SELECTION OF CONSTRUCTION PROJECT MANAGERS BY APPLYING COPRAS-G METHOD

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There is a number of attributes and associated sub-factors influencing the matching of managers to construction projects. Attributes and sub-attributes were identified based on a thorough review of the related literature and interviews of management personnel involved in the selection of project managers. Project managers' characteristics are considered to be less important for effective project management. The model is based on multi-attribute evaluation of project managers. The evaluation embraces the identified attributes influencing the process of construction project manager selection. This paper considers the application of grey relations methodology for defining the utility of alternatives, and a multiple criteria method of COmplex PRoportional ASsessment of alternatives with Grey relations (COPRAS-G) is offered. In this model, the parameters of the alternatives are determined by the grey relational grade and expressed in intervals. A case study presents the selection of construction project manager. The results obtained show that this method may be used as an effective decision aid in multi-attribute selection.

Keywords: *COPRAS, grey relations, manager, selection*

1. Introduction

In recent years, the number of construction projects has been growing rapidly. Therefore, it is very important to find the right project managers for such projects. It has become a major task in project implementation. Different projects require different skills and capabilities on the part of the project manager. All stakeholders, consultants, and contractors are looking for a few good project managers available. They are indeed hard to find and even a search firm is hardly capable of finding the suitable staff even though the target candidate (a good project manager) can practically write his own pay. This paper presents the analysis of matching managers to construction projects.

2. The Analysis of Factors Influencing Manager Selection for Construction Projects

The role of construction project manager is very important in the process of construction. The construction process is risky and its success largely depends on the choice of the right project manager.

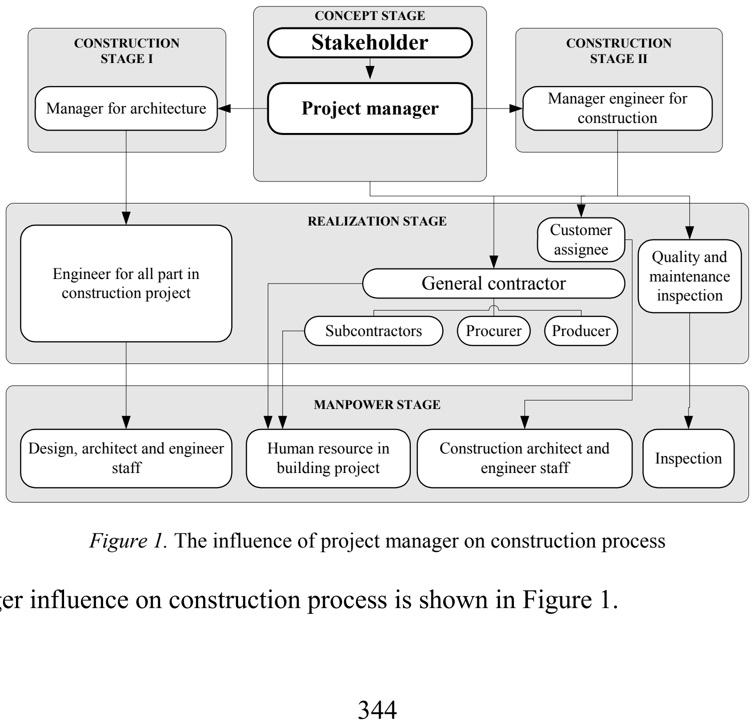

Figure 1. The influence of project manager on construction process

Project manager influence on construction process is shown in Figure 1.

Project management is a complicated task. Every building project differs in place, size, time, cost, etc. The factors influencing project manager selection mentioned in the review of the related literature are presented in Table 1. Collins takes a holistic view of the project manager candidates, which also provides for the addition of any selection criteria deemed relevant to a specific project. The results are scored and in the case of a close score between candidates, the candidates' availability could help swing the decision.

