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Evaluation of Contractors Performance in Iraqi Construction Projects Using Multiple Criteria Complex Proportional Assessment Method (COPRAS)

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Abstract The construction industry is a significant part of every economy and that performance assessment holds the key to its success in national socio-economic goals. Successful Construction projects are closely related to contractor's performance, where increases a suitable contractor the chances of satisfactory completion of a project in time, cost and quality specified. Contractors' performance can provide robust benchmarks for contractors and help to identify ways towards performance improvement. Contractor performance can be defined by the level and quality of projects delivered to clients. The objective of this research work is to study evaluate contractor performance for construction projects, and how it can be employed technical grounds (The Method Of Multiple Criteria Complex Proportional Assessment) in the assessment of contractors Performance for construction projects, through the identification of criteria used to select the best contractor in terms performance as well as determining the list contractors of to choose the optimal contractor of these terms. For achieving the goal of the research its data collecting from the literature that addressed the factors Affecting Contractor Performance and method of multiple criteria complex proportional assessment (COPRAS), and finally personal interviews of engineers, contractors and owners qualified. The results of data analysis for the sample and then Rank Order Centroid method (ROC) and distinctive in their application showed that criteria of the quality of work, project management, technical knowledge, and timeliness of performance are the most important criteria for bilateral comparisons between contractors. Finally, and by calculating the relative importance, priorities of alternatives, and the benefit degree we find that the C1 has received the largest share of the benefit and importance.

In the end, was a set of conclusions and recommendations of various aspects of the topic from accelerating the application of techniques of decision- making multi-criteria in the evaluation of contractors performance in addition to expediting the application of the systems proposed by the researcher for the evaluation of contractors performance.

Key words: Contractor Performance ,multiple criteria decision making (MCDM), complex proportional assessment of alternatives (COPRAS)



1. Introduction

The construction industry serves as a catalyst to drive the economic development of a nation and the industry is referred to as a growth engine. Numerous government studies have however criticized the weak performance of the industry in terms of production, efficiency and quality systems. Implement many construction companies an integrated framework to ensure continuity and better building efficiency [1]. Poor performance of contractors results in poor quality of the products and time delay in construction resulting in cost and time overrun. This can be avoided by the proper choice of contractors when past performance data is available. Performance evaluation of contractors provides a base for the selection of contractors based on the importance of work and capability of the contractor. Comparison provides a base for improvements in the performance of contractors [2]. In construction projects public or private then the goal of all parties (owners, consultants, contractors, subcontractors, and suppliers) is to complete the project on schedule, within the planned budget, with the quality high, and most safely [3]. The client's selection is made depending on the evaluation of contractors performance. So, contractors must be creators in their work and always looking for a better method to completion t their work accurately [4]. Project success reflects a good contractor and its skills in site management and project failure indicates a lack of expertise and a poor communication skill among the employees. Usually, the performance of the contractor is responsible for either negative or positive factors impacting the performance of the project [5]. The author of the study decided to analyze the problem of evaluating the performance of contractors companies by following a multi-criteria approach, and use the COBRAS method. COPRAS (COmplex PROportional ASsessment) method was firstly presented by is presented by Zavadskas and Kaklauskas as a multiple-criteria decision-making method (Zavadskas et al., 1994) [6]. COPRAS approach uses the systematic rating and evaluation of alternative procedures in terms of their importance and degree of utility [7]. Explanation of COPRAS methods and possibilities of its use are published in a great number of papers as follows:

Arzu Organ et al. (2016) applied COPRAS to the performance evaluation of the research assistant [8]. Jaber (2018) used COPRAS to assessment risk in construction projects in Iraq [9]. George et al. (2019) used COPRAS for selecting the best supplier of construction projects [10]. Jasim (2016) used COPRAS to assessment of design quality management for diyala city projects [11]

2. Objectives of study

Regular use technology to be supportive of the multiple Criteria decision-making process such as:

1. To study contractor performance and their best practices for construction projects.
2. To identify the factors affecting the performance of contractor construction projects.
3. Select the best contractor in terms of performance.
4. To give suggestions and recommendations for the effective performance of the contractor in construction projects.

3. Methodology of study

The research objective was achieved by following the steps as shown in Figure 1 below:

1. A literature review is conducted for previous studies related to the scope of research, including books, papers, websites, and theses.
2. The practical part of the research includes a questionnaire and personal interviews with specialists in the field of contracting
3. Application of the COPRAS method to assess the performance of contractors in Iraqi construction projects.

