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MULTICRITERIA SELECTION OF PROJECT MANAGERS BY APPLYING GREY CRITERIA

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Abstract. There is a number of criteria and associated sub-criteria influencing the match of managers to construction projects. Criteria and sub-criteria were identified based on a thorough review of the related literature and interviews of management personnel involved in the project managers selection. Project managers characteristics are considered to be less important for an effective project management. The model is based on multicriteria evaluation of project managers. The evaluation embraces the identified criteria influencing the process of construction project manager selection. This paper considers the application of grey relations methodology to defining the utility of alternatives, and offers a multiple criteria method of *CO*mplex *PR*oportional *AS*sessment of alternatives with grey relations (COPRAS-G) for analysis. In this model, the parameters of the alternatives are determined by the grey relational grade and expressed in terms of 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 multicriteria selection.

Keywords: COPRAS, grey relations, manager, selection.

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1. Introduction

In recent years, the number of construction projects has been growing rapidly. Nowadays, companies have to face rapid transformation of their competitive environment. The design and construction processes are unique, always dealing with risk (Zou *et al.* 2007; Zavadskas *et al.* 2008a) and risk management (Schieg 2007; Savčuk 2007; Shevchenko *et al.* 2008). In the field of design, project managers are aware of both the impact of the designers' competencies in the project performance and of the requirement for a fast development of these competencies (Belkadi *et al.* 2007). Projects are collective, purposeful activities based upon the development of common understandings and interpretations of means and ends. They generate the personal and group knowledge contributing to their own success (Jackson and Klobas 2008). Often, a construction project has limited resources (Gabriel *et al.* 2006). Therefore, it is very important to find the right project managers for such projects. Different projects require different skills and capabilities of the project manager. All stakeholders, consultants and contractors are looking for a few good project managers. 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. Multicriteria problem of project manager selection in construction

2.1. Problem of project manager in construction

The construction process is risky and its success largely depends on the choice of the right project manager. The construction project-related risk criteria show a significant inverse correlation with financial success. The level of venture managers' prior experience in the venture's target market area and their level of prior experience show an even greater correlation with financial success.

Modern management control systems in construction are supposed to provide local management with useful information, reflecting company's performance from different stakeholders' perspectives. However, the tools of management control (Jurkšienė *et al.* 2008) sometimes fail to provide this main function.

Sykes (1986) classified success criteria of project as follows:

a) Extrinsic or environmental criteria are those determined by the form of investment sponsorship and the characteristics of the investment into a construction project. Extrinsic criteria are segregated into two categories:

- Structural criteria (technology, market, organization, and people) are summed up as the overall degree of structural congruence. The authors postulate that the degree of congruence is directly related to venture success within the corporation. To take the corporation into new markets some incongruence is required. Too much incongruence probably pushes the risk of failure too high. The corporation's procedures in managing this incongruence will determine the degree to which it can successfully diversify its business.
- Procedural criteria (control, selection of venture managers, incentive compensation, and financing) are dealt with as differences between the project environment and an independent venture environment.

b) Intrinsic criteria are those inherent in the venture itself, and are subdivided into two categories:

- product-related (market and technical risk levels);
- managerial (relative experience levels).

Project management processes organize and describe the work of the project. These procedures are performed by people and, much like project phases, are interrelated and interdependent. The project management processes include 5 groups:

- Initiating,
- Planning,
- Executing,
- Monitoring and Controlling,
- Closing.

Project manager's influence on construction process is shown in Fig. 1.

Collins (1998) takes a holistic view on the project manager candidates, which also includes the addition of any selection criterion deemed relevant to a specific project. The results are scored and, in case of a close score between candidates, the candidates' availability could help swing the decision.

While this has some merit, it must be noted that using the criteria in the table could result in selecting a project manager for the wrong reasons. Collins (1998) 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."

The criteria influencing project manager selection, mentioned in the review of the related literature, are presented in Table 1.

