

## Application of Multi-Criteria Decision-Making Topsis for Evaluation and Prioritization of Reasons for Claims of Contractors in D-B-B Contracts

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**Abstract:** Disagreements in construction contracts are costly, time-consuming and inconvenient. They also affect the price and quality of contracts. In most projects using different delivery systems, entities particularly contractors may make claims. Moreover, claims and disagreements are inevitable in design and build projects, particularly in D-B-B contracts which are not commonly used in Iran. The focus of this study is the reasons for claims made in projects delivered by D-B-B contracts. It is noteworthy that the role of consultant engineering is seen within the framework of roles and goals of the owner. Naturally, it is essential and complicated to decide on the type of claims made by contractors in projects. In this regard, there are many factors, among which major causes of claims made by contractors of construction contracts are identified. Then, these causes are prioritized by decision-making techniques to determine their importance. Accordingly, criteria and sub-criteria are determined by multi-criteria decision-making techniques to prioritize the reasons for claims of contractors.

**Key words:** Claim management, contractors, D-B-B contract, contract, multi-criteria decision-making technique, TOPSIS

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### INTRODUCTION

Claims are an integral part of construction contracts which currently occur in a routine basis. Although, contract claim is not a new concept, managers poorly evaluate the effectiveness of claims and respond to them (Hwang and Ng, 2013). Generally, development projects are complicated for their specific functional role. These projects involve a large amount of financial and human resources. Thus, a successful project is delivered on time with expected cost and quality predetermined by issues involved in the project. Therefore, a project will be successful if the predicted time, quality and cost are satisfied. These three parameters can be exemplified by a triangle in which flaws and shortcomings of a side will affect other sides. These three parameters are also considered as the criteria and limitations of a project. Complexity, workload, duration and the number of members involved in the project can act as a platform for various disputes between different entities of the contract (Niu and Issa, 2015). In order to satisfy final goals of the project, project management needs to dominate the factors effective on delays and changes to make decisions by predictions based on the conditions. Therefore, it is essential to overview the major causes of financial claims made by contractors. Given the above, this study

identifies and evaluates the most important reasons of claims made by contractors by field studies in construction projects as well as interviews and consultations with relevant theorists and experts. Using a multi-criteria decision-making method, the reasons are prioritized to develop a model for claims of contractors in D-B-B (Design-Bid-Build) contracts. Claim refers to contractor's demand for extension or additional payment, while disagreement refers to the lack of agreement between entities concerning the claims or other administrative aspects of the contract (Mok *et al.*, 2015). The disagreement between entities and dispute will have devastating effects on the project, including interrupted delivery, discouraged entities, jeopardized contractor-owner relations, expensive time-consuming settlement, ignored documents, deeper disagreements and involvement of outsiders. Avoided or alleviated disagreements will be followed by significant economic savings in the projects (Aibinu, 2008). According to the Iranian General Terms of Contract which presents an identical contract for D-B-B construction projects, the first channel of settlement is negotiation in the presence of an expert and then arbitration; however, unresolved disagreements constantly impose high costs on projects. Several effective factors, high turnover, specialized tasks, workload, innovation, sensitivity and diverse locations

lead to complex, unique and dynamic projects (Bakhary *et al.*, 2015). These conditions increase the risk of claims and conflicts in various stages of the project. It will be difficult to deliver construction projects without considering potential disagreements and increased reliability of entities in resolving these agreements (Bakhary *et al.*, 2015). Development projects require time, budget and other resources acquired by relevant entities; these resources in turn create a right for the parties. Improperly contracted projects, unfair distribution of responsibilities and authorities as well as traditional approach and governing culture regarding contractors have caused complexities in meeting the demands of contractors (Sabah *et al.*, 2003; Preez, 2014). Obviously this will weaken the financial strength of contractors and discourage them to work properly. Moreover, disagreements caused between entities may lead to early termination and extension of delivery schedule (Zaneldin, 2006).

