



Choosing by Advantages (CBA) Used as a Qualitative Assessment Methodology in Lean Construction

Zied Dahmani

AECOM, Doha, Qatar
zdahmani@ashghal.gov.qa

Juhaina Essa Al-Sulaiti

Public Works Authority (Ashghal), Doha, Qatar
jalsulaiti@ashghal.gov.qa

Ayman Naser

Dorsch Gruppe – Middle East, Doha, Qatar
an1401569@qu.edu.qa

Abstract

Decision making is part of the daily duties of researchers, engineers, and consultants, and taking the right decisions requires quantitative assessment which usually needs data and analysis. In construction industry, data collection or detailed analysis are practically complicated that cannot drive the right results. This fact leads to the common use of qualitative assessment where the numbers are not available, and the evaluation involves various criteria from diverse perspectives. As a Lean tool, Choosing by Advantage (CBA) is used predominately in the Design process. This paper's characteristics and contributions to the existing body of knowledge presents the CBA practice as a qualitative assessment tool in construction phases in the Lean Construction implementation in infrastructure projects, proposing equations through the technique which determines exactly how to assess the percentage advantage for each factor for qualitative factors with different grades or different ranks. The flexibility of CBA as a multicriteria decision-analysis (MCDA) model helped overcome the differences between criteria, categories, and value-based analysis. This paper describes the experience of selecting the option that considers advantages from various criteria in an extensive assessment.

Keywords: Choosing by Advantage (CBA); Multi-criteria decision-analysis (MCDA); Qualitative assessment; Public Works Authority

1 Introduction

The construction industry is very resource-intensive, and it is not uncommon for decisions to be made with inadequate information (Pryshlakivsky & Searcy, 2021). When it comes to the day-to-day operations of project management, poor decision-making may cause unnecessary expenditures and tension. Decisions may be made more intricately due to stakeholder participation and contemporary sustainability challenges (Zhuang et al., 2019). Lack of understanding of multi-criteria decision making is another barrier to good decision-making in the construction business (Belay et al., 2022). The challenges associated with making decisions needs a methodical approach. In addition, getting everyone on the same page requires a well-thought-out decision-making structure. Therefore, Lean Construction (LC) implementation is usually introduced as a new framework for project management to support decision-making for planning and project delivery (Gunduz & Naser, 2019). The typical project management assessment methodologies are based on quantitative data comparisons. In most cases, this data is incomplete and inconsistent between different disciplines such as Health and Safety

(H&S), Quality, Progress, Environment and Sustainability (E&S), and Public Relations (PR). This requires configuration of a multicriteria evaluation matrix, then alignment to a clear and consistent assessment tool. The assessment tool should summarize performance in reference to contractual requirements which are qualitative in nature (Agyekum-Mensah et al., 2020). In addition to other approaches to multicriteria decision-making, the CBA technique was used here. Using cost-benefit analysis (CBA), you may objectively evaluate how several options stack up against one another. The CBA framework relies on a small number of facts and criteria that have been established in advance in order to eliminate or greatly minimise the role of subjectivity in decision-making (Paredes & Herrera, 2020). Therefore, this study set out to provide a solid multi-criteria decision-making framework for analysing the critical factors contributing to the success of using CBA as a qualitative evaluation tool in the construction business. The findings of this research provide important additions to the existing body of knowledge and methods used to make decisions in the construction sector.

2 Literature Review

In the fields of Architecture, Engineering, and Construction (AEC), choices are often taken with just a cursory comprehension of the complexities of the issues at hand and after doing only the barest of analyses. When managers of a project are unable to make good judgements, the process of managing the project and operating it becomes fraught with conflict and waste. The complexity of decision-making is increased by factors such as the expanding involvement of project stakeholders and growing concerns over the social and environmental repercussions of a project (Li et al., 2016). Despite the fact that practitioners are looking for improved decision-making tools, there is a dearth of relevant literature, which makes it difficult for them to choose the most appropriate approach for every given situation (Danesh et al., 2018). In this context, a strategy of decision-making that is both methodical and scientific and that considers several factors is required in order to successfully navigate the problems connected with decision-making. In addition to this, it fosters openness and provides a common justification for advocating in favour of a more sustainable option (Danesh et al., 2018).