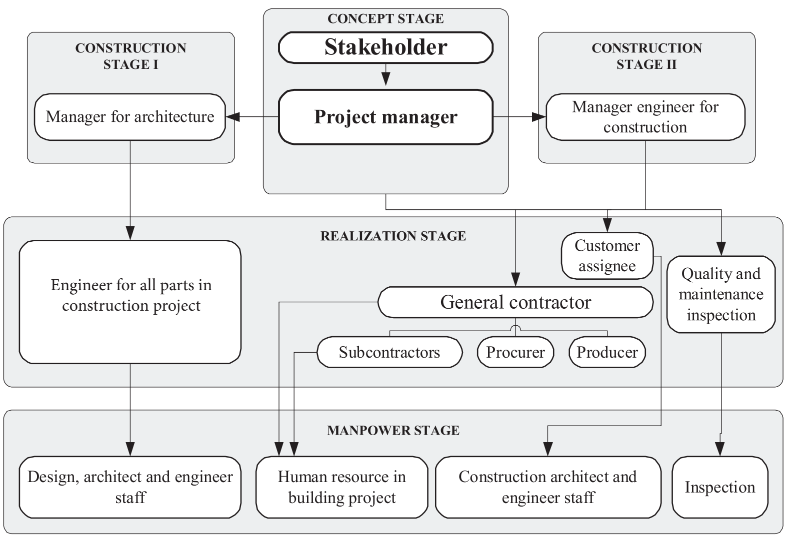

Fig. 1. Team of project and role of the project manager in construction process

Table 1. A set of the main construction manager selection criteria

No.	CRITERIA	No of reference												Σ
		1	2	3	4	5	6	7	8	9	10	11	12	
1.	Education level	•			•		•			•			•	5
2.	Age				•					•			•	3
3.	Racial stock				•								•	2
4.	Insufficient time spent in family								•				•	2
5.	Gender											•	•	2
6.	Personal skills													23
6.1.	*Personal skills*					•								1
6.2.	*Mobilizing*										•		•	2
6.3.	*Verbal communications*		•		•		•	•	•	•	•		•	8
6.4.	*Coping with situation*										•			1
6.5.	*Delegating authority*										•			1
6.6.	*Political sensitivity*										•		•	2
6.7.	*Conflict resolution diplomacy*		•						•	•				3
6.8.	*High self-esteem*										•		•	2
6.9.	*Enthusiasm*									•	•		•	3
7.	Dependability	•												1
8.	Experience (in similar projects)	•		•	•	•		•	•			•	v	8
9.	Self views			•		•		•	•					4
10.	Self relevant goals			•		•		•	•				•	5
11.	Paperwork								•					1
12.	Job stress								•	•			•	3
13.	Pay									•			•	2
14.	Problem specification, selection, analysis of alternatives						•	•	•		•			4
15.	Conceptual and organizational skills													5
15.1.	*Planning*										•		•	2
15.2.	*Organizing*										•		•	2
15.3.	*Strong goal orientation*										•			1
16.	Project management skills													13
16.1.	*Project management skills*												•	1
16.2.	*Leadership of team*		•						•					2
16.3.	*Developing resource plans*		•				•			•				3
16.4.	*Knowledge of project implementation process*		•	•		•	•	•	•		•			7
17.	Business skills (markets)													9
17.1.	*Business skills (markets)*												•	1
17.2.	*Strategic thinker*		•				•							2
17.3.	*Ability to meet the requirements of the customer*		•				•							2
17.4.	*Business case development*		•				•							2
17.5.	*Internal investments*							•						1
17.6.	*Venture capital*							•						1
18.	Technical skills													5
18.1.	*Technical skills*						•							1
18.2.	*Engineering background*		•			•		•			•			4
19.	Appropriate computer tools developed						•				•		•	3
20.	Control							•		•			•	3
21.	Quality	•					•		•					3

References: [1]Figueira *et al.* 2005; [2]Collins 1998; [3]Lorda and Brown 2001; [4]Adobor 2004; [5]Lievens *et al.* 2003; [6]Sykes 1986; [7]Haynes and Love 2004; [8]Chen *et al.* 2008; [9]El-Sabaa 2001; [10]Ogunlana *et al.* 2002; [11]Ling 2003; [12]Mustapha and Naoum 1998.