In most cases, claims are agreed at higher levels of ownership, i.e., board of directors and solutions are provided; otherwise, the contractor will pursue his claims to legal authorities which may cause problems such as high costs and time of hearing and most importantly inclusion of outsiders in the project (Tran *et al.*, 2014; Chaphalkar *et al.*, 2015). Although these claims may compromise the project, overestimation of claims and disputes can cause problems for the project (Budayan *et al.*, 2015). Accordingly, the present study identifies the reasons for claims of contractors considering the problems of construction projects, particularly D-B-B projects to provide a preventive solution for disagreements of contractor and owners.

**MATERIALS AND METHODS**

The methodology used in this study was an applied, descriptive survey. Data was collected by interviews with experts in the construction industry, particularly D-B-B projects. Accordingly, reasons for claims of contractors were evaluated by experiences of finished and ongoing D-B-B projects. To this end, major factors were extracted from 300 reasons identified by archival studies, available theses and interviews with experts. Then, interviewees were given checklists. Data was analyzed by pairwise comparisons based on judgments of respondents using multi-criteria decision-making analyses such as AHP and TOPSIS.

**Ranking of reasons for claims of contractors in D-B-B contracts using topsis:** TOPSIS was developed by Hwang and Ng (2013). This technique is based on the notion that each selected factor must be in the shortest distance from the ideal positive (most important) factor and in the longest distance from the ideal negative (least important)

factor. In other words, this method measures the distance of a factor from an ideal positive or negative factor which is a measure of scoring and prioritization of factors. Steps of TOPSIS are described below for evaluating the reasons for claims of contractors. The following table shows the criteria effective on claims of contractors.

**Criteria for evaluation of reasons for claims of contractors:**

- Criterion
- Changes in provisions and working level (C1)
- Overtime/under-time request (C2)
- Changes in delivery schedule (C3)
- Changes in project costs (C4)
- Effectiveness of the contract (C5)
- Elimination of obstacles and potential opponents (C6)
- Necessary permits from the competent authorities (C7)
- Insufficient attention to social and local conditions (C8)
- Ambiguity and contradiction in the contract (C9)
- Weather conditions (C10)
- Delays in works (C11)
- Fundamental flaws and errors in design (C12)
- Quality of equipment (C13)
- Availability of location (C14)
- Changes in developmental policies (C15)
- Force majeure project (C16)
- Difficulty/complexity of the project (C17)

Three following alternatives indicating main reasons for claims of contractors were considered for evaluation and prioritization:

- Changes in contractual agreements (A1)
- Delays in commitments of the owner (A2)
- Major discrepancies in the contract (A3)

In the following, steps of TOPSIS are described for prioritizing claims of contractors in D-B-B contracts.

**Step 1 (formation of decision matrix):** The following matrix is a decision-making matrix in which alternatives are presented in rows and columns. In addition, the final row shows the weight of each criterion calculated by Shannon entropy. Each element of this matrix shows the importance of each alternative given by each respondent considering the relevant criterion (Table 1).

Table 1: Decision-making matrix

Criterion/alternative	C <sub>1</sub>	C <sub>2</sub>	...	C <sub>n</sub>
A <sub>1</sub>	r <sub>11</sub>	r <sub>12</sub>	...	r <sub>1n</sub>
A <sub>2</sub>	r <sub>21</sub>	r <sub>22</sub>	...	r <sub>2n</sub>
A <sub>m</sub>	r <sub>m1</sub>	r <sub>m2</sub>	...	r <sub>mn</sub>
W <sub>j</sub>	W <sub>1</sub>	W <sub>2</sub>	...	W <sub>n</sub>

Table 2: Decision-making matrix

Matrix	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17
<b>Type of criterion (positive)</b>																	
A1	8.930	7.772	7.500	5.320	6.650	7.325	7.161	7.827	5.605	5.555	5.935	5.935	7.040	6.494	6.966	6.506	5.987
A2	7.930	9.320	9.270	6.175	7.930	7.765	8.726	8.470	7.062	5.660	6.315	5.777	6.475	7.325	6.880	5.770	7.150
A3	6.040	7.472	8.215	7.211	6.215	6.320	7.611	5.900	9.465	7.965	8.215	8.272	6.930	7.415	7.725	8.300	7.123
Weight	0.059	0.058	0.059	0.059	0.059	0.059	0.059	0.058	0.059	0.059	0.059	0.059	0.058	0.059	0.059	0.059	0.059