CBA has several examples of use in the construction literature. Parrish and Tommelein (2009), for instance, investigated the feasibility of using CBA to decide on a rebar design for a beam-column junction. In combination with set-based design, CBA enabled the engineer to systematically explore a wide range of options for satisfying both mandatory and desirable design requirements. Arroyo et al. (2014) examined the usage of Weighting Rating and Calculating (WRC) and Choosing by Advantages (CBA) in the selection of a structural system for a Palo Alto, California campus residential project. The case study revealed that both approaches led to the same conclusion, but their underlying assumptions were distinct. CBA contributed more to transparency than WRC. Karakhan et al. (2016) provided a case study on the use of CBA to a building project in order to make safety design choices for a facility's permanent elements. The findings suggested that CBA is a good decision-making technique that may be used by project teams to make early-stage safety judgements. Using the analytic hierarchy technique (AHP), Diabagate et al. (2015) provided a method for identifying the best offer for a tender (AHP). AHP has several restrictions. The first is that the phenomena of rank reversal must be taken into account in AHP procedures, which implies that when any choice alternative is added or withdrawn from the problem, the rank of decision alternatives changes. The subjectivity of the modelling process is seen as a second restriction of AHP (Arroyo et al., 2015).

Since it evaluates just the value-added benefits of a number of options, CBA is a reliable method for making decisions based on several factors. For the USDA Forest Service, Jim Suhr came up with the concept in 1999 (Suhr 1999). The CBA relies on mutually agreed-upon standards and relevant

information to make choices, making the process more objective and less prone to bias. This strategy entails focusing on the positive aspects of a situation instead than dwelling on its flaws, and grounding decisions in relevant facts and quantitative data to reduce the likelihood of prejudice and irrational thinking (Suhr, 1999). Although various multi-criteria decision-making methodologies, including linear optimization and weighting-rating calculation (WRC) and Analytical Hierarchy Process, were available for use in the research, the CBA method offers specific benefits over other frameworks (AHP). Collaboration, transparency of trade-offs across components, distinguishing the alternatives, maintaining consistency, and assessing the subjectivity of the alternative are all areas in which CBA has been shown to excel in previous research (Arroyo et al., 2015; Arroyo et al., 2016).

3 Point of Departure

As a part of contractual enhancements in infrastructure projects in the State of Qatar, Lean Construction was introduced to support project delivery and minimise programme disruption. While Lean Construction is not a typical discipline that performs beyond H&S, Quality, E&S and PR, integrating the overall lean performance needs to be aligned with other disciplines to reflect compliance and identify areas for improvement.

Besides, any discipline compliance can elude the added value behind the integration of Lean concepts at programme wide. Lean practitioners should “measure contractual compliance” to validate the Lean performance of each project (Nguyen & Akhavian, 2019).

Moreover, conventional project portfolio evaluation is often “progress oriented,” which may lead to misguided strategy fulfilment and, in some circumstances, muddled reflections. Therefore, CBA was developed to evaluate the benefits of the alternatives, and decision-makers may readily pick the option that would provide the highest value for their project.

In a variety of ways, current research differs from all the related literature in different aspects. Choosing by Advantages is proposed as a straightforward method for choosing criteria in the present research. The suggested method provides contractors with equations that precisely specify how to calculate the percentage advantage for each qualitative factors with different grades/ranks basis.

4 Assessment Matrix

Construction projects’ portfolios are managed through standardised performance dashboards, either combined per discipline or per project, highlighting several metrics to summarize performance in a report like format. Basic metrics, such as progress percentages, total manhours without Loss Time Injury (LTI), and work inspections approval rate, are quantitative measurement systems of single performance aspect. Usually, those metrics indicate a “status” and help take corrective actions when necessary. While this quantitative assessment can summarize staggered performances, it cannot reflect neither a holistic project performance nor the project compliance with contractual requirements.

Performance dashboards can be helpful for the “top performers’ projects” to emphasize on their achievements, but they are helpless to depict the “low performers’ projects” especially regarding contractual requirements. This dashboard’s evaluation is part of a decision-making process for commercial approvals that needs a stringent outlook while the quantitative metrics can be confusing.