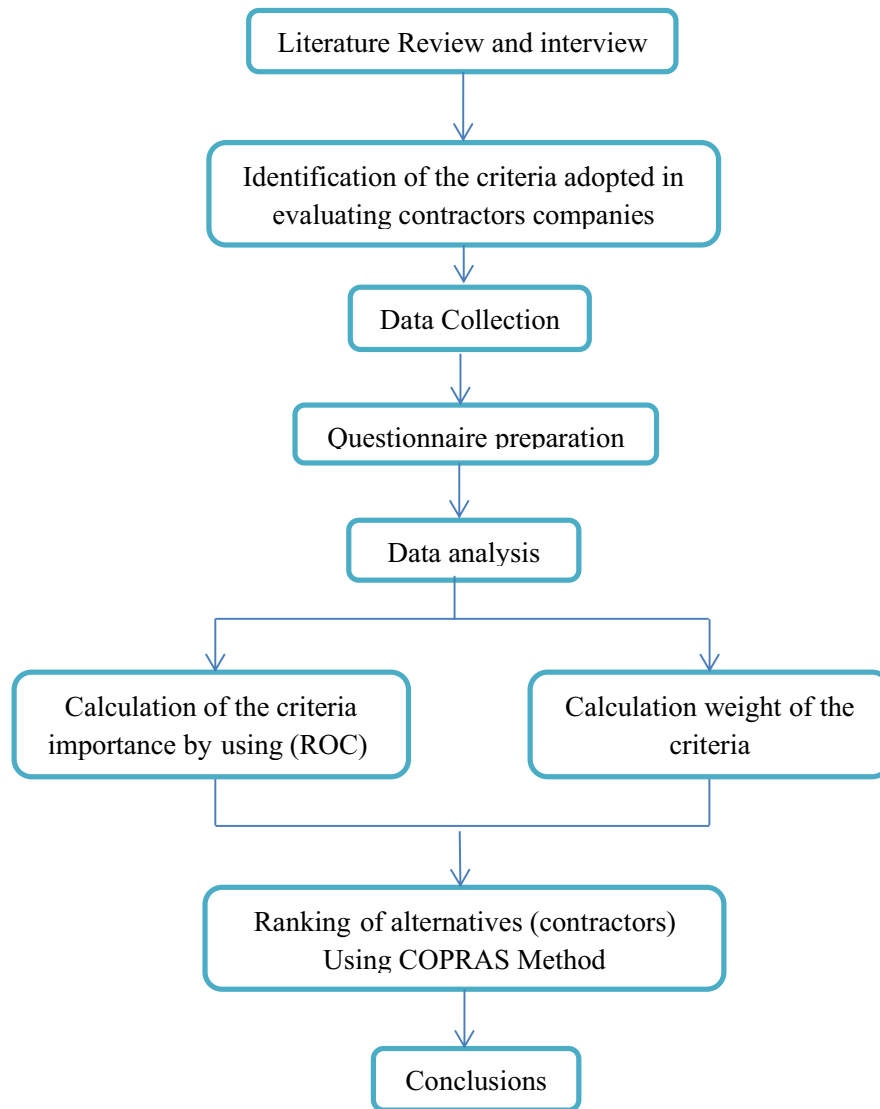


Figure 1. Process Evaluation of Contractors Performance

4. Steps to implement COPRAS Method

Method of the COPRAS includes several steps [8, 10-13]:

Step 1. Construction of Decision Matrix

As in all decision-making problems of multiple criteria, first of all decision matrix is constructed. The matrix of decision is as follows:

$$X = [x_{ij}]_{m \times n} = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} \quad (1)$$

Where x_{ij} is the i -th alternative assessment value with respect to the j -th criterion, m is the number of alternatives and n is the number of criteria.

Step 2: Normalization of decision matrix using the equation below:

$$R = [r_{ij}]_{m \times n} = \frac{x_{ij}}{\sum_{i=1}^m x_{ij}} \quad (2)$$

Step 3: Determination of the weighted normalized decision matrix, D , by using the following equation:

$$D = [y_{ij}]_{m \times n} = r_{ij} \cdot w_j, \quad (i = 1, \dots, m \text{ and } j = 1, \dots, n) \quad (3)$$

Where r_{ij} is the normalized performance value of i -th alternative on j -th criterion and w_j is the weight of j -th criterion.