Table 1. Factors taken from the review of the related literature which are relevant to project manager selection [1-12]

No.	FACTORS	RELATED LITERATURE SOURCE											
		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
1.	**Education level**	●			●		●			●			●
2.	**Age**				●					●			●
3.	**Racial stock**				●								●
4.	**Insufficient time spent in family**								●				●
5.	**Gender**											●	●
6.	**Personal skills**		●		●	●	●	●	●	●	●		●
6.1.	Mobilizing										●		●
6.2.	*Verbal communications*		●		●		●	●	●	●	●		●
6.3.	*Coping with situation*										●		
6.4.	*Delegating authority*										●		
6.5.	*Political sensitivity*										●		●
6.6.	*Conflict resolution diplomacy*		●						●	●			
6.7.	*High self-esteem*										●		●
6.8.	*Enthusiasm*									●	●		●
7.	**Dependability**	●											
8.	**Experience (in similar projects)**	●		●	●	●		●	●			●	●
9.	**Self views**			●		●		●	●				
10.	**Self relevant goals**			●		●		●	●				●
11.	**Paperwork**								●				
12.	**Job stress**								●	●			●
13.	**Pay**									●			●
14.	**Problem specification, selection, analysis of alternatives**						●	●	●		●		
15.	**Conceptual and organizational skills**										●		●
15.1.	*Planning*										●		●
15.2.	*Organizing*										●		●
15.3.	*Strong goal orientation*										●		
16.	**Project management skills**		●	●		●	●	●	●	●	●		●
16.1.	*Leadership of team*		●						●				
16.2.	*Developing resource plans*		●				●			●			
16.3.	*Knowledge of project implementation process*		●	●		●	●	●	●		●		
17.	**Business skills (markets)**		●				●	●					●
17.1.	*Strategic thinker*		●				●						
17.2.	*Ability to carry out the requirement of the customer*		●				●						
17.3.	*Business case development*		●				●						
17.4.	*Internal investments*							●					
17.5.	*Venture capital*							●					
18.	**Technical skills**		●			●	●	●			●		
18.1.	*Engineering background*		●			●		●			●		
19.	**Appropriate computer tools developed**						●				●		●
20.	**Control**							●		●			●
21.	**Quality**	●					●		●				

While this has merit, it must be noted that using the criteria in the table could result in selecting a project manager for the wrong reasons. Collins states: “The process focuses on the premise that a successful project manager must master two primary skill sets: the project manager's technical skills and leadership skills. Technical skills mentioned by Collins include the following items: integration management, scope management, time management, cost management, quality management, risk management and procurement management. Leadership skills include items like individual influence, integrity, strategic leadership, teamwork and collaboration, communication and tenacity. He concludes: "As these [project managers] continue to improve, they can become more proficient in the role and assume a broader spectrum of complex projects [2]. Lorda and Brown define self-concept as a broad amalgam of knowledge, experience, self views and possible selves, self relevant goals that individuals see as self relevant or self descriptive" [3].

3. Research Methodology

3.1. A method of multiple criteria COmplex PRoportional ASsessment

In order to evaluate the overall efficiency of a project, it is necessary to identify selection attributes, to assess information, relating to these attributes, and to develop methods for evaluating the attributes to meet the participants' needs. Decision analysis is concerned with the situation in which a decision-maker has to choose among several alternatives by considering a particular set of attributes. The COPRAS method presented in the paper uses a stepwise ranking and evaluating procedure of the alternatives in terms of significance and utility degree. This method was applied to the solution of various problems in construction [13-15].

3.2. A method of multiple criteria COmplex PRoportional ASsessment with values expressed in intervals

In 1982, Deng developed the Grey system theory [16]. In 1988, Deng [17] presented grey decision-making systems. According to Deng [18], the Grey relational analysis has some advantages: it involves simple calculations and requires a smaller number of samples; a typical distribution of samples is not needed; the quantified outcomes from the Grey relational grade do not result in contradictory conclusions to qualitative analysis; the Grey relational grade model is a transfer functional model that is effective in dealing with discrete data.

The idea of COPRAS-G method is based on the real conditions of decision making and applications of the Grey systems theory. In 2008, Zavadskas *et al.* developed the COPRAS-G method [19].COPRAS-G method was applied to the selection of the effective walls for a dwelling house [19].

The procedure of using the COPRAS-G method consists in the steps shown in Figure 2.

