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Criteria Evaluation for Contractor Selection in Cultural Heritage Projects Using Multiple Criteria Approach

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Abstract. The low bid is the most common applicable method in the contractor selection process, considering by only one dominant criterion. However, the lowest price criterion not allows selecting qualified, responsible, sophisticated, and knowledgeable contractor for cultural heritage projects. Moreover, the improper contractor selection may induce claims, litigation, and poor quality work, increased costs for project performance or management. Selection of appropriate contractor is very important for the success and excellent accomplishment of cultural heritage projects. This study presents criteria evaluation for contractor selection in cultural heritage projects. This paper provides reviews of contractor selection and proposed criteria evaluation, and determines the criteria of culture heritage contractor selection. This study applies the multiple criteria approach: AHP, PROMETHEE and EDAS approaches.

Keywords: contractor, selection, cultural heritage, projects, MCDM, AHP, PROMETHEE, EDAS.

Introduction

There are many presented studies of contractor, subcontractor or supplier selection in construction industry. However, contractor selection relevant to cultural heritage projects has been much less researched. Heritage project is more complexity and originality, according to construction projects. Moreover, culture heritage create cultural significance, which is a combination of architectural, historical, spiritual, aesthetic, symbolic, economic and social values. The preservation and restoration of heritage buildings are critical process, requiring an experienced, qualified, flexible, and disciplined contractor. Furthermore, the success of heritage project belongs to proper contractor selection.

Nowadays, the contractor selection is based on the low price, which can not ensure the quality (Konno, 2018) and future costs of the construction and heritage projects. Moreover, improper contractor selection usually accompanied by claims, litigation, disputes, inexperienced employee, that always results in schedule delays and cost overruns.

The criteria selection is a complicated task, seeking to evaluate and select appropriate contractor for heritage projects. Furthermore, the researchers have presented construction contractor selection criteria, which are generic and not including the specific criteria relevant with heritage projects. Different criteria selection allows evaluate the values of contractors.

This study presents criteria evaluation for contractor selection in cultural heritage projects. This paper provides reviews of contractor selection and proposed criteria evaluation, and determines the criteria of culture heritage contractor selection. This study applies the multiple criteria approach: AHP, PROMETHEE and EDAS approaches.

1. Literature review

1.1. Contractor selection approaches

Nowadays, the client for contractor selection applies various type of public tendering procedures, such as open tendering, restricted tendering, competitive negotiated tendering (Niento-Morote & Ruz-Vila, 2012), competitive dialogue, subsided public housing contracts procedure, works concessions procedures, innovation partnership or design contest. Tenders are evaluated by the lowest price or the most economically advantageous tender.

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The lowest price tender don't ensure the transparency of the low-bid methodology and determines the disadvantages of unrealistic low bids (Awwad & Ammoury, 2019). According to (Mousakhadi, Ranjbar, & Ashoori, 2018), the lowest price may induce the risk of not selecting the suitable contractor who obtains the necessary capabilities. Moreover, the low price may cause poor quality of the construction performance, uncertain of future costs or potential for claims and litigations. (Eriksson, 2017) and (Loosemore & Richard, 2015) claimed that, the low price could reduce improvement across the construction projects and contractor's motivation to innovative.

The most economically advantageous tender is proposed to apply where value for money can be determined as a balance between price and quality. However, nowadays, this type of tender is rarely applying for contractor selection, especially in heritage projects. Moreover, till now the economically advantageous tender, mostly, is based on the lowest price criterion.

In seeking to select the qualified, experienced, and conscientious contractor for construction projects, many researchers have proposed multi-criteria decision-making (MCDM) approaches for solving contractor selection problems. AHP approach (Martin, Koyloss, & Welch, 2018; Assaf, Hassanain, Hadidi, & Amman, 2017; Chiang, Yu, & Luarn, 2017; Hadidi & Khater, 2015; Fong & Choi, 2000) was presented for contractor, sub-contractor and supplier selection. Some researchers have suggested AHP method integrated with other multi-criteria decision-making approaches: AHP and ANP (Sarkis, Meade, & Presley, 2012), AHP and PROMETHEE (Polat, 2016), AHP and Fuzzy AHP technique (Plebankiewicz & Kubek, 2016), AHP and Zero one integer linear programming (Rajaprasad, 2018), and AHP and Value Engineering Technique (Aboelmagd, 2018).