The sum of weighted normalized values of each criterion is equal to the weight for that criterion:

$$\sum_{i=1}^m y_{ij} = w_j \quad (4)$$

Step 4: In this step the sums of weighted normalized values are calculated for both the beneficial and non-beneficial criteria by using the following equations:

$$S_{+i} = \sum_{j=1}^n y_{+ij} \quad S_{-i} = \sum_{j=1}^n y_{-ij} \quad i = 1; \dots; n; j = 1; \dots; m \quad (5)$$

Where y_{+ij} and y_{-ij} are the weighted normalized values for the beneficial and non-beneficial criteria, respectively.

Step 5: Determination the relative significances of the alternatives, Q_i , by using the following equation:

$$Q_i = S_{+i} + \frac{\min S_{-i} \sum_{i=1}^m S_{-i}}{S_{-i} \sum_{i=1}^m \left(\frac{\min i S_{-i}}{S_{-i}} \right)} \quad i = 1; \dots; m \quad (6)$$

Where S_{-i} is the minimum value of S_{-i} .

Step 6: Calculation of the quantitative utility, U_i , for i -th alternative by using the following equation:

$$U_i = (Q_i / Q_{max}) \times 100\% \quad (7)$$

Where Q_{max} is the maximum relative significance value.

The degree of utility of the alternative is determined by comparing the analyzed alternatives with the most efficient alternative. All the benefits of the degree of benefit related to the analyzed alternatives will range from 0% to 100%.

5. Calculation of the criteria importance

There are several methods used to calculate the importance of criteria, in this research we used (Rank Order Centroid Method) (ROC), it was first used by (Barron and Barrett) in 1996 [14].

This method is an uncomplicated way to give weight to a number of paragraphs arranged depending on their importance, and the decision-makers can arrange the properties or criteria far easier than to give them weight, this method takes that arrangement as inputs and turns it into weights for each of those criteria.

The first step is to arrange the properties or criteria from the most important to the least important, and then each ROC value is assigned a value that reflects its weight, according to the following formula [15-17].

$$W_j = \left(\frac{1}{M}\right) \sum_{j=1}^M \frac{1}{M} \quad j = 1, 2, \dots, M \quad (8)$$

6. Factors Identification

The comprehensive literature on contractor performance methodology has been reviewed, factors affecting the contractor's performance have been identified, summarized, and included below [2-4, 18-20].

1. Quality of work.
2. Timeliness of performance.
3. Project satisfaction.
4. Safety and health compliance.
5. Budget management.
6. Project management.
7. Technical knowledge.
8. Stress in work.
9. Tender problems.
10. Human related factor.
11. Communication Issues.
12. External factors.

Table 1: The criteria and sub-criteria adopted in evaluating contractors Performance

7. Performance Evaluation of Contractors by COPRAS Method

By following the steps of the COPRAS technology described in the previous sections, the primary objective is to assess the contractor performance of the construction projects and the criteria that have been adopted [2-5,18-21] they are:

Project management (X1), Timeliness of performance (X2), Technical knowledge (X3), Quality of work (X4), Budget management (X5), Stress in work (X6), External factors (X7), Resource Availability (X8), Tender problems (X9), Human related factor (X10), Communication Issues (X11), Safety and health compliance (X12).

As for the sub-criteria that were approved for this evaluation, which were taken from previous research [14,15], through which decision makers can determine the preferences of each alternative decision in terms of their contribution to each criterion, as shown in the Table 1.

To evaluate contracting companies Performance have been chosen four of the contracting companies (alternatives) that work within Diyala University projects, and their names were as follows:

Ard Al-Sharifi Company (C1), Ard Al-Nashma Company (C2), Hatharat AI- Aamgad Company (C3), Al-Ghaith Company (C4). The performance of the contracting companies in Iraq has been evaluated by conducting a field questionnaire that includes the criteria approved in the evaluation, and the companies that will be evaluated to choose the best ones in terms of performance.

Then the results of the questionnaire were scheduled in the light of the answers obtained, as shown in Tables 2 and 3. To calculate the importance of the criteria of performance, and depending on what was mentioned in the steps to implement the Rank Order Centroid Method (ROC) in the previous steps and then performing the important calculations of the criteria as shown in the Table 4 and Figure 2.

Based on what was mentioned in the steps of implementing the COPRAS technique in steps (4,5,6), the calculations were made for the companies within the criteria of Performance as shown in Table 5.