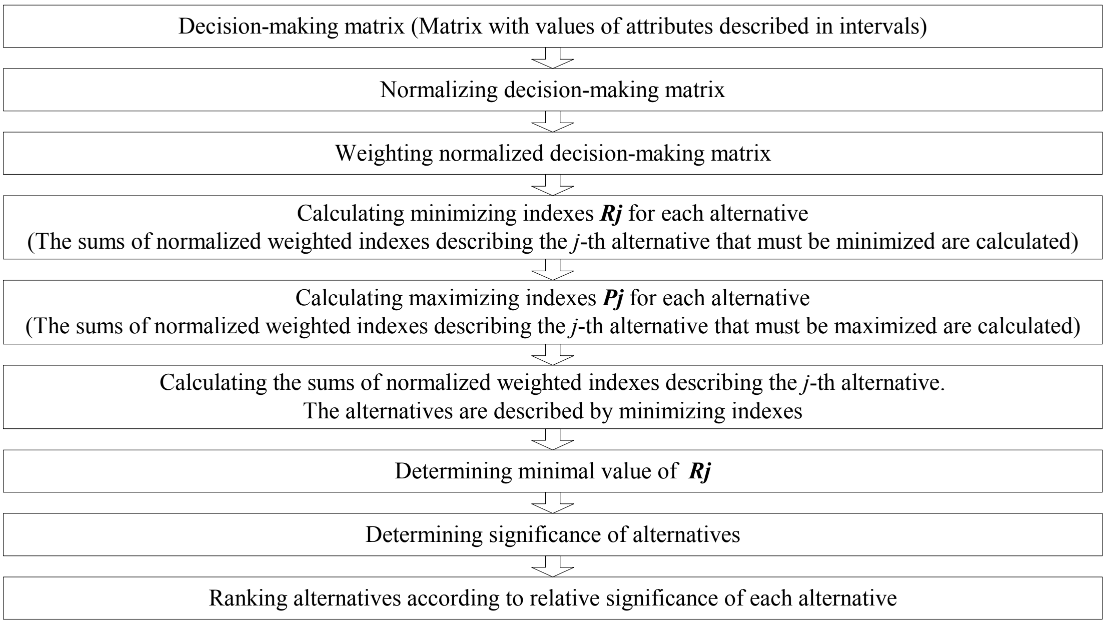

Figure 2. Ranking of alternatives by applying COPRAS-G method

The procedure of using the COPRAS-G method with attribute values expressed in intervals consists in the following steps:

1. Selecting the set of the most important attributes, describing the alternatives;
2. Constructing the decision-making matrix X :

$$X=\begin{bmatrix} [w_{11};b_{11}] & [w_{12};b_{12}] & \dots & [w_{1m};b_{1m}] \\ [w_{21};b_{21}] & [w_{22};b_{22}] & \dots & [w_{2m};b_{2m}] \\ \vdots & \vdots & \dots & \vdots \\ [w_{n1};b_{n1}] & [w_{n2};b_{n2}] & \dots & [w_{nm};b_{nm}] \end{bmatrix};\ j=\overline{1,n};\ i=\overline{1,m}; \quad (1)$$

where w_{ij} is the smallest value, the lower limit, b_{ij} is the biggest value, the upper limit.

3. Determining weights of the attributes q_j .

4. Normalizing the decision-making matrix $\overline{X}$. The normalized values of this matrix [20; 21] are calculated as follows:

$$\overline{w_{ij}} = \frac{w_{ij}}{\frac{1}{2}\left(\sum_{j=1}^{n} w_{ij} + \sum_{j=1}^{n} b_{ij}\right)} = \frac{2w_{ij}}{\sum_{j=1}^{n} w_{ij} + \sum_{j=1}^{n} b_{ij}};$$
$$\overline{b_{ij}} = \frac{b_{ij}}{\frac{1}{2}\left(\sum_{j=1}^{n} w_{ij} + \sum_{j=1}^{n} b_{ij}\right)} = \frac{2b_{ij}}{\sum_{j=1}^{n} (w_{ij} + b_{ij})};$$
$$i = \overline{1,n} \ \ and \ \ j = \overline{1,m}; \tag{2}$$

In formula (2), w_{ij} is the lower value of the *j* attribute in the *i* alternative of the solution; b_{ij} is the upper value of the *j* attribute in the *i* alternative of the solution; *m* is the number of attributes; *n* is the number of the alternatives compared.