Moreover, contractor or subcontractor prequalification and selection have been presented by several researchers, applying Fuzzy Sets (Niento-Morote & Ruz-Vila, 2012; Afshar, Alipouri, Sebt, & Chan, 2017; Alhumaidi, 2015; Nassar & Hosny, 2013; Plebankiewicz, 2012) and Fuzzy Sets approaches combine with MCDM techniques: Fuzzy AHP (Nyongesa, Musumba, & Chileshe, 2017), Fuzzy AHP and Fuzzy TOPSIS (Taylan, Kabli, Porcel, & Herrera–Viedma, 2018; Polat, Eray, & Bingol, 2017; Nasab & Ghamsarian, 2015), Fuzzy Set Theory and EDAS (Keshavarz Ghorabaee, Amiri, Zavadskas, Turskis, & Antuchevičienė, 2018), Fuzzy ELECTRE (Hashemi, Mousavi, Zavadskas, Chalekaee, & Turskis, 2018).

Additionally, contractor evaluation was suggested, developing ANP (Rashvand, Abd Majid, & Pinto, 2015; Cheng & Li, 2004), WASPAS – G (Zavadskas, Turskis, & Antuchevičienė, 2015; San Cristobal, 2012), TOPSIS and DEMATEL (Zhang, Qi, & Liang, 2018), CILOS and IDOCRIW (Trinkūnienė et al., 2017), MOORA (Brauers, Zavadskas, Turskis, & Vilutienė, 2008), COPRAS (Zavadskas, Kaklauskas, & Vilutiene, 2009; Kaklauskas et al., 2006) methods.

Many researchers of their studies presented the contractor, subcontractor or supplier prequalification, evaluation and selection of construction projects, but currently, contractor selection related to heritage projects has received less attention by researchers.

1.2. Criteria discussed

Tender evaluation may consist of various diverse criteria, follows as technical and management capability, financial ability, previous experience, environment and quality management. The economically advantageous tender could ensure the application of these criteria, because in this type of tender the lowest price criterion cannot create the basis for the reward. The criteria set consist of the various criteria and their combination, which are based on the client requirements. Moreover, the most economically advantageous tender criteria are usually applied when the quality of performance or service is important for client. For this reason, the client can take into account not only the direct costs of purchase, but and the life cycle costs. However, the economically advantageous criteria, mostly, are not related to purchase's object and aren't evaluating contractor's performance of the construction project. Generally, the economically advantageous criteria evaluate the pursued policies of the contractor. Moreover, determined criteria set is not be objectively compared.

However, the lowest price creates the basis for the award in the most economically advantageous tender. The lowest price is dominant criterion in the contractor selection process, and it usually manages less partnership among diverse parties involved in the construction projects and possible compromise of the project quality (Awwad & Ammoury, 2019). This price's domination is not satisfying the sustainable development principles and effectiveness money management.

Considering the lowest price is as the singular reward criterion may lead to an unqualified, inexperienced, insufficient, incompetent contractor selection (Polat, 2016).

Presently, researchers have determined the contractor selection criteria. The most common criteria presented in the studies are financial soundness (Fong & Choi, 2000; Polat, 2016; Gao, 2018;(Vahdami, Meysam Mousavi, Hashemi, Mousakhami, & Tavakkoli-Moghaddam, 2013), technical capability (Niento-Morote & Ruz-Vila, 2012; Zavadskas et al., 2015; Zhang et al., 2018; Vahdami et al., 2013), management ability (Niento-Morote & Ruz-Vila, 2012; Chiang et al., 2017; Kaklauskas et al., 2006), health and safety (Chiang et al., 2017; Taylan et al., 2018; Gao, 2018; Holt, 1998) and reputation (Kaklauskas et al., 2006; Keung & Yiu, 2015; Enshassi, Mohamed, & Modough, 2013; Darvish, Yasaei, & Saeedi, 2009). Furthermore, along these criteria was proposed additional criteria, namely, previous performance (Hadidi & Khater, 2015; Cheng & Li, 2004; Ulubeyli & Kazaz, 2016), quality (Martin et al., 2018; Marzouk, El Kherbawy, & Khalifa, 2013; Juan, Perng, Castro–Lacouture, & Lu, 2009); and experience (Yang, H. Wang, W. Wang, & Ma, 2016; Topcu, 2004).