2.2. Multicriteria selection models

The survey of literature (Table 1) shows that manager selection in construction is a multicriteria problem. Multiple criteria decision-making problems are encountered in various situations where a number of alternatives and actions or candidates need to be chosen based on a set of criteria. In Fig. 2 a set of the most often mentioned criteria in the surveyed references is presented. According to this graphical representation, it is clear that the most important criteria for a project manager in construction selection are personal skills, project management skills, business skills and experience.

When we consider a discrete set of alternatives described by some criteria, there are three different types of analyses that can be performed for providing a significant support to decision-makers:

- Ensure that the decision-maker follows a "rational" behaviour (normative option) – Value functions, Utility theory, distance to the Ideal;
- Give some advice based on reasonable (but not indisputable) rules;
- Find the preferred solution from the partial decision hypothesis – Interactive methods.

The analysis of the purpose can be performed by the criteria of effectiveness, which have different dimensions, different significances (Zavadskas and Vilutienė 2006) and different directions of optimization (Kendall 1970; Kaklauskas *et al.* 2006; Viteikienė and Zavadskas 2007; Bardauskienė 2007). The discrete criteria values can be normalized by applying different normalization methods (Zavadskas and Turskis 2008). The purpose of analysis can also be different (Banaitienė and Banaitis 2006; Kaklauskas *et al.* 2007; Ginevičius and Podvezko 2006; Ginevičius *et al.* 2007; Bregar *et al.* 2008). Multiple criteria decision aid (Hwang and Yoon 1981) provides several powerful and effective tools (Figueira *et al.* 2005; Zavadskas and Kaklauskas 2007; Zavadskas *et al.* 2007; Ustinovichius *et al.* 2007; Banaitienė *et al.* 2008; Ginevičius *et al.* 2008; Zavadskas *et al.* 2008b) for confronting sorting problems.

There is a wide range of methods based on multicriteria utility theory: SAW – Simple Additive Weighting (Ginevičius *et al.* 2008; Sivilevičius *et al.* 2008); MOORA – Multi-Objective Optimization on the Basis of Ratio Analysis (Brauers and Zavadskas 2006; Brauers *et al.* 2008; Kalibatas and Turskis 2008); TOPSIS – Technique for Order Preference by Similarity to Ideal Solution (Hwang and Yoon 1981; Zavadskas *et al.* 2006); VIKOR – a compromise ranking method (Zavadskas and Antuchevičienė 2007); COPRAS – Complex Proportional Assessment (Zavadskas *et al.* 2007); games theory methods (Peldschus and Zavadskas 2005; Antuchevičienė *et al.* 2006) and other approaches (Turskis 2008).

The solution of each multicriteria problem begins with constructing the decision-making matrix X. In this matrix, the values of the criteria x_{ji} may be real numbers, intervals, probability distributions, possibility distributions, qualitative labels or grey numbers.