Table 3: Normalized decision matrix

Matrix	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17
A1	0.667	0.545	0.518	0.489	0.551	0.590	0.526	0.604	0.429	0.494	0.497	0.507	0.596	0.529	0.559	0.541	0.510
A2	0.593	0.654	0.640	0.567	0.657	0.626	0.641	0.654	0.540	0.504	0.529	0.494	0.548	0.596	0.552	0.480	0.609
A3	0.451	0.524	0.567	0.663	0.515	0.509	0.559	0.455	0.724	0.709	0.688	0.707	0.587	0.604	0.619	0.690	0.607

Table 4: Weighted normalized matrix (V)

Matrix	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17
A1	0.039	0.032	0.031	0.029	0.033	0.035	0.031	0.035	0.025	0.029	0.029	0.030	0.035	0.031	0.033	0.032	0.030
A2	0.035	0.038	0.038	0.033	0.039	0.037	0.038	0.038	0.032	0.030	0.031	0.029	0.032	0.035	0.033	0.028	0.036
A3	0.027	0.030	0.033	0.039	0.030	0.030	0.033	0.026	0.043	0.042	0.041	0.042	0.034	0.036	0.037	0.041	0.036

In the above matrix,  $r_{ij}$  represents score of the  $i$ th alternative in the  $j$ th criterion and  $W_j$  represents weight of the  $j$ th criterion. The 10-point Likert scale of Saati was used to collect data. Once opinions of experts in the construction industry were collected, the data was aggregated by arithmetic mean. By collecting expert opinions, weights of criteria were calculated by Shannon Entropy; these weights are reported in Table 2. Table 2 shows the decision matrix which is based on aggregated opinions of 50 experts. The second row of the matrix shows the type of criteria. Obviously, all criteria are positive; a positive criterion will be more ideal if its value is higher.

**Step 2 (normalization of decision matrix):** The second step of TOPSIS was normalization of the decision matrix using Eq. 1. For this purpose, Euclidean norm was used. Table 3 shows the normalized decision matrix:

$$n_{ij} = \frac{r_{ij}}{\sqrt{\sum_{i=1}^m r_{ij}^2}} \quad (1)$$

**Step 3 (formation of weighted normalized decision matrix):** To form the weighted normalized matrix (V), the normalized decision matrix was multiplied by the square matrix  $W_{n \times n}$  where main diagonal elements were weights of criteria and other elements were zero: Table 4 shows the weighted normalized decision matrix:

$$V = N \times W_{n \times n} \quad (2)$$

Table 5: PIS and NIS for each criterion

Criterion	PIS	NIS
C1	0.039	0.027
C2	0.038	0.030
C3	0.038	0.031
C4	0.039	0.029
C5	0.039	0.030
C6	0.037	0.030
C7	0.038	0.031
C8	0.038	0.026
C9	0.043	0.025
C10	0.042	0.029
C11	0.041	0.029
C12	0.042	0.029
C13	0.035	0.032
C14	0.036	0.031
C15	0.037	0.033
C16	0.041	0.028
C17	0.036	0.030

**Step 4 (determination of PIS and NIS):** In this step, two positive and negative ideal alternatives known as Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS) were determined. PIS and NIS can be calculated by Eq. 3 and 4 for series of positive criteria and series of negative criteria, respectively. It is noteworthy that all evaluation criteria used in this study were positive. PIS:

$$\{V_1^+, V_2^+, \dots, V_n^+\} = \left\{ \left( \max_i V_{ij} | j \in J \right), \left( \min_i V_{ij} | j \in J \right) \right\}_{i=1, 2, 3, \dots, m} = A^+ \quad (3)$$

NIS:

$$\{V_1^-, V_2^-, \dots, V_n^-\} = \left\{ \left( \min_i V_{ij} | j \in J \right), \left( \max_i V_{ij} | j \in J \right) \right\}_{i=1, 2, 3, \dots, m} = A^- \quad (4)$$

Table 5 shows PIS and NIS for criteria separately.

