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IMPROVEMENT OF DECISION MAKING EFFICIENCY BY SOFTWARE SUPPORT

Abstract: *This paper presents methodological concepts of software development support for improving quality of decision making process. Software support is related to solving problems of multi-criteria decision making. This paper presents a universally applicable method which may represent a starting point for improvement of decision making process*

Keywords: *Software Support, Decision Making*

1. INTRODUCTION

The function of achieving quality largely depends on the quality of business decisions. Computer support is an essential element for improving the quality of decision-making. As in other applications, the application of computer technology is in place to support the systems and methods for decision making. The most significant impact of computer support, in this regard, is reflected in the automation of theoretical mathematical models, created for this purpose. This achieves greater speed and accuracy of the obtained results, eliminating the possibility of error, which open new possibilities, such as rapid analysis of different possible versions of the solution.

Unstructured management problems suggest the need for computer support which will be implemented in such a way. Specificity of computer technology, in solving these problems, is primarily reflected in the fact that the obtained results are in form of alternatives or possible solutions. It allows a decision maker to focus his primary attention on selection and analysis of criteria, in terms of describing preferences, to the choice of alternatives by which will examine and analyze the results.

Computer technology usually has its wider application in support of multi-criteria decision making, allowing to obtain a wide range of information needed in solving semistructured or unstructured problems. The modern development of computer technology, telecommunications, the flow rate of Internet, enables obtaining data from internal and external sources, analysis of results from various aspects, their visual representation, which is very important from the point of requirements of modern management decision making.

Decision Support Systems represents a broad methodology for decision support implementation in which the computer technology is an essential element [1] - [4].

Today, many authors suggest various aspects of the development of decision support systems:

- Intelligent business analytics [5]
- A web-based decision support system [6]
- Analysis of various problems and trends of decision support systems [7]
- Manu new types of intelligent decision support systems [8]

Decision support systems have a wide range of applications [9] - [12].

Emphasizing the need for such a decision support, Jarupathirun and Zahedi (2007) point out [13]: „Many complex and unstructured decisions are hindered by a lack of clear understanding of various underlying assumptions and perspectives involved in the decision process.“

Papamichail and French (2005) emphasize the importance of these systems [14]: „Intelligent Decision Support Systems (DSSs) use expert systems technology to enhance the capabilities of decision makers (DMs) in understanding a decision problem and selecting a sound alternative. Because of the people-centred focus of such technologies, it is important not only to assess their technical aspects and overall performance but also to seek the views of potential users.“

This paper is an attempt to present a methodological approach for developing of a computer decision support solutions. The applied mathematical model is a model of Compromise ranking. The specificity of this study is that the user is presented methodological approach which can be applied in individual development of computer support.

2. METHODOLOGICAL APPROACH TO THE DEVELOPMENT OF COMPUTER SUPPORT

Compromise programming is a method of multicriteria analysis based on a mathematical model. Computer support in this paper refers to the automation of calculation of the mathematical model, more described in the literature, Opricovic (1992) [15] based on the equations (1) – (3). Mathematical approach to the choice of the best alternative, in this model, is based on the distance of individual alternatives to the best, the ideal alternative:

$$S_j = \sum_{i=1}^{n} w_i \left(f_i^* - f_{ij}\right) / \left(f_i^* - f_i^-\right) \qquad (1)$$

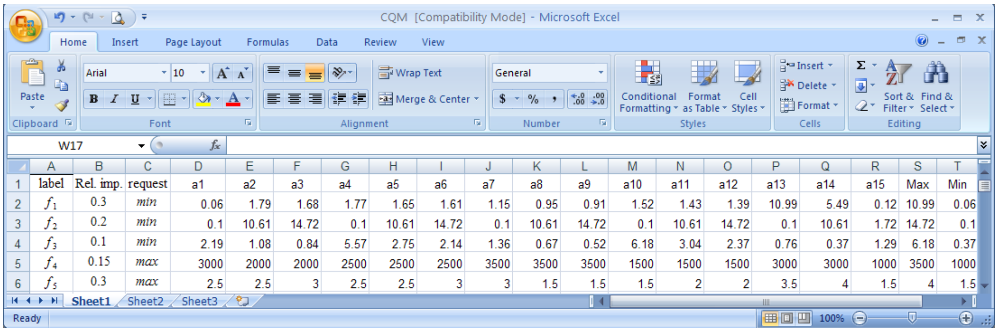
Where:

$f_i^* = \max_j f_{ij}$, $i = 1,\dots,n$;

$f_i^- = \min_j f_{ij}$, $i = 1,\dots,n$;

w_i – relative importance

It is necessary to emphasize that f_i^* at the request of criteria for maximization, this is a maximum value of the individual alternatives, in relation to given criteria. At the request for minimization, it is minimum value. The reverse is true for the most distant alternative from the ideal f_i^-.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	label	Rel. imp.	request	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15	Max	Min
2	f_1	0.3	min	0.06	1.79	1.68	1.77	1.65	1.61	1.15	0.95	0.91	1.52	1.43	1.39	10.99	5.49	0.12	10.99	0.06
3	f_2	0.2	min	0.1	10.61	14.72	0.1	10.61	14.72	0.1	10.61	14.72	0.1	10.61	14.72	0.1	10.61	1.72	14.72	0.1
4	f_3	0.1	min	2.19	1.08	0.84	5.57	2.75	2.14	1.36	0.67	0.52	6.18	3.04	2.37	0.76	0.37	1.29	6.18	0.37
5	f_4	0.15	max	3000	2000	2000	2500	2500	2500	3500	3500	3500	1500	1500	1500	3000	3000	1000	3500	1000
6	f_5	0.3	max	2.5	2.5	3	2.5	2.5	3	3	1.5	1.5	1.5	2	2	3.5	4	1.5	4	1.5

Figure 1. The initial values of alternatives

The values of individual alternatives, which are subject to calculation, are given the symbol f_{ij}

The initial values of 15 ranking

alternatives in relation to the five criteria, are shown in Figure 1 They represent the initial values on which is made the ranking of alternatives.

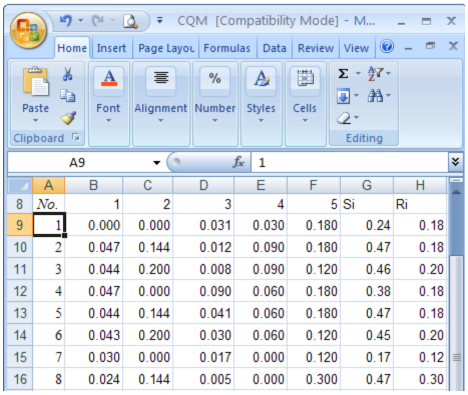
In this sense are calculated maximal and minimum values of alternatives according to individual criteria:

S2=MAX(D2:R2)
S3=MAX(D3:R3)
S4=MAX(D4:R4)
...
or respectively:
T2=MIN(D2:R2)
T3=MIN(D3:R3)
T4=MIN(D4:R4)
....

Mathematical calculation is based on the distance of some alternative to the best, Figure 2

B9=$B$2*($T$2-D2)/($T$2-$S$2)
B10=$B$2*($T$2-E2)/($T$2-$S$2)
B11=$B$2*($T$2-F2)/($T$2-$S$2)
...
C9=$B$3*($T$3-D3)/($T$3-$S$3)
C10=$B$3*($T$3-E3)/($T$3-$S$3)
C11=$B$3*($T$3-F3)/($T$3-$S$3)
...
D9=$B$4*($T$4-D4)/($T$4-$S$4)
D10=$B$4*($T$4-E4)/($T$4-$S$4)
D11=$B$4*($T$4-F4)/($T$4-$S$4)
...
E9=$B$5*($S$5-D5)/($S$5-$T$5)
E10=$B$5*($S$5-E5)/($S$5-$T$5)
E11=$B$5*($S$5-F5)/($S$5-$T$5)
...
F9=$B$6*($S$6-D6)/($S$6-$T$6)
F10=$B$6*($S$6-E6)/($S$6-$T$6)
F11=$B$6*($S$6-F6)/($S$6-$T$6)
...