Table 1 :The criteria adopted in evaluating contractors Performance

No	criteria	Code	Sub-criteria
1	Project management	X1	strong monitoring effectiveness of coordination adequate team selection Training effective project scheduling and budgeting Effective communication development and motivation project manager competence decision making skills Troubleshooting Project conformed to contract requirements Presence of an Organizational structure Site preparation time Coordination of contractors work in a timely manner
2	Timeliness of performance	X2	Timely decision making Average delay in regular payments Delays in schedule tackled in an efficient manner Timely performance of the tasks Timely completion of project with sophisticated schedule Timely performance of tasks
3	Technical knowledge	X3	Personnel assigned to the project are well versed and experienced for the work Overall technical capability of the personnel is good Experienced managers and technical personnel available to resolve problems contractor cash flow Contractor experience Good quality of materials supplied at required time Quality in workmanship Frequent inspections carried out in site Proper training programs conducted for workers Project works in compliance with drawings and specifications
4	Quality of work	X4	Project conformed to contract requirements Efforts made to overcome deviations and deficiencies Quality of equipment and raw materials Quality assessment system in organization Suitability of equipment Conformance to specification availability of competent staff
5	Budget management	X5	Timely documentation effectiveness of cost control system

			Budget adherence to target cost Accurate and reliable budget estimate Escalation of material price Excessive variation orders Adherence to target costs on the contract level Proper planning and scheduling of works Labors subjected to stresses in various complex activities
6	Stress in work	X6	Stress-free work environment Workers ability to concentrate on performing their work Productivity problems due to stress Physical conditions
7	External factors	X7	level of technological advancement Economic influence (economic climate) policy Government conditions weather availability of modern equipment Equipment in good operating condition
8	Resource Availability	X8	Timely supply of materials and manpower Availability manpower skilled Experience of workers Quality Control of material Understanding peoples requirements and needs
9	Tender problems	X9	Tendering procedures followed as per by law Issues in quoting rates for the project solved smoothly Overcome issues in the approval of tender Management of tender problems Subcontractors, sub consultants, suppliers and labor force well managed client satisfaction
10	Human Related Factor	X10	contractor characteristics Stakeholder relationship Adherence to target costs on the contract level Good Supplier Experienced managers and technical personnel available to resolve problems
11	Communication Issues	X11	Communication lines are established effectively Good communication and coordination speed of information flow Safety precautions are provided for workers
12	Resource Availability	X12	Safety and health policies forms a part of company core values Implementation of safety and health policies

Table 2: Decision Matrix

Criteria	Contractors (Alternatives)				
	C1	C2	C3	C4	SUM
X1	70	65	65	60	260
X2	65	65	65	55	250
X3	70	60	60	60	250
X4	80	70	60	55	265
X5	75	75	65	60	275
X6	80	75	60	60	275
X7	75	70	65	60	270
X8	70	70	65	55	260
X9	80	70	70	60	280
X10	75	70	65	60	270
X11	70	70	55	50	245
X12	75	70	60	60	265

Table 3: Normalized matrix & weight calculation

Criteria	Contractors			
	C1	C2	C3	C4
X1	0.269	0.25	0.25	0.231
X2	0.26	0.26	0.26	0.22
X3	0.28	0.24	0.24	0.24
X4	0.302	0.264	0.226	0.208
X5	0.273	0.273	0.263	0.218
X6	0.29	0.273	0.218	0.218
X7	0.278	0.259	0.241	0.222
X8	0.269	0.269	0.25	0.212
X9	0.286	0.25	0.25	0.214
X10	0.278	0.259	0.241	0.222
X11	0.286	0.286	0.224	0.204
X12	0.283	0.264	0.226	0.226

Table 4: Calculation of the criteria importance

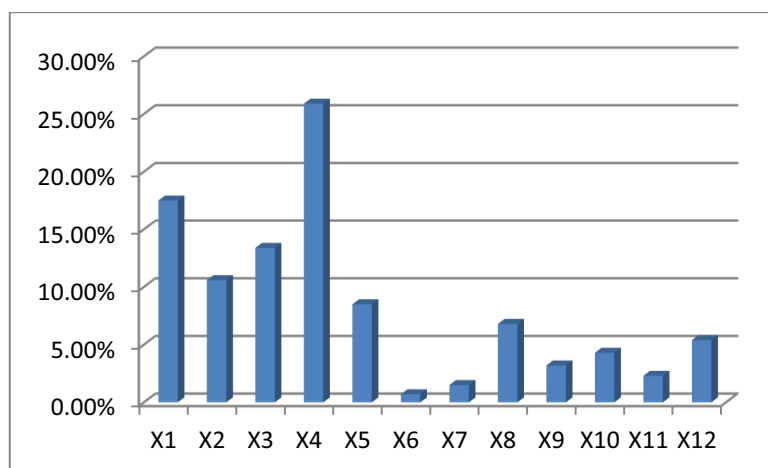
Criteria	Criteria Arrangement(m)	Criteria Arrangement (1/m)	$\sum_{j=1}^M 1/m$	$= (\frac{1}{M}) \sum_{j=1}^M 1/m$
X1	2	1/2	2.103	0.175
X2	4	1/4	1.27	0.106
X3	3	1/3	1.603	0.134
X4	1	1	3.103	0.259
X5	5	1/5	1.02	0.085
X6	12	1/12	0.083	0.007
X7	11	1/11	0.174	0.015
X8	6	1/6	0.82	0.068
X9	9	1/9	0.385	0.032

