frac{r_{ij}}{\sum_{j=1}^{n} r_{ij}}, \qquad (2)$$

($\sum_{j=1}^{n} \tilde{r}_{ij} = 1,\ i = 1,2,...,m;\ j = 1,2,...,n$), where r_{ij} is the value of the *i-th* criterion for the *j-th* alternative.

Evaluation of a single unique “isolated” object is only possible if a measurement scale for all criteria is uniform. The choice is wide: percentage scale, parts of unity, ten- or five-point scale, etc.

Consider evaluation of strategic potential of an enterprise (Ginevicius *et al*. 2010b). In the paper 14 criteria for evaluation of strategic potential of four enterprises were used. The criteria can be found in the cited paper. Estimations of weights of the criteria are presented in Table 1. Averages of estimations of values of criteria, elicited from experts are presented in the ten-point scale in Table 2.

Table 1. Weights and priorities (places) of strategic potential possibilities

No. of index	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Weights	0.018	0.280	0.033	0.086	0.066	0.049	0.014	0.156	0.037	0.123	0.078	0.026	0.019	0.014
Places	12	1	9	4	6	7	14	2	8	3	5	10	11	13

Table 2. The mean values obtained in the criteria evaluation performed by 13 experts for four enterprises

Criterion / Enterprise	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 enterprise	7.22	3.84	3.81	3.30	2.41	2.05	7.23	6.52	6.61	7.50	4.20	5.09	8.13	7.86
2 enterprise	6.43	2.38	3.21	4.29	4.40	4.52	7.26	4.76	7.02	7.50	5.12	4.33	6.43	7.02
3 enterprise	5.80	3.52	3.65	4.55	3.07	3.92	7.87	5.92	6.44	7.29	4.49	5.24	7.67	8.04
4 enterprise	6.12	3.77	3.94	4.42	2.94	2.00	7.12	6.76	6.24	7.42	5.25	5.11	6.24	7.12

In the mentioned paper (Ginevicius *et al*. 2010b) values of the cumulative criteria S_j of the *SAW* method for the enterprises under consideration were obtained using formulae (1)-(2). The enterprises were distributed in the ranking order (Table 3).

Now we will attempt to evaluate each enterprise, independently of other enterprises. A parallel comparison of all the four enterprises will only serve the purpose of inspection of different evaluation MCDA methods.

Table 3. Cumulative criteria S_j of the SAW method for the enterprises under consideration

Method		Enterprise			
		1	2	3	4
SAW	Value	0.250	0.234	0.256	0.260
	Rank	3	4	2	1

The following formula (3) will be used for the evaluation of the *j-th* enterprise.

$$\tilde{S}_j = \sum_{i=1}^{m} \omega_i r_{ij} \,, \qquad (3)$$

Note that now we use not normalised values of the decision matrix, presented in Table 2.

The maximum theoretically possible value of the cumulative criterion $\tilde{S}_j$ equals to 10 in the case, when all estimations of values of criteria equal to 10, while the minimum possible value of the criterion equals to 0. The value of the criterion will reveal the real level of strategic potential of the enterprise, comparing to the maximal possible level of 10.

Values of the cumulative criterion $\tilde{S}_j$ obtained in accordance with formulae (3)-(5) based on values of criteria and their weights from Table 2 are presented in Table 4. Observe that rankings of enterprises obtained after the calculations did not alter. Moreover, values of the cumulative criterion $\tilde{S}_j$ after their normalisation in accordance with the following formula (the bottom row in Table 4) are close to the values of S_j found in Table 3.

$$\hat{S}_j = \frac{\tilde{S}_j}{\sum_{j=1}^{4} \tilde{S}_j}$$

In theory, there is no guarantee that values of the cumulative criteria S_j и $\hat{S}_j$ would match. In fact, observing the formulae for these values it becomes clear that they cannot be transformed one into another:

$$S_j = \sum_{i=1}^{m} \omega_i \tilde{r}_{ij} = \sum_{i=1}^{m} \omega_i \frac{r_{ij}}{\sum_{j=1}^{n} r_{ij}} , \qquad (4)$$

$$\hat{S}_j = \frac{\tilde{S}_j}{\sum_{j=1}^{n} \tilde{S}_j} = \frac{\sum_{i=1}^{m} \omega_i r_{ij}}{\sum_{j=1}^{n}\sum_{i=1}^{m} \omega_i r_{ij}} \qquad (5)$$

The matching results of the calculations by two notably different methods confirm the methodology of evaluation proposed in the paper.