The cells $B$2, $B$3, $B$4 ... represent the relative importance of individual criteria. Considering the requirement for minimization, which are expressed in the first three criteria, $T$4 is the minimum value of alternatives in relation to each criterion. In contrast to the requirement for maximization, the last two criteria are expressed by $S$5. Distance of the best alternative, compared to the worst, at the request for minimization, is expressed by: $T$2-$S$2. In contrast, distance of the best alternative, in relation to the worst, at the request for maximization, is expressed by $S$6-$T$6.



	A	B	C	D	E	F	G	H
8	No.	1	2	3	4	5	Si	Ri
9	1	0.000	0.000	0.031	0.030	0.180	0.24	0.18
10	2	0.047	0.144	0.012	0.090	0.180	0.47	0.18
11	3	0.044	0.200	0.008	0.090	0.120	0.46	0.20
12	4	0.047	0.000	0.090	0.060	0.180	0.38	0.18
13	5	0.044	0.144	0.041	0.060	0.180	0.47	0.18
14	6	0.043	0.200	0.030	0.060	0.120	0.45	0.20
15	7	0.030	0.000	0.017	0.000	0.120	0.17	0.12
16	8	0.024	0.144	0.005	0.000	0.300	0.47	0.30

Figure 2. Distance of some alternative to the best

Values which are not given absolute references are individual alternatives. The next step in calculating is fulfillment of requirements that a good alternative must not be very bad for any of the criteria (2).

$$R_j = \max_i w_i \left(f_i^* - f_{ij}\right) / \left(f_i^* - f_i^-\right)$$
(2)

On this basis are calculated values R_j:

H9=MAX(B9:F9)
H10=MAX(B10:F10)
H11=MAX(B11:F11)
...

Final values, basis for final ranking by Compromise programming is a measure of Q_j [28] by which are combined values S_{aj} and R_{aj} metrics (3).

$$Q_j = v\left(S_j - S^*\right)/\left(S^- - S^*\right) + (1-v)\left(R_j - R^*\right)/\left(R^- - R^*\right); \quad j = 1,\ldots,J$$
(3)

where:

$$S^* = \min_j S_j; \qquad S^- = \max_j S_j$$
$$R^* = \min_j R_j; \qquad R^- = \max_j R_j$$
$$f_i^* = \max_j f_{ij}; \quad i = 1,\ldots,n$$
$$f_i^- = \min_j f_{ij}; \quad i = 1,\ldots,n$$

At the same time S^* and S^-, or R^* and R^- represent the best and the worst values of the two metrics:

C25=MIN(G9:G23)
C26=MAX(G9:G23)
C27=MIN(I9:I23)
C28=MAX(I9:I23)

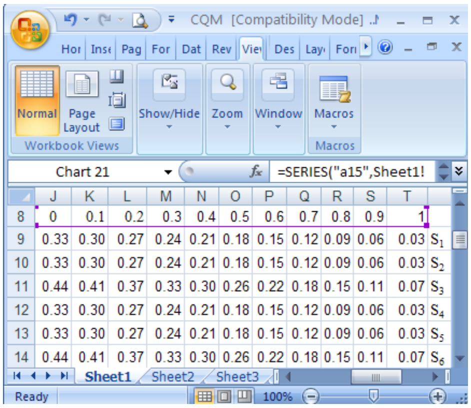
Compromise programming method allows ranking of alternatives depending on the severity of the strategy of decision making ν ($0 \le v \le 1$).As a result, the final rank of alternatives is obtained by taking into account the weight of decision making strategies, Figure 3:

ν = 0

J9=$J$8*($H9-$C$25)/($C$26-$C$25)+(1-$J$8)*($I9-$C$27)/($C$28-$C$27)
J10=$J$8*($H10-$C$25)/($C$26-$C$25)+(1-$J$8)*($I10-$C$27)/($C$28-$C$27)
J11=$J$8*($H11-$C$25)/($C$26-$C$25)+(1-$J$8)*($I11-$C$27)/($C$28-$C$27)
...
ν = 0.1
K9=$K$8*($H9-$C$25)/($C$26-$C$25)+(1-$K$8)*($I9-$C$27)/($C$28-$C$27)
K10=$K$8*($H10-$C$25)/($C$26-$C$25)+(1-$K$8)*($I10-$C$27)/($C$28-$C$27)
K11=$K$8*($H11-$C$25)/($C$26-$C$25)+(1-$K$8)*($I11-$C$27)/($C$28-$C$27)
...