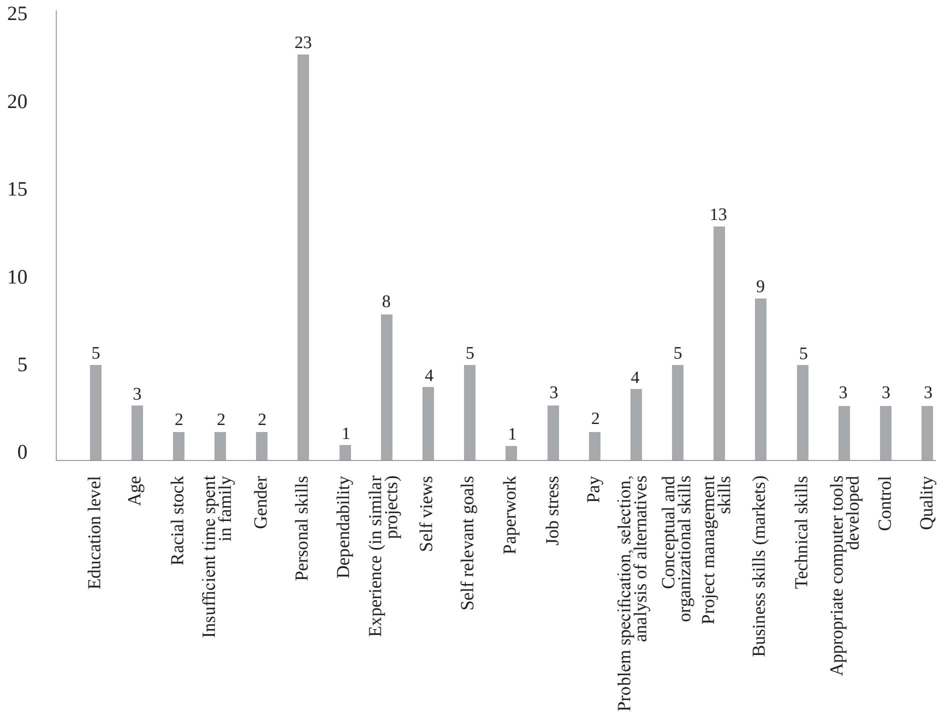

Fig. 2. The most important criteria of project manager selection in construction (the points indicate how many times they are mentioned in the reviewed literature)

3. Research methodology

3.1. Grey system theory

The project manager's work always deals with the future, and values of criteria cannot be expressed exactly. This multicriteria decision-making problem must be determined not with the exact criteria values, but with fuzzy values or with values taken from some intervals.

Deng (1982) developed the Grey system theory. According to him, 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 from the qualitative analysis; the Grey relational grade model is a transfer functional model that is effective in dealing with discrete data (Deng 1988).

Many authors investigated Grey system theory in decision-making. Zhang *et al.* (1994) analysed information entropy of discrete grey numbers, Liu and Lin (2006) – information content of grey numbers, Olson and Wu (2006) – multicriteria models for grey relationships, while Kuo *et al.* (2008) used grey relational analysis in multiple criteria decision-making problems. The Grey system has been applied in many fields, such as economics, agriculture, geography, weather, earthquakes, science etc. Noorul Haq and Kannan (2007) developed a hybrid normalized multicriteria decision-making model for evaluating and selecting the vendor using Analytical Hierarchy Process and Fuzzy Analytical Hierarchy Process and an integrated approach of Grey Relational Analysis to a Supply Chain model. Lin and Lee (2007) proposed a novel forecasting model. Lin *et al.* (2008) presented subcontractor selection model by applying grey TOPSIS method.

3.2. COPRAS-G method

In order to evaluate the overall efficiency of a project, it is necessary to identify selection criteria, to assess information, relating to these criteria, and to develop methods for evaluating the criteria 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 criteria. For this reason COPRAS method can be applied. This method was applied to the solution of problems in construction (Kaklauskas *et al.* 2006; Viteikienė and Zavadskas 2007; Zavadskas *et al.* 2007; Zavadskas *et al.* 2008c) presented the main ideas of COPRAS-G method. The idea of COPRAS-G method with the criterion values expressed in terms of intervals is based on the real conditions of decision making and applications of the Grey system theory. The COPRAS-G method uses a stepwise ranking and evaluating procedure of the alternatives in terms of significance and utility degree.