Table 6: Ranking of alternatives

Alternatives	Distance of alternatives from PIS	Distance of alternatives from NIS	CL	Rank
A1	0.034	0.017	0.331	3
A2	0.027	0.024	0.472	2
A3	0.023	0.033	0.594	1

**RESULTS AND DISCUSSION**

**Step 5 (calculation of distance of alternatives from PIS and NIS):** In this step, the distance of each alternative was calculated from PIS and NIS. For this purpose, Eq. 5 and 6 were used. Distance of alternatives from PIS:

$$d_i^+ = \sqrt{\sum_{j=1}^n (V_{ij} - V_j^+)^2}, i = 1, 2, \dots, m \quad (5)$$

Distance of alternatives from NIS:

$$d_i^- = \sqrt{\sum_{j=1}^n (V_{ij} - V_j^-)^2}, i = 1, 2, \dots, m \quad (6)$$

Distance of alternatives was calculated from PIS and NIS and reported in the third and fourth columns of Table 6.

**Step 6: calculation of closeness of alternatives to PIS and NIS:** At this step, similarity and Closeness (CL) of each alternative was calculated to PIS and NIS using Eq. 7:

$$CL_i = \frac{d_i^-}{d_i^- + d_i^+} \quad (7)$$

CL calculated for alternatives are reported in the fifth column of Table 6.

**Step 7: ranking of alternatives:** In this step, alternatives were ranked based on CL; any alternative with higher CL earned a better rank. The last column of Table 6 shows rank and priority of alternatives. The results obtained by ranking alternatives by TOPSIS technique show that the alternative ‘Major discrepancies in the contract’ is in the higher priority than other alternatives. The figure below graphically depicts CL and ranks of alternatives. According to Table 6 and Fig. 1, alternatives are prioritized as follows:

- First rank; major discrepancies in the contract
- Second rank; delays in commitments of the owner

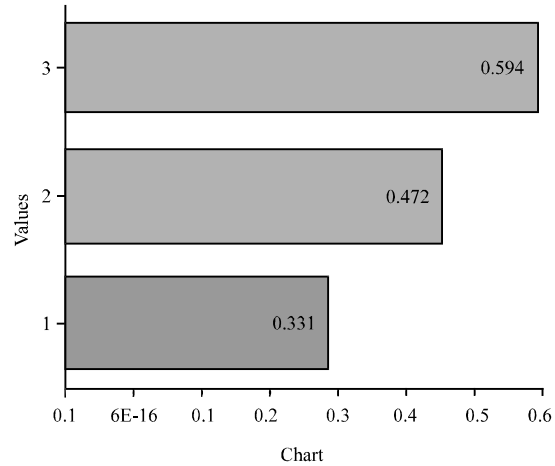


Fig. 1: CL and priority of alternatives

**CONCLUSION**

By field visits to construction projects and literature review, this study identified main reasons for claims of contractors in D-B-B contracts. In order to prioritize these factors, a questionnaire was developed based on pairwise comparisons of criteria and sent to 50 experts. Then, data was extracted from completed questionnaires. The reasons for claims of D-B-B contractors were prioritized by MCDM TOPSIS; it was concluded that the alternative ‘major discrepancies in the contract’ was in the higher priority than other alternatives. Moreover, the criteria ‘changes in provisions and working level’ and ‘fundamental flaws and errors in design’ were the most important reasons of claims made by contractors in D-B-B projects. These reasons are caused by technical flaws in design which are related to consultant engineers (in most projects, entities of the contracts are contractors and the owners; however, the role of consultant engineering is seen within the framework of goals of the owner); legal flaws in the contract.

In conclusion, a successful project is contracted by considering technical and legal terms and conditions (budget, inflation rate, etc). Entities of a proper contract are encouraged to work as a team with mutual, yet non-conflicting, interests and fair distribution of risk. In Iran, responsibilities are mostly assigned to one single

entity and the contracts are mostly in favor of the owners. The owners are authorized to accept or deny the claims of the contractors. Thus, owners prefer to use these authorities to reduce the costs of the project and usually ignore claims. Clearly, this will reduce the financial capabilities of the contractors and discourage standard performance. Moreover, the claims may lead to disputes between entities; these disputes may lead to early termination and extension of the delivery schedule.

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