Several researchers (Niento-Morote & Ruz-Vila, 2012; Assaf et al., 2017; Polat, 2016; Hasnain, Thaheem, & Ullah, 2018; Attar, Khanzadi, Dabirian, & Kalhor, 2013) determined contractor selection sub-criteria, which has grouped into principal criteria.

The researchers have suggested diverse criteria for contractor selection, however these criteria are common and could not contain the special criteria relating with heritage projects.

2. Criteria determination for contractor selection evaluation

Cultural heritage buildings are intangible value, having architectural, spiritual, artistic, historical and cultural characteristics. Therefore, it is important to preserve and restore for future generation, providing economic and social growth, helping to generate tourism income, encourage innovation and creativity, and getting to strength community's identity. The appropriate contractor selection is important process for cultural heritage preservation and restoration.

Studies have showed that the lowest price or the most economically advantageous tender is not sufficient to ensure the proper results, seeking to select a suitable contractor. The cultural heritage project is complex, requiring experienced, and qualified, flexible, integrity, disciplined and conscientious contractor. Furthermore, the proper contractor has to have good communication, managing, and technical skills.

The present study determines six principal criteria (Figure 1). There is a mix of quantitative and qualitative criteria. The principal quantitative criterion is financial stability (x_1), contracts (x_2) and sub-contractors (x_3). The main qualitative criterion is management capability (x_4), personnel management (x_5), risk (x_6) and reputation (x_7). Financial stability criterion includes income (x_{11}), value of reward (x_{12}), days sales (x_{13}) and payable (x_{14}) outstanding, current ratio (x_{15}) and profit before tax (x_{16}) sub-criteria.