ν = 0.2
L9=$L$8*($H9-$C$25)/($C$26-$C$25)+(1-$L$8)*($I9-$C$27)/($C$28-$C$27)
L10=$L$8*($H10-$C$25)/($C$26-$C$25)+(1-$L$8)*($I10-$C$27)/($C$28-$C$27)
L11=$L$8*($H11-$C$25)/($C$26-$C$25)+(1-$L$8)*($I11-$C$27)/($C$28-$C$27)
...

A diagrammatic representation of ranking alternatives, depending on the severity of criteria, is shown in Figure 4.



	J	K	L	M	N	O	P	Q	R	S	T	
8	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	
9	0.33	0.30	0.27	0.24	0.21	0.18	0.15	0.12	0.09	0.06	0.03	S_1
10	0.33	0.30	0.27	0.24	0.21	0.18	0.15	0.12	0.09	0.06	0.03	S_2
11	0.44	0.41	0.37	0.33	0.30	0.26	0.22	0.18	0.15	0.11	0.07	S_3
12	0.33	0.30	0.27	0.24	0.21	0.18	0.15	0.12	0.09	0.06	0.03	S_4
13	0.33	0.30	0.27	0.24	0.21	0.18	0.15	0.12	0.09	0.06	0.03	S_5
14	0.44	0.41	0.37	0.33	0.30	0.26	0.22	0.18	0.15	0.11	0.07	S_6

Figure 3. Final results of ranking of alternatives, depending on the severity of the decision making strategy

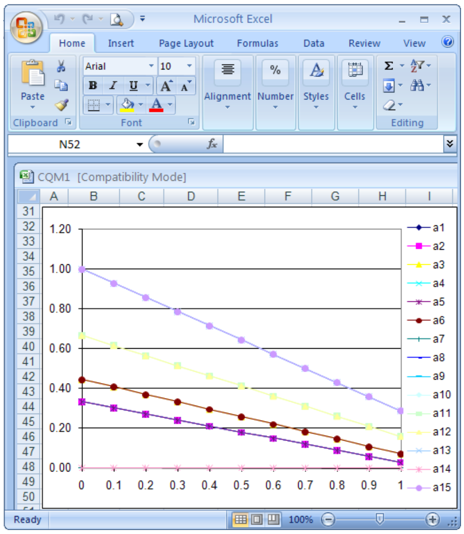


Figure 4. Graphical presentation of results

3. CONCLUSION

This paper presents the steps of development of computer support in the application of a mathematical model for decision making - Compromise ranking. Methodological approach enables the holder of Deision Making to create his own computer support for decision-making. The importance of automation of calculation, primarily reflects in elimination of the possibility of error and in the speed of decision making. This allows analysis of different variants of criterion requirements in a simple way.

Results are automatically displayed visually, which is important for intuitive insight of decision makers.

The specificity of this work is not presentation of a finished software solution, but pointing to the development of their own computer support. Preview of Compromise ranking method, in this way, allows universal application in decision-making process.

It is undisputable that computer support has a significant impact on the quality of decision making, and therefore on the quality of the overall business. To this purpose, presented review has its contribution in achieving the overall quality of business.

Improvement of business through different support systems is now inevitable. A large amount of investment, the requirements for an adequate response to the speed of making business decisions, eliminating errors, further emphasize the importance of implementation of decision support systems in modern business.

The presented method enables obtaining a multiple criteria rank, selecting the best alternative. As it is shown in this paper, criteria by which is made the comparison, in addition to requirements for maximization or minimization, can be defined by the relative importance. Alternatives can be expressed in different units.

This indicates that considered methodology can be a general approach and initial basis for the decisions.

In this paper is made the effort that the applied methodology is as simple as possible,acceptable for decision makers in practice. MS Excel is a widely accepted and known platform, which significantly affect the acceptance by many users.