Then, the decision-making matrix is normalized:

$$\overline{X} = \begin{bmatrix} [\overline{w_{11}};\overline{b_{11}}] & [\overline{w_{12}};\overline{b_{12}}] & \dots & [\overline{w_{1m}};\overline{b_{1m}}] \\ [\overline{w_{21}};\overline{b_{21}}] & [\overline{w_{21}};\overline{b_{22}}] & \dots & [\overline{w_{2m}};\overline{b_{2m}}] \\ \vdots & \vdots & \dots & \vdots \\ [\overline{w_{n1}};\overline{b_{n1}}] & [\overline{w_{n2}};\overline{b_{n2}}] & \dots & [\overline{w_{nm}};\overline{b_{nm}}] \end{bmatrix}. \tag{3}$$

5. Calculating the weighted normalized decision matrix $\hat{X}$. The weighted normalized values $\hat{x}_{ij}$ are calculated as follows:

$$\hat{w}_{ij} = \overline{w_{ij}} \cdot q_j;$$
$$\hat{b}_{ij} = \overline{b_{ij}} \cdot q_j. \tag{4}$$

In formula (4), q_j is the significance (weight) of the $j-th$ attribute.

Then, the decision-making matrix is normalized:

$$\hat{X} = \begin{bmatrix} [\hat{w}_{11};\hat{b}_{11}] & [\hat{w}_{12};\hat{b}_{12}] & \dots & [\hat{w}_{1m};\hat{b}_{1m}] \\ [\hat{w}_{21};\hat{b}_{21}] & [\hat{w}_{21};\hat{b}_{22}] & \dots & [\hat{w}_{2m};\hat{b}_{2m}] \\ \vdots & \vdots & \dots & \vdots \\ [\hat{w}_{n1};\hat{b}_{n1}] & [\hat{w}_{n2};\hat{b}_{n2}] & \dots & [\hat{w}_{nm};\hat{b}_{nm}] \end{bmatrix}. \tag{5}$$

6. Calculating the sums P_j of the attribute values, whose larger values are more preferable (optimization direction is maximization), for each alternative (each row of the decision-making matrix):

$$P_j = \frac{1}{2}\sum_{i=1}^{k} (\hat{w}_{ij} + \hat{b}_{ij}) \tag{6}$$

In formula (6), ***k*** is the number of attributes which must be maximized (it is assumed that, in the columns of decision-making matrix, the attributes with optimization direction maximum are placed first and only then the attributes with optimization direction minimum are inserted).

7. Calculating the sums R_j of attribute values, whose smaller values are more preferable (optimization direction is minimization), for each alternative (each row of the decision-making matrix):

$$R_j = \frac{1}{2}\sum_{i=k+1}^{m} (\hat{w}_{ij} + \hat{b}_{ij}); \ \ i = \overline{k,\ m}. \tag{7}$$

In formula (7), $(m-k)$ is the number of attributes which must be minimized.

8. Determining the minimal value of R_j :

$$R_{\min} = \min_j R_j; \quad j = \overline{j,m}. \tag{8}$$

9. Calculating the relative weight of each alternative Q_j :

$$Q_j = P_j + \frac{R_{\min}\sum_{j=1}^{n} R_j}{R_j \sum_{j=1}^{n} \frac{R_{\min}}{R_j}}. \tag{9}$$

Formula (9) can be written as follows:

$$Q_j = P_j + \frac{\sum_{j=1}^{n} R_j}{R_j \sum_{j=1}^{n} \cdot \frac{1}{R_j}}. \tag{9*}$$

10. Determining the optimality criterion ***K***:

$$K = \max_j Q_j; \quad j = \overline{1,n}. \tag{10}$$

11. Determining the priority of the project. The greater the significance (relative weight of alternative) Q_j , the higher the priority (rank) of the project. The relative significance Q_j of project *j* indicates the satisfaction degree of the needs of the project participants. In the case of $Q_{\max}$, the satisfaction degree is the highest compared to the relative significance of other projects.