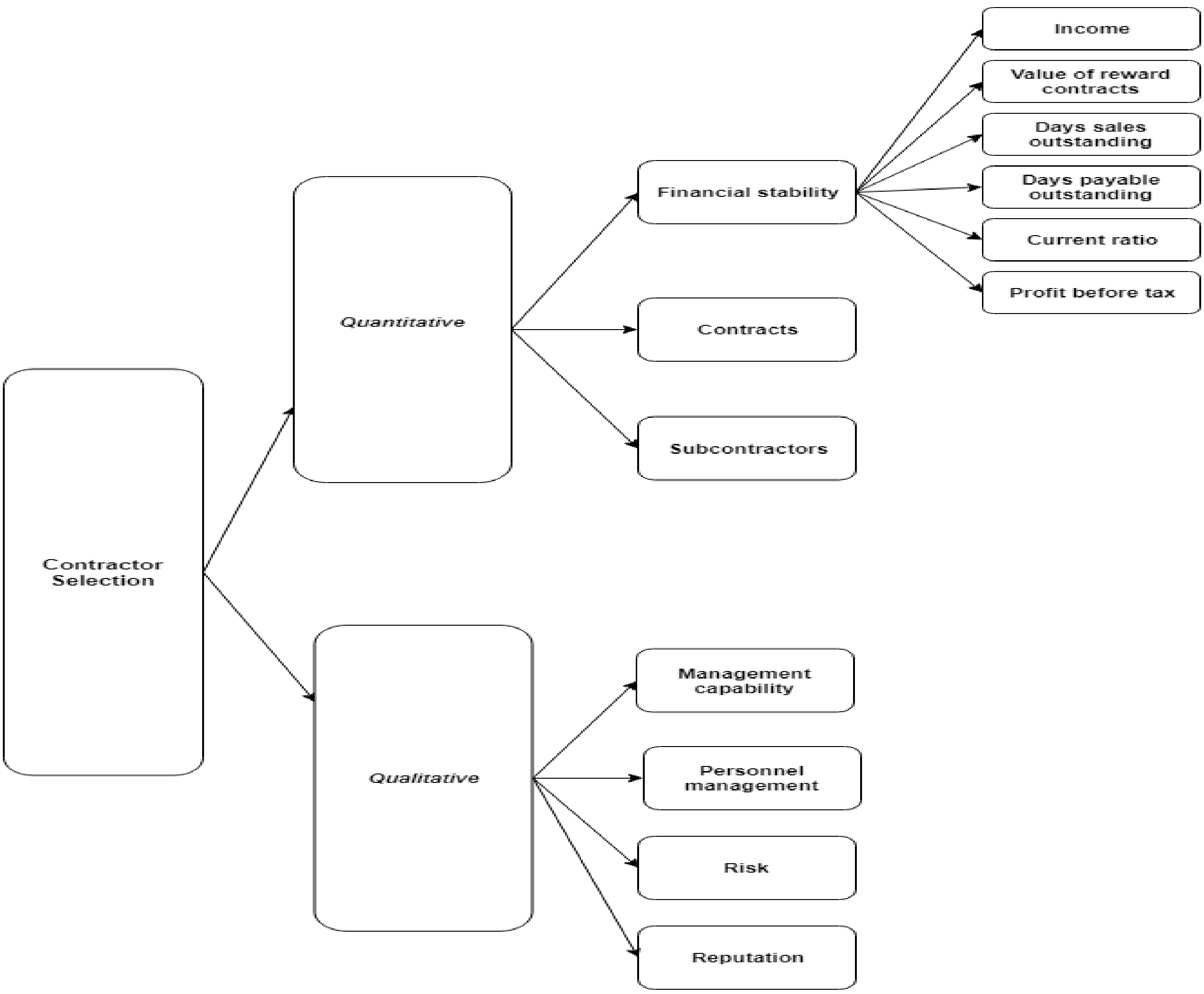

Figure 1. Criteria determination for contractor selection

The authors determined criteria are applying, seeking to select qualified, disciplined, flexible, and integrity contractor for cultural heritage projects. This criteria set is applying, considering to the specified criteria characteristics, shows in Table 1.

Table 1. Criteria characterisics

Criterion	Characteristic
Financial stability	Contractor financial capacity: evaluate enterprise's income or profit, measure capability to pay out short-term and long-term responsibilities, seeking to identify company's financial troubles, probable bankruptcy
Contracts	Company's capability to award both construction and heritage projects contracts, according to contracts' values and numbers
Sub-contracts	Procurement's number, in which have attended and rewarded with sub-contractors' company
Management capability	Management capability is core to successful company's activity, business, and innovation
Personnel management	Company's ability to plan, organize and manage the human resource (employee)
Risk	Contractor dependence of various risk group
Reputation	Reputation is directly proportionate to the quality of the work and services that contractor offer

The authors of the article analysed the problem, selecting four construction companies (Table 2), which are related with performance of cultural heritage buildings. The full names of these companies are not provided for the sake of confidentiality. Problem is analysing by applying a multi-criteria approach.

3. The application of AHP, PROMETHEE and EDAS approaches

MCDM methods are a valuable tool for decision makers and were developed in various civil engineering areas, like in sustainability (Shen, Zavadskas, & Tzeng, 2018; Zavadskas, Antucheviciene, Vilutiene, & Adeli, 2017), energy efficient (Kaya, Çolak, & Terzi, 2018), sustainable material selection (Govindan, Shankar, & Kannan, 2016), green supply chain (Banasik, Bloemhof-Ruwaard, Kanellopoulos, Claassen, & van der Vorst, 2018). This study applies the multiple criteria approach: AHP, PROMETHEE II (Morkūnaitė, Podvezko, Zavadskas, & Baušys, 2019) and EDAS approaches.

Table 2. The cultural heritage contractor selection alternatives, financial stability's criterion and sub-criteria

Criteria		The evaluation of criteria, min/max	Alternatives			
			A_1	A_2	A_3	A_4
Quantitative criteria						
Financial stability	x_1	*max*				
Income (*million Eur*)	x_{11}	*max*	58.93	38.67	5.47	4.32
Value of rewarded contracts (*million Eur*)	x_{12}	*max*	22.5	13.09	10.6	13.36
Days sales outstanding (*days*)	x_{13}	*max*	48.31	60.85	47.06	76.3
Days payable outstanding (*days*)	x_{14}	*min*	37.27	116.59	44.62	57.15
Current ratio	x_{15}	*max*	1.66	1.56	2.34	4.85
Profit before tax (%)	x_{16}	*max*	2.07	0.83	5.08	0.71

The alternatives were evaluated by financial stability sub-criteria. The financial stability's partial criteria weights determined, using AHP method (Table 3).

Table 3. Financial stability's partial criteria weights

ω_{11}	ω_{12}	ω_{13}	ω_{14}	ω_{15}	ω_{16}
0.4522	0.2075	0.0715	0.0441	0.1262	0.0287

In the EDAS approach determines alternatives based on the distance from average solution (Keshavarz Ghorabaee, Zavadskas, Olfat, & Turskis, 2018; Čereška, Podviezko, & Zavadskas, 2018). Two measures for calculating the cumulative criterion of the method are used. The first measure is the positive distance from average (PD), and the second is the negative distance from average (ND). Evaluation of the alternatives is made according to higher values of PD and lower values of ND. The steps for using the EDAS method are as follows:

Step 1: The decisions matrix (R) is constructed:

$$R = \left\| r_{ij} \right\|, \tag{1}$$

which contains statistical data (experimental criterion values). This decision matrix will also be used in other MCDM methods.