The procedure of applying the COPRAS-G method consists of the following steps:

1. Selecting the set of the most important criteria, describing the alternatives.
2. Constructing the decision-making matrix $\otimes X$:

$$\otimes X = \begin{bmatrix} [\otimes x_{11}] & [\otimes x_{12}] & \cdots & [\otimes x_{1m}] \\ [\otimes x_{21}] & [\otimes x_{22}] & \vdots & [\otimes x_{2m}] \\ \vdots & \vdots & \ddots & \vdots \\ [\otimes x_{n1}] & [\otimes x_{n2}] & \cdots & [\otimes x_{nm}] \end{bmatrix} = \tag{1}$$

$$\begin{bmatrix} [\underline{x}_{11};\overline{x}_{11}] & [\underline{x}_{12};\overline{x}_{12}] & \cdots & [\underline{x}_{1m};\overline{x}_{1m}] \\ [\underline{x}_{21};\overline{x}_{21}] & [\underline{x}_{22};\overline{x}_{22}] & \cdots & [\underline{x}_{2m};\overline{x}_{2m}] \\ \vdots & \vdots & \ddots & \vdots \\ [\underline{x}_{n1};\overline{x}_{n1}] & [\underline{x}_{n2};\overline{x}_{n2}] & \cdots & [\underline{x}_{nm};\overline{x}_{nm}] \end{bmatrix}; \quad j=\overline{1,n}; \quad i=\overline{1,m},$$

where $\otimes x_{ji}$ is determined by $\underline{x}_{ji}$ (the smallest value, the lower limit) and $\overline{x}_{ji}$ (the biggest value, the upper limit).

3. Determining significances of the criteria q_i.
4. Normalizing the decision-making matrix $\otimes X$:

$$\tilde{\underline{x}}_{ji} = \frac{\underline{x}_{ji}}{\frac{1}{2}\left(\sum_{j=1}^{n} \underline{x}_{ji} + \sum_{j=1}^{n} \overline{x}_{ji}\right)} = \frac{2\underline{x}_{ji}}{\sum_{j=1}^{n} \underline{x}_{ji} + \sum_{j=1}^{n} \overline{x}_{ji}}; \quad \tilde{\overline{x}}_{ji} = \frac{\overline{x}_{ji}}{\frac{1}{2}\left(\sum_{j=1}^{n} \underline{x}_{ji} + \sum_{j=1}^{n} \overline{x}_{ji}\right)} = \frac{2\overline{x}_{ji}}{\sum_{j=1}^{n} (\underline{x}_{ji} + \overline{x}_{ji})}; \quad (2)$$

$j = \overline{1,n}$ and $i = \overline{1,m}$.

In formula (2), $\underline{x}_{ji}$ is the lower value of the i criterion in the alternative j of the solution; $\overline{x}_{ji}$ is the upper value of the criterion i in the alternative j of the solution; m – the number of criteria; n – the number of the alternatives compared.

Then, the decision-making matrix is normalized:

$$\otimes\tilde{X} = \begin{bmatrix} [\tilde{\underline{x}}_{11}; \tilde{\overline{x}}_{11}] & [\tilde{\underline{x}}_{12}; \tilde{\overline{x}}_{12}] & \cdots & [\tilde{\underline{x}}_{1m}; \tilde{\overline{x}}_{1m}] \\ [\tilde{\underline{x}}_{21}; \tilde{\overline{x}}_{21}] & [\tilde{\underline{x}}_{22}; \tilde{\overline{x}}_{22}] & \cdots & [\tilde{\underline{x}}_{2m}; \tilde{\overline{x}}_{2m}] \\ \vdots & \vdots & \ddots & \vdots \\ [\tilde{\underline{x}}_{n1}; \tilde{\overline{x}}_{n1}] & [\tilde{\underline{x}}_{n2}; \tilde{\overline{x}}_{n2}] & \cdots & [\tilde{\underline{x}}_{nm}; \tilde{\overline{x}}_{nm}] \end{bmatrix} \quad (3)$$

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

$$\otimes\hat{x}_{ji} = \otimes\tilde{x}_{ji} \cdot q_i \ \text{or} \ \hat{\underline{x}}_{ji} = \tilde{\underline{x}}_{ji} \cdot q_i \ \text{and} \ \hat{\overline{x}}_{ji} = \tilde{\overline{x}}_{ji} \cdot q_i. \quad (4)$$

In formula (4), q_i is the significance of the i-th criterion.