12. Calculating the utility degree of each alternative. The degree of project utility is determined by comparing the analyzed projects with the best project. The values of the utility degree range from 0% to 100% between the worst and the best alternatives. The utility degree N_j of each alternative j is calculated as follows:

$$N_j = \frac{Q_j}{Q_{\max}} 100\%, \tag{11}$$

where Q_j and $Q_{\max}$ are the significances of projects obtained from Eq. (9*).

The decision approach proposed in this section allows the evaluation of the direct and proportional dependence of the significance and utility degree of the alternatives on a system of attributes, weights and attribute values.

4. Case Study: The Selection of Managers for Construction Projects Applying COPRAS-G Method

Based on the review of literature, six key indicators were identified for using in project manager selection. In order to determine the significance of the above indicators, a survey of five experts was conducted. The results obtained are presented in Table 2. The initial decision making values and intermediary calculation data and the weighted normalized values of the attributes describing the compared alternatives, are also presented in Table 2.

All the attributes are scored. Optimization directions of the selected attributes are as follows:

- $x_1, x_2, x_3, x_4, x_5 \xrightarrow{optimization\ \ direction} \max$;
- $x_6 \xrightarrow{optimization\ \ direction} \min$.

The respondents were stakeholders of construction projects having the experience in construction project administration of five and more years. The determination of quantitative values of attributes is based on the data provided by similar project managers.

Table 2. Initial decision-making matrix with the attribute values described in intervals and weighted normalized values of the attributes describing the compared alternatives

Alternative No	Personal skills (Score)		Project management skills (Score)		Business skills (Score)		Technical skills (Score)		Quality skills (Score)		Time of decision making (Score)	
Optimization direction	*max*		*max*		*max*		*max*		*max*		*min*	
Attribute weight – q_j	0.25		0.15		0.12		0.20		0.13		0.15	
	x_1		x_2		x_3		x_4		x_5		x_6	
	w_1	b_1	w_2	b_2	w_3	b_3	w_4	b_4	w_5	b_5	w_6	b_6
Project manager 1	50	60	40	55	10	20	50	70	50	45	30	40
Project manager 2	70	80	60	70	40	45	60	75	70	80	70	60
Project manager 3	60	70	55	70	30	40	70	80	55	65	40	50
	Normalized weighted values of the attributes describing the compared alternatives – matrix $\hat{X}$											
	$\hat{w}_1$	$\hat{b}_1$	$\hat{w}_2$	$\hat{b}_2$	$\hat{w}_3$	$\hat{b}_3$	$\hat{w}_4$	$\hat{b}_4$	$\hat{w}_5$	$\hat{b}_5$	$\hat{w}_6$	$\hat{b}_6$
Project manager 1	0.064	0.077	0.034	0.047	0.013	0.026	0.049	0.069	0.036	0.032	0.031	0.041
Project manager 2	0.090	0.103	0.051	0.060	0.052	0.058	0.059	0.074	0.050	0.057	0.071	0.062
Project manager 3	0.077	0.090	0.047	0.060	0.039	0.052	0.069	0.079	0.039	0.046	0.041	0.052

According to the calculation results, project manager 2 is the best. Project manager 2 is also the best in terms of the utility degree that equals 100 %. Project manager 3 with the utility degree of 87.66 % is ranked second. Project manager 1 with the utility degree of 66.93 % is ranked third. The vector of optimality criterion values N_j= [65.93; 100; 87.66]. According to the N_j, the ranks obtained in the procedure of project manager selection are as follows: Project manager 2 $\succ$ Project manager 3 $\succ$ Project manager 1.

Conclusions

- In actual multi-attribute modelling of multi-alternative assessment problems, attribute values referring to the future can be expressed in intervals.
- COPRAS-G is a newly developed method for assessment of alternatives by multiple-attribute values expressed in intervals.
- This approach is intended to support decision making and to increase the efficiency of the resolution process.
- The method COPRAS-G may be applied to the solution of a wide range of problems associated with the selection of construction project managers by using discrete multi-attribute assessment technique.