Table 4. Cumulative criteria $\tilde{S}_j$ of the *SAW* method for isolated enterprises

Method		Enterprise			
		1	2	3	4
	Rank	3	4	2	1
$\tilde{S}_j$	Value	4.884	4.528	4.910	5.026
$\hat{S}_j$	Value	0.252	0.234	0.254	0.260

Note that in our case experts were free to evaluate strategic potential of a single enterprise without the necessity to make any comparisons to other enterprises. Similarly, evaluations presented in this section were made separately for every single enterprise.

Results obtained reveal that the level of strategic potential of, say the first enterprise using the set of all chosen criteria reaches approximately 4.9 points of 10 possible.

3. The evaluation case of comparison with the best and the worst objects

Other case of usage of MCDA methods for evaluation of single objects proposed hereafter is based on the idea of expanding the set of evaluated alternatives by artificially adding the best hypothetical and the worst hypothetical alternatives. In fact, any quantitative multicriteria method can be used for making a comparison of the chosen real alternative with the best and the worst hypothetical alternatives. Wherever the *SAW* method is used after applying the "classic" normalisation as in formula (2), the sum of its cumulative criteria S_j is always equal to unity (Podvezko 2011). The average in case of three alternatives equals to 1/3≈0.333, therefore the chosen alternative for evaluation could be compared with the average, as well as with the "ideally" best or worst alternatives.

Values of the best and the worst alternatives could be elicited from experts or reduced from statistical data.

Consider the task of evaluation of performance of registered in Lithuania commercial banks in 2009 (Podviezko, Ginevicius 2010; Ginevicius, Podviezko 2011; Podviezko 2011).

Eight commercial banks registered in Lithuania are evaluated by 10 criteria. The names of the banks and variables are provided in Table 5 below, as well as statistical data for the eight banks for 2009, which is provided in columns under numbers 1-8. The data has been obtained from annual reports of the commercial banks (AB DnB NORD bankas 2009; AB Parex bankas 2009; AB SEB bankas 2009; AB Siauliu bankas 2009; AB bankas SNORAS 2009; AB Swedbank 2009; AB Ukio bankas 2009; UAB Medicinos bankas 2009). In the second column the type of each criterion is shown: + for the maximising criteria, and - for the minimising criteria. The "worst" values of criteria for the whole set of banks (the lowest value for the minimising, and the largest value for the maximising criteria) are provided in the column named "Alt Min". Similarly, the "best" values of criteria for the whole set of banks are provided in the column named "Alt Max".

Table 5. Statistical values of criteria of performance for 2009 of eight commercial banks registered in Lithuania.

Ratios	2009										
	Max or Min	Alt Min	Alternatives								Alt Max
			1	2	3	4	5	6	7	8	
1. CAPITAL	+	6.39	6.39	10.29	10.14	7.31	6.43	11.29	9.26	8.05	11.29
2. NII	+	0.08	2.58	2.77	2.17	2.09	0.08	3.15	1.52	0.80	3.15
3. TL	−	87.00	86.36	66.17	87.00	71.10	53.18	76.60	80.05	71.82	53.180
4. DELINQ	−	7.66	3.36	3.02	5.56	2.94	7.66	6.45	0.95	5.51	0.95
5. LD	−	6.45	4.77	1.88	4.33	6.45	1.39	5.52	2.08	2.12	1.39
6. NIC	−	52.82	24.33	30.95	52.82	29.61	27.66	27.61	22.15	32.25	22.15
7. PPP	+	-0.75	2.47	1.98	-0.75	1.25	1.95	3.16	0.78	0.08	3.16
8. NI	+	-10.60	-3.93	0.05	-7.77	-10.60	0.18	-9.11	-1.67	-2.08	0.18
9. DEP	+	33.10	33.10	113.31	41.55	56.57	148.07	84.11	92.74	110.93	148.07
10. LIQ	+	34.61	37.61	55.31	40.74	60.31	41.26	45.50	34.61	50.86	60.31

Notes: Alternatives are: 1 - AB DnB NORD, 2 – UAB Medicinos Bankas, 3 - AB Parex bankas, 4 - AB SEB bankas, 5 - AB bankas SNORAS, 6 - AB Swedbank, 7 - AB Siauliu bankas, 8 - AB Ukio bankas.