The complexity of the mathematical model, the possibility of creating errors in the calculation, need to learn new methodologies, often causes resistance in the application of methods for multicriteria decision making.

The methodology of computer support for this purpose, which is shown in this paper, is intended to remove that barrier, bringing approach to this problem in the easiest and acceptable way.

REFERENCES

[1] Arnott D. and Pervan G.: “Eight key issues for the decision support systems discipline”, Decision Support Systems, Vol. 44., Iss. 3., Elsevier Science Publishers B. V., Amsterdam, The Netherlands, February, 2008., pp. 657-672.

[2] Martinsons M. G. and Davison R. M.: “Strategic decision making and support systems: Comparing American, Japanese and Chinese management”, Decision Support Systems, Vol. 43., Iss. 1., Elsevier Science Publishers B. V. Amsterdam, The Netherlands, February, 2007., pp. 284-300.

[3] Power D. J. and Sharda R.: “Model-driven decision support systems: Concepts and research directions”, Decision Support Systems, Vol. 43, Iss. 3., Elsevier Science Publishers B. V. Amsterdam, The Netherlands, April, 2007., pp. 1044-1061.

[4] Marakas G. M.: “Decision Support Systems (2nd Edition)”, Prentice Hall, 2002.

[5] Azvine B., Nauck D. and Ho C.: "Intelligent Business Analytics — A Tool to Build Decision-Support Systems for eBusinesses", BT Technology Journal, Vol. 21., No. 4., Springer, Netherlands, November 03, 2004, pp. 65-71.
[6] Sheng Q.; Lei-shan Z. and Yi-xiang Y.: "A web-based distributed group decision support system for railway construction organization", Informatics in Control, Automation and Robotics (CAR), 2010 2nd International Asia Conference, Wuhan, China, 6-7 March 2010, pp. 362 – 365.
[7] Sheng Y. and Zhang Sh.; "Analysis of Problems and Trends of Decision Support Systems Development", E-Business and Information System Security, 2009. EBISS '09. International Conference, May 23-24, Wuhan, China, 2009, pp. 1 – 3.
[8] Zhou F.; Yang B., Li L. and Chen Zh.: "Overview of the New Types of Intelligent Decision Support System", Innovative Computing Information and Control, 2008. ICICIC '08. 3rd International Conference , Dalian, China, June 18 - 20, 2008., pp 267.
[9] VanSchaik F.D. and Sol H.G.: "Effectiveness of decision support systems", System Sciences, 1990., Proceedings of the Twenty-Third Annual Hawaii International Conference, Hawaii, Vol. 3., 2-5 Jan 1990., pp. 50 – 58.
[10] Lee S. J.; Mo K. and Seong P. H.: "Development of an Integrated Decision Support System to Aid the Cognitive Activities of Operators in Main Control Rooms of Nuclear Power Plants", Computational Intelligence in Multicriteria Decision Making, IEEE Symposium, Honolulu, HI, 1-5 April 2007., pp. 146 – 152.
[11] Anya O.; Tawfik H. and Nagar A.: "Designing Context-Awareness into Decision Support Systems for e-Collaboration", Developments in eSystems Engineering (DESE), 2009 Second International Conference", Abu Dhabi, UAE, 14-16 Dec. 2009., pp. 53 – 58.
[12] Xiao-Feng D., Yu-Jiong G. and Kun Y.: "Study on intelligent maintenance decision support system using for power plant equipment", Automation and Logistics, 2008. ICAL 2008. IEEE International Conference, 1-3 Sept. 2008., pp. 96 – 100.
[13] Jarupathirun S. and Zahedi F. M.: "Dialectic decision support systems: System design and empirical evaluation", Decision Support Systems, Vol. 43., Iss. 4., Elsevier Science Publishers B. V. Amsterdam, The Netherlands, August, 2007., pp. 1553-1570.
[14] Papamichail K. N. and French S.: "Design and evaluation of an intelligent decision support system for nuclear emergencies", Decision Support Systems, Vol. 41., Iss. 1., Elsevier Science Publishers B. V. Amsterdam, The Netherlands, November 2005., pp. 84-111.
[15] Opricović S.: Optimization of a system, Nauka, Belgrade, 1992.

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