References

1. Figueira, J., Greco, S. & EhrGott, M. *Models decision making - multiple criteria decision analysis. Springer.* 2005.
2. Collins, P. Project manager selection and development process. *PMI International symposium in Long Beach*, California. 1998.
3. Lord, R.G., Brown, D.J., Leadership, values, and subordinate self-concepts, *The leadership quarterly*, Vol. 12, Issue 2, Summer 2001, pp. 133-152.
4. Adobor, H. Selecting management talent for joint ventures: A suggested framework, *Human resource management review*, Vol. 14, No 2, 2004, pp. 161-178.
5. Lievens, F., Harris, M.M., Van Keer, E., Bisqueret, C. Predicting Cross-Cultural Training Performance: The Validity of Personality, Cognitive Ability, and Dimensions Measured by an Assessment Center and a Behavior Description Interview, *Journal of applied psychology*, Vol. 88, No 3, 2003., pp. 476-489.
6. Sykes, H.B. The anatomy of a corporate venturing program: Factors influencing success, *Journal of business venturing,* Vol. 1, No 3, 1986, pp. 275-293.
7. Haynes, N.S. and Love, P.E.D. Psychological adjustment and coping among construction project managers, *Construction management and economics*, Vol. 22, No 2, 2004, pp.129-140.
8. Chen, H.-Ch., Chu, Ch-I, Wang, Y.-H., Lin, L.-Ch. Turnover factors revised: A longitudinal study of Taiwan-based staff nurses, *International journal of nursing studies,* Vol. 45, Issue 2, 2008, pp. 277-285.
9. El-Sabaa, S. The skills and career path of an effective project manager, *International journal of project management*, Vol. 19, Issue 1, 2001, pp. 1-7.

10. Ogunlana, S., Siddiqui, Z., Yisa, S., Olomolaiye, P. Factors and procedures used in matching Project managers to construction projects in Bangkok, *International journal of project management,* Vol. 20, Issue 5, 2002, pp. 385-400.
11. Ling, Y.Y. A conceptual model for selection of architects by Project managers in Singapore. *International journal of project management,* Vol. 21, Issue 2, 2003, pp. 135-144.
12. Mustapha, F.H., Naoum, S. 2000. Factors influencing the effectiveness of construction site managers. *International Journal of Project Management,* 16(1): 1-8.
13. Kaklauskas, A., Zavadskas, E.K., Raslanas, S., Ginevicius, R., Komka, A., Malinauskas, P. Selection of low-e tribute in retrofit of public buildings by applying multiple criteria method COPRAS: A Lithuanian case. *Energy and buildings*, Vol. 38, 2006, pp. 454-462.
14. Viteikiene, M., Zavadskas, E.K. Evaluating the sustainability of Vilnius city residential areas, *Journal of civil engineering and management*, Vol. 8, No 2, 2007, pp. 149-155.
15. Zavadskas, E.K., Kaklauskas, A., Peldschus, F., Turskis, Z. Multi-attribute assessment of road design solution by using the COPRAS method, *The Baltic journal of road and bridge engineering*, Vol. 2, No 4, 2007, pp. 195-203.
16. Deng, J.L. Control problems of grey system, *Systems and control letters,* Vol. 1, No 5, 1982, pp. 288-294.
17. Deng, J.L. Introduction to Grey System Theory, *The journal of grey theory*, Vol. 1, Issue 1, 1988, pp. 1-24.
18. Deng, J.L. Properties of relational space for grey systems*, In essential topics on grey system—theory and applications*, China Ocean, 1988. pp. 1-13.
19. Zavadskas, E.K., Kaklauskas, A., Turskis, Z., Tamošaitienė, J. Selection of the effective dwelling house walls by applying attributes values determined at intervals, *Journal of civil engineering and management*, Vol. 14, No 2, 2008, pp. 85-93.
20. Hwang, C.L. and Yoon, K. *Multiple Attribute Decision Making: Methods and Applications.* Springer-Verlag, New York, 1981.
21. Zavadskas, E.K. *Complex estimation and choice of resource saving decisions in construction* [Комплексная оценка и выбор ресурсо оберегающих решений в строительстве]. Mokslas, Vilnius, 1987.