Estimation of weights of criteria elicited from experts is provided in Table 6 (Podviezko, Ginevicius 2010).

Table 6. Estimation of weghts of criteria

Criterion	1	2	3	4	5
Weight ω_i	0.223	0.052	0.052	0.052	0.052
Criterion	6	7	8	9	10
Weight ω_i	0.160	0.153	0.072	0.080	0.098

We could compare all 8 banks between themselves (or 10 banks by adding two hypothetical banks), but our aim is to evaluate each single bank with no its relation to other banks by taking the "best" and the "worst" banks as benchmarks.

For example, for evaluation of the first bank, data of three alternatives, namely columns "AltMin", 1-st column, and "AltMax" are used. The column "AltMin" is assembled of the worst criteria from the set of all banks, while "AltMax" is assembled of the best criteria from the set of all banks. The column in the middle contains real values of performance of the 1-st bank.

The idea will be utilised by using two MCDA methods *SAW* and *COPRAS*. The *SAW* method was described above (see formulae (1) and (2)). The *COPRAS* (Complex Proportional Assessment) method (Zavadskas, Kaklauskas 1996; Podvezko 2011) accounts maximizing and minimizing criteria for each alternative separately for computing the cumulative criterion. Its description follows in the next section.

4. The *COPRAS* method

The evaluation component S_{+j} of the cumulative criterion of *j*-th alternative of maximising criteria matches the sum S_j of normalized weighted values in the method *SAW* (see formula (1)). This implies that in case if only maximising criteria and classical normalization (2) of criteria values are used, the calculation results obtained by the method *COPRAS* match the data obtained by the method *SAW* (Ginevicius, Podvezko 2007).

The values of the criterion Z_j in *COPRAS* are obtained using formulae (6)-(8):

$$Z_j = S_{+j} + \frac{S_{-\min}\sum_{j=1}^{n} S_{-j}}{S_{-j}\sum_{j=1}^{n}\frac{S_{-\min}}{S_{-j}}} \qquad (6)$$

where

$$S_{+j} = \sum_{i=1}^{m} \omega_{+i}\tilde{r}_{+ij} \qquad (7)$$

is the sum of maximising weighted criteria values $\tilde{r}_{+ij}$, normalized in accordance with formula (2) for each *j-th* alternative;

$$S_{-j} = \sum_{i=1}^{m} \omega_{-i}\tilde{r}_{-ij} \qquad (8)$$

is the sum of minimising weighted normalised criteria values $\tilde{r}_{-ij}$; *j*=1,2,...,*n*; *n* is the number of the compared alternatives; $S_{-\min} = \min_j S_{-j}$. The sign '+' shows that only normalised values of *j*-th alternative's maximising criteria $\tilde{r}_{+ij}$, multiplied by their weights ω_{+i}, are summed up. Similarly, the sign '–' applies to minimising criteria and their weights ω_{-i}.

Evaluation of each bank by the *SAW* and the *COPRAS* methods has been applied in a way that comparisons of the banks with the best and the worst hypothetical banks were made. In Table 7 the result of the evaluation of each bank is presented. The value of the cumulative criterion S_j of the *SAW* method relates to the evaluated bank, $S_{j(\min)}$ to the worst hypothetical bank, and $S_{j(\max)}$ to the best hypothetical bank. Z_j, $Z_{j(\min)}$, and $Z_{j(\max)}$ relate to the *COPRAS* method accordingly.