Now, the normalized decision-making matrix is of the form:

$$\otimes\hat{X} = \begin{bmatrix} [\otimes\hat{x}_{11}] & [\otimes\hat{x}_{12}] & \cdots & [\otimes\hat{x}_{1m}] \\ [\otimes\hat{x}_{21}] & [\otimes\hat{x}_{22}] & \cdots & [\otimes\hat{x}_{2m}] \\ \vdots & \vdots & \ddots & \vdots \\ [\otimes\hat{x}_{n1}] & [\otimes\hat{x}_{n2}] & \cdots & [\otimes\hat{x}_{nm}] \end{bmatrix} = \begin{bmatrix} [\hat{\underline{x}}_{11}; \hat{\overline{x}}_{11}] & [\hat{\underline{x}}_{12}; \hat{\overline{x}}_{12}] & \cdots & [\hat{\underline{x}}_{1m}; \hat{\overline{x}}_{1m}] \\ [\hat{\underline{x}}_{21}; \hat{\overline{x}}_{21}] & [\hat{\underline{x}}_{22}; \hat{\overline{x}}_{22}] & \cdots & [\hat{\underline{x}}_{2m}; \hat{\overline{x}}_{2m}] \\ \vdots & \vdots & \ddots & \vdots \\ [\hat{\underline{x}}_{n1}; \hat{\overline{x}}_{n1}] & [\hat{\underline{x}}_{n2}; \hat{\overline{x}}_{n2}] & \cdots & [\hat{\underline{x}}_{nm}; \hat{\overline{x}}_{nm}] \end{bmatrix}. \quad (5)$$

6. Calculating the sums P_j of the criterion values, whose larger values are more preferable by the formula:

$$P_j = \frac{1}{2}\sum_{i=1}^{k} (\hat{\underline{x}}_{ji} + \hat{\overline{x}}_{ji}). \quad (6)$$

7. Calculating the sums R_j of the criterion values, whose smaller values are more preferable by the formula:

$$R_j = \frac{1}{2} \sum_{i=k+1}^{m} (\underline{\hat{x}}_{ji} + \hat{\bar{x}}_{ji}); \quad i = \overline{k,\ m}. \tag{7}$$

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

8. Determining the minimal value of R_j as follows:

$$R_{\min} = \min_j R_j; \quad j = \overline{1,n}. \tag{8}$$

9. Calculating the relative significance of each alternativeby Q_j the expression:

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

10. Determining the optimality criterionby K the formula:

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

11. Determining the priority order of the alternatives.
12. Calculating the utility degree of each alternative by the formula:

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

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

4. Case study: selection of project manager in construction

Stakeholders decided to build a large office building in Vilnius. They needed a good manager for this project. In order to obtain a set of criteria for selecting senior managers, successful project managers were asked to provide a list of all qualitative and quantitative demands to a manager of a complex project. In other words, they were asked for a detailed job description focussing on large-scale construction skills. Based on the review of literature and managers' questionnaires, 6 key indicators were identified for project manager selection:

- $\otimes x_1$ Personal skills (Score);
- $\otimes x_2$ Project Management skills (Score);
- $\otimes x_3$ Business skills (Score);
- $\otimes x_4$ Technical skills (Score);
- $\otimes x_5$ Quality skills (Score);
- $\otimes x_6$ Time of decision-making (Score).