X10	8	1/8	0.510	0.043
X11	10	1/10	0.274	0.023
X12	7	1/7	0.653	0.054

Table 5: Index value, performance value & ultimate ranking of alternatives

Criteria	* ^a	Weight	Contractors			
			C1	C2	C3	C4
X1	+	0.175	0.047	0.044	0.044	0.040
X2	+	0.106	0.028	0.028	0.028	0.023
X3	+	0.134	0.038	0.029	0.029	0.029
X4	+	0.259	0.078	0.068	0.059	0.054
X5	+	0.085	0.023	0.023	0.022	0.019
X6	+	0.007	0.002	0.002	0.002	0.002
X7	+	0.015	0.004	0.004	0.004	0.003
X8	+	0.068	0.018	0.018	0.017	0.014
X9	+	0.032	0.009	0.008	0.008	0.007
X10	+	0.043	0.012	0.011	0.01	0.01
X11	+	0.023	0.007	0.007	0.005	0.005
X12	+	0.054	0.015	0.014	0.012	0.012
S+			0.281	0.256	0.24	0.218
S-			-	-	-	-
Qi	Relative importance		0.281	0.256	0.24	0.218
Rank			1	2	3	4
Ui			100	91.1	85.4	77.58

^a The sign (*) indicates the value of the largest or smallest criterion, which is of the greatest importance to the beneficiaries

**Figure 2.** Compare the relative importance of criteria

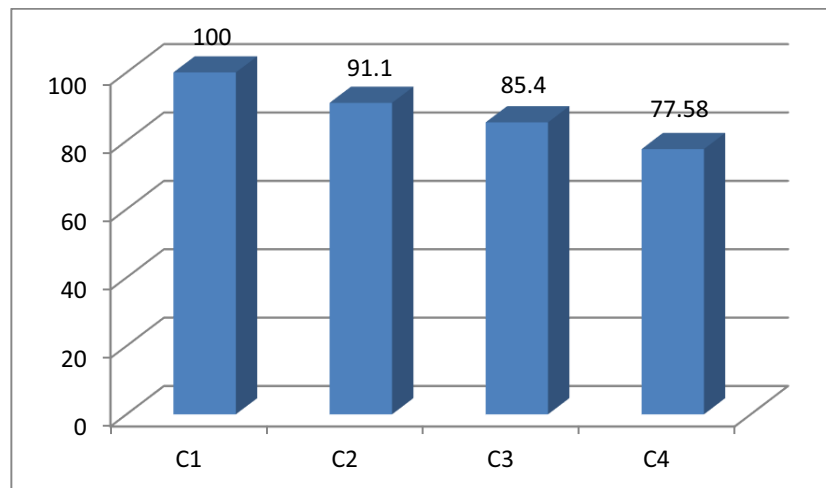


Figure 3. Compare the relative importance of alternatives (contractors)

8. Conclusions

The author of the article used the COPRAS method to analyze the problem of evaluating the performance of contractors in construction projects is very important where the presence of contractors having high efficiency increases the company's success and gives supremacy in competition. Where the current study presented successfully a new criterion for the evaluation of contractors performance in Iraq

This study identified 12 criteria for assessment Contractors Performance in Iraqi construction projects assessment based on the literature review and interviews with experts. The ROC method was applied to obtain the weights of these criteria. The results of the ROC assessment showed that X4: quality of work, X1: project management, X3: technical knowledge, and X2 : timeliness of performance were the top four criteria with weights of 0.259, 0.175, 0.134, and 0.106 respectively.

Then the researcher analyzed four contractors symbolized as C1,C2,C3,C4 by application of the COPRAS method, and the results of the research using the complex multi-criteria ratio technique showed that the lowest value is a relative importance in terms of performance is C4 he got (21.8%) and with a quantitative utility (77.58%).As for the highest relative importance value, it is C1 at (28.1%) and with a benefit amount of (100%).in the end, it is established that contractor symbolized as C1 has the best performance and therefore we can say that the rank of contactors as follows: $C1 > C2 > C3 > C4$.

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