Table 7. Results of evaluation of single banks

Method	Bank Criterion	Alternatives							
		1	2	3	4	5	6	7	8
SAW	$S_{j(\min)}$	0.1727	0.1580	0.1798	0.1711	0.1659	0.1607	0.1626.	0.1693
	S_j	0.3130	0.3704	0.2252	0.2927	0.3283	0.3414	0.3483	0.3072
	$S_{j(\max)}$	0.5144	0.4716	0.5650	0.5362	0.5058	0.4979	0.4991	0.5235
	Rank	5	1	8	7	4	3	2	6
	$S^- = S_j - S_{j(\min)}$	0.1403	0.2124	0.0454	0.1216	0.1624	0.1807	0.1857	0.1379
	$S^+ = S_{j(\max)} - S_j$	0.2014	0.1012	0.3398	0.2435	0.1775	0.1496	0.1508	0.2163
COPRAS	$Z_{j(\min)}$	0.1738	0.1570	0.1657	0.1723	0.1693	0.1643	0.1603	0.1702
	Z_j	0.3181	0.3833	0.2423	0.2948	0.3259	0.3418	0.3502	0.3091
	$Z_{j(\max)}$	0.5164	0.4830	0.5216	0.5285	0.5048	0.4938	0.4895	0.5207
	Rank	5	1	8	7	4	3	2	6
	$Z^- = Z_j - Z_{j(\min)}$	0.1443	0.2263	0.0766	0.1225	0.1566	0.1775	0.1899	0.1389
	$Z^+ = Z_{j(\max)} - Z_j$	0.1983	0.0997	0.2793	0.2337	0.1789	0.1520	0.1393	0.2116

Notes: Alternatives are: 1 - AB DnB NORD, 2 – UAB Medicinos Bankas, 3 - AB Parex bankas, 4 - AB SEB bankas, 5 - AB bankas SNORAS, 6 - AB Swedbank, 7 - AB Siauliu bankas, 8 - AB Ukio bankas.

In case if the distance between the value of the criterion S_j (and Z_j) of the evaluated bank and the best hypothetical bank is smaller than the distance between the value of the criterion to the worst hypothetical bank, then position of the bank is above average among all of the banks being evaluated and the bank is found in the group of the leaders. Our case yields three banks, which attained top three positions by both *SAW* and *COPRAS* methods: UAB Medicinos Bankas, AB Siauliu bankas, and AB Swedbank. For the fourth bank the distances do not differ considerably.

An unequivocal quantitative index exposing relative positions of banks in relation to the worst and the best hypothetical banks in a very clear form could be the difference between S^- and S^+

for the *SAW* method or between Z^- and Z^+ for the *COPRAS* method. Whenever the difference is positive and larger for the certain bank, the closer is bank to the hypothetical best bank. And whenever the difference is negative and smaller, the closer is bank to the hypothetical worst bank. Calculated differences are presented in Table 8.

Table 8. Distances of values of cumulative criteria from the average point

Method	Bank Criterion	Alternatives							
		1	2	3	4	5	6	7	8
SAW	$S^- - S^+$	-0.0611	0.1112	-0.2944	-0.1219	-0.0151	0.0311	0.0349	-0.0784
	Rank	5	1	8	7	4	3	2	6
COPRAS	$Z^- - Z^+$	-0.0540	0.1266	-0.2027	-0.1112	-0.0223	0.0255	0.0506	-0.0727
	Rank	5	1	8	7	4	3	2	6

Notes: Alternatives are: 1 - AB DnB NORD, 2 – UAB Medicinos Bankas, 3 - AB Parex bankas, 4 - AB SEB bankas, 5 - AB bankas SNORAS, 6 - AB Swedbank, 7 - AB Siauliu bankas, 8 - AB Ukio bankas.

Observe that the ranks of the banks obtained by the traditional MCDA approach and the ranks obtained by comparisons of separately chosen banks with hypothetical best and worst banks appeared to be the same. Nevertheless, the latter case provided the opportunity to evaluate each single "isolated" object.

5. Conclusions

MCDA methods are being used in cases, when a number of evaluated and compared alternatives is present. The result of the methods is being provided in the form of ranking of alternatives in relation to their attractiveness to the aim of the research. Alternatively, result could be provided by indicating the best alternative. Nevertheless, this approach is not always feasible in evaluation of socio-economical processes, since they often are unique and there are no analogous alternatives available for making comparisons.

A new multicriteria approach proposed in this paper allows evaluating a single object, without relating it to other similar objects. Two proposed methods reveal capabilities of such evaluations. Application of the described methods for making quantitative multicriteria evaluations revealed effectiveness of the methods.

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