Optimization directions of the selected criteria are as follows:

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

- $\otimes x_6 \xrightarrow{optimization\ \ direction} \min.$

Personal skills. Personal skill (Lorda and Brown 2001; El-Sabaa 2001) is used to connote the ability of a project manager to work effectively as a group member and to build a co-operative effort within the team he leads. Personal skill includes *political and cross-cultural management skills* (Adobor 2004; Ogunlana *et al.* 2002), that equates political behaviour with self-interested behaviour. The political model in organizations is conceptualized as coalitions accept, and political activity may actually be beneficial for decision making (Ogunlana *et al.* 2002). Cross-cultural management skills will be useful in adapting the challenges of working in a multi-cultural organization.

Project management skills include *technical competence and business knowledge* and *concept of leadership.* Technical competence and business knowledge will positively affect the performance of key management tasks such as that the higher the technical competence and business knowledge of a manager, the greater the likelihood that he or she will be effective in the role (Ogunlana *et al.* 2002). Leadership includes items like individual influence, integrity, strategic leadership, teamwork and collaboration, communication and tenacity (Collins 1998). Team members are characterized by an understanding of the need for cooperation and emphasis on listening to people and by the motivation of the staff, individual approach (Adobor 2004; Tafel and Alas 2007), etc. Championing is positively associated with the use of influence tactics and transformational leadership, such as the higher the championing ability of a manager, the greater the likelihood that he or she will be effective in the role (Ogunlana *et al.* 2002).

Business skills. These include an excellent understanding the business (Adobor 2004), an ability to hire, train, and motivate other employees. In addition, managers need to be flexible, cooperative, and open to opposing viewpoints.

Technical skill implies (El-Sabaa 2001) an understanding of, and proficiency in, a specific kind of activity, particularly one that involves methods, processes, procedures or techniques. Technical skills mentioned by Collins (1998) include the following items: integration management, scope management, time management, cost management, quality management, risk management and procurement management.

Quality skills. Based on the economic theory of the firm which states that the objective of the firm is to maximize its profit, it is hypothesised that a stakeholder may select project manager who quotes low fees so as to minimize the initial costs. This hypothesis is tested in the fieldwork, with the awareness that fees should be not an important issue, and value adding by project manager is much more important. Added value by project manager is difficult to quantify, but it can manifest itself in designs, which have a high technical and functional quality, are accurate and error-free, being within the stake holder's budget (Ling 2003).

Time of decision-making depends on management, business and technical skills in terms of planning, organizing, staffing, directing, and controlling.

The significances q_i of attributes (Table 2) were determined by the expert judgment method by Kendall (Kendall 1970; Zavadskas 1987; Turskis *et al.* 2006; Zagorskas and Turskis 2006). A survey has been conducted and 35 experts have been questioned. The respondents were stakeholders and managers of construction projects having the experience in construction project administration of 5 and more years.

Criteria values describing the performance of each potential project manager are collected according to the test results, on the basis of direct communication with stakeholders and according to their past work experience.

Stakeholders rated managers for performance of a project by applying COPRAS-G method. The initial decision-making values and intermediary calculation data as well as the weighted normalized values of the criteria describing the compared alternatives, are also presented in Table 2.

Table 2. Initial decision-making matrix with the criterion values described in intervals $\otimes X$ and normalized weighted matrix $\otimes \hat{X}$