Step 2: Vector of weights is created:

$$\Omega = (\omega_j), \tag{2}$$

where $i = 1,2, ..., n$; $j = 1,2, ..., m$; m – the number of criteria; n – the number of options compared.

Step 3: The average solution is calculated:

$$\mathrm{AV}_j = \sum_{i=1}^{n} r_{ij} \big/ n. \tag{3}$$

Step 4: Positive distances from average (PD) and the negative distances from the average solution (ND) are calculated for the maximizing criteria:

$$\mathrm{PD}_{ij} = \frac{\max(0, (r_{ij} - \mathrm{AV}_j))}{\mathrm{AV}_j}; \tag{4}$$

$$\mathrm{ND}_{ij} = \frac{\max(0, (\mathrm{AV}_j - r_{ij}))}{\mathrm{AV}_j}, \tag{5}$$

and for the minimizing criteria:

$$\mathrm{PD}_{ij} = \frac{\max(0, (\mathrm{AV}_j - r_{ij}))}{\mathrm{AV}_j}; \tag{6}$$

$$\mathrm{ND}_{ij} = \frac{\max(0, (r_{ij} - \mathrm{AV}_j))}{\mathrm{AV}_j}, \tag{7}$$

where PD_{ij} and ND_{ij} denote the positive and negative distance of the i-th alternative from the average solution in terms of j-th criterion, respectively.

Step 5: The weighted sum of PD and ND is calculated for all alternatives:

$$\mathrm{SP}_i = \sum_{j=1}^{m} \omega_j \cdot \mathrm{PD}_{ij}; \tag{8}$$

$$\mathrm{SN}_i = \sum_{j=1}^{m} \omega_j \cdot \mathrm{ND}_{ij}, \tag{9}$$

where ω_j is the weight of j-th criterion.

Step 6: Values of SP and SN are normalized for all alternatives:

$$\mathrm{NSP}_i = \frac{\mathrm{SP}_i}{\max_i \mathrm{SP}_i}; \tag{10}$$

$$\mathrm{NSN}_i = 1 - \frac{\mathrm{SN}_i}{\max_i \mathrm{SN}_i}. \tag{11}$$

Step 7: The cumulative criterion AS of the EDAS method is calculated for all alternatives:

$$\mathrm{AS}_i = \frac{1}{2}(\mathrm{NSP}_i + \mathrm{NSN}_i), \tag{12}$$

where $0 \leq \mathrm{AS}_i \leq 1$.

In seeking to compare results of two different MCDM methods, authors presented the alternatives evaluation, applying PROMETHEE II and EDAS methods. The results are presented in Table 4.

Table 4. Financial stability's sub-criteria by PROMETHEE and EDAS evaluation

		A_1	A_2	A_3	A_4
PROMETHEE	F^+	1.868	1.024	0.169	0.661
	F^-	0.268	0.855	1.450	1.150
	F	1.600	0.169	–1.281	–0.489
	Ranks	*1*	*2*	*4*	*3*
EDAS	AS_1	0.934	0.507	0.039	0.132
	Ranks	*1*	*2*	*4*	*3*
Total Ranks		1	2	4	3

Conclusions

The selection of appropriate and qualified contractor is a crucial task for the success of heritage project. Moreover, the proper contractor selection allows avoiding the increased costs for project performance or management, failures, claims or poor work. Nowadays, the low price is a dominant criterion, but it can not ensure the quality of work. Therefore, the proper methods and criteria of heritage contractor selection can ensure qualified contractor selection. This study proposes a set of the criteria for evaluating and selecting the proper heritage contractor. These criteria include financial stability, contracts and sub-contractors, management capability, personnel management, risk and reputation issues. The model for contractor selection is based on using multicriteria evaluation methods AHP, PROMETHEE II and EDAS. Taking into account the financial stability's sub-criteria used in the calculations, the results of applied methods are matched. The priority was given to the A_1 heritages' contractor. The last priority was given to the A_3 heritages' contractor.

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