Initial decision-making matrix $\otimes X$												
Criteria												
	$\otimes x_1$		$\otimes x_2$		$\otimes x_3$		$\otimes x_4$		$\otimes x_5$		$\otimes x_6$	
Opt.	*max*		*max*		*max*		*max*		*max*		*min*	
q_i	0.25		0.15		0.12		0.20		0.13		0.15	
Manager	$\otimes x_1$		$\otimes x_2$		$\otimes x_3$		$\otimes x_4$		$\otimes x_5$		$\otimes x_6$	
	$\underline{x}_1$	$\overline{x}_1$	$\underline{x}_2$	$\overline{x}_2$	$\underline{x}_3$	$\overline{x}_3$	$\underline{x}_4$	$\overline{x}_4$	$\underline{x}_5$	$\overline{x}_5$	$\underline{x}_6$	$\overline{x}_6$
1	50	60	40	55	10	20	50	70	50	45	30	40
2	70	80	60	70	40	45	60	75	70	80	70	60
3	60	70	55	70	30	40	70	80	55	65	40	50
Normalized weighted matrix $\otimes \hat{X}$												
	$\hat{\underline{x}}_1$	$\hat{\overline{x}}_1$	$\hat{\underline{x}}_2$	$\hat{\overline{x}}_2$	$\hat{\underline{x}}_3$	$\hat{\overline{x}}_3$	$\hat{\underline{x}}_4$	$\hat{\overline{x}}_4$	$\hat{\underline{x}}_5$	$\hat{\overline{x}}_5$	$\hat{\underline{x}}_6$	$\hat{\overline{x}}_6$
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
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
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 values presented in the initial decision-making matrix (Table 2), we can state that:

- the first alternative is the worst, according to the optimistic values that must be maximized, and the best, according to the sixth criterion, that must be minimized (according to the pessimistic values, the same conclusion can be made);
- the second alternative is the best, according to the optimistic values of first, second, third and fifth criteria, but it is ranked second according to the fourth criterion and the third according to the sixth criterion values (according to the pessimistic values, a similar conclusion can be made);
- the third alternative is ranked second, according to all the criteria values (except for the fourth criterion, according to which it is ranked first) in both cases, when decision is made according to the pessimistic and optimistic criteria values.

According to the algorithm presented above, the utility degree of each alternative was estimated. The vector of significance of alternatives is $Q = [0.260; 0.394; 0.346]$, while the vector of utility degree values is $N = [65.93; 100; 87.66]$. According to the significance of alternatives of $Q_2 = 0.394$, the second project manager is the best. The second project manager is also the best in terms of the utility degree that N_2 = 100%. The third project manager with the utility degree of N_3 = 87.66% is ranked second. The first project manager with the utility degree of N_1 = 65.93% is ranked third. According to N, the ranks obtained in the procedure of project manager selection are as follows: project manager 2 $\succ$ project manager 3 $\succ$ project manager 1. Based on the results of this ranking, the second project manager was selected.

5. Conclusions

- Project manager selection in construction is a multicriteria problem.
- In actual multicriteria modelling of multi-alternative assessment problems, the criteria values referring to the future can be expressed in terms of intervals.
- COPRAS-G (a COPRAS method with grey criteria values) is a method for assessing the alternatives by multiple-criteria values expressed in terms of 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 solving a wide range of problems associated with the construction project selection.

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PROJEKTŲ VALDYTOJO PARINKIMO DAUGIATIKSLIO VERTINIMO MODELIS

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Santrauka

Rodiklių ir susietų subrodiklių skaičius daro poveikį statybos projektų vadovo parinkimui. Išnagrinėjus literatūrą buvo atrinkti pagrindiniai rodikliai, turintys įtaką projektų valdytojo atrankai. Išskirtos svarbiausios projektų valdytojo charakteristikos, gerinančios efektyvų statybos projektų valdymą. Projektų valdytojo modelis pagrįstas daugiatikslio vertinimo metodais. Straipsnyje apžvelgtas intervalais išreikštų sprendinių metodologijos pritaikymas, apibrėžtas alternatyvų naudingumas. Pateiktas daugiatikslio vertinimo kompleksinio proporcingumo įvertinimo metodas naudojant intervalais išreikštus rodiklius intervalais (COPRAS-G). Pateikiamame modelyje alternatyvų parametrai išreikšti intervalais, alternatyvos ranguojamos, nustatomas jų prioritetas. Sprendžiamas uždavinio pavyzdys rodo efektyvų statybos projektų valdytojo parinkimą. Tai iliustruoja gauti rezultatai.

Reikšminiai žodžiai: COPRAS, sprendiniai, išreikšti intervalais, valdytojas, parinkimas.

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