Such deficiencies require an extensive assessment involving all project’s disciplines and considering multiple factors. This assessment is defined in the multicriteria decision-analysis (MCDA). MCDA approach is to have a set of criteria linked to specific requirements than develop a multi-dimensional model to integrate those criteria (Abraham et al., 2013). MCDA requires a configuration of decision criteria divided

into components for evaluation and interrelated for an overall insight (Seppälä et al., 2002).

The transition from typical construction project portfolio dashboards to a holistic assessment matrix using MCDA approach was explored to support group assessment and decision-making.

5 CBA Mathematical Model

For qualitative characteristics with n grades including, for example, excellent, very good, and good. Assign 100% to the attribute with the highest rating and 0% to the attribute with the lowest grade. Apply Eq. (1a – c) to any intermediate property. Therefore, if there is just one intermediate level, $A_{b=1} = 1$ (A is: the order of the intermediate level) and $C = 50\%$. Additionally, if there are two intermediate grades, the first will be allocated $A_{b=1} = 1$ and $C = 60\%$, while the second will be assigned $A_{b=2} = 0.5$. Then, C_1^* equals 60% and, C_2^* equals 30%. This means that the multiplier ($A_{b=1}$) for the first intermediate is 1 regardless of the number of intermediates, the multiplier ($A_{b=2}$) for the second intermediary is 0.5, the multiplier ($A_{b=3}$) for the third intermediate is 0.25, and so on.

Where C^* is the percentage of advantage in case of qualitative factors with n grades.

$$\text{For } n \leq 3, \text{ use } A_1 = 1, \text{ and for } n > 3 \text{ use } A_b = \left[\frac{1}{2}\right]^{b-1}, \text{ where } b = 2, \dots, n - 2 \quad (1a)$$

$$C \% = 100 \left[\frac{(n-1)}{(n+1)}\right] \quad (1b)$$

$$C^* \% = A_b \times C \% \quad (1c)$$

Then, to obtain importance advantage for each criterion at each factor, multiply the importance index (I-index) by the percentage of advantage for each criterion. For qualitative criteria with n grades, use equation (2).

$$\text{Importance Advantage} = (\text{qualitative factors with n grades}) = I \text{ index} \times C^* \quad (2)$$

6 CBA Implementation

While MCDA approach has a panoply of technical methodologies, CBA was chosen to structure the assessment for several reasons: it is a “mechanism” developed over 20 years that promotes decision-making at first hand (Suhr, 1999), and performance evaluation; it integrates different aspects with different measurement scales; it is flexible and can be customised to specific needs.

CBA has been practiced as a Lean Construction methodology mainly for design phase and pre-construction evaluations, focusing on advantages of alternatives and independent criteria integration.

Qualitative assessment enables not just performance comparison, but it fosters a deeper understanding of the problem from the people’s perspective (Ivankova & Creswell, 2009). CBA’s flexibility supports the qualitative assessment using a customised scale to reflect either contractual compliance or any other performance. This scale is developed from an inherited scoring scale of quality performance, covering INRs, NCRs, and other metrics, as indicated in Table 1.

Table 1: Scoring Scale

Score	Criteria
1	Not Acceptable
2	Needs improvement
3	Acceptable
4	Above Expectations

CBA practice had been performed on a three phases plan (Figure 1): Individual CBA, Combined CBA then Group CBA.

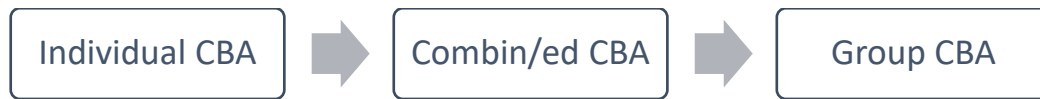


Fig. 1: CBA Phases

6.1 Phase One: Individual CBA

This phase aims to facilitate transition from quantitative metrics to MCDA approach and getting familiar to the new scoring scale. Each discipline lead develops qualitative criteria inspired by contractual requirement, with a focus on advantages. Then, each advantage was defined the acceptable performance either in numbers, when possible, or in an objective description. Once projects portfolio assessment is completed, an individual review should be conducted to level criteria scoring between projects. The criteria can be revisited to maximise the advantage consideration and address disbenefits if required.

6.2 Phase Two: Combined CBA

Once all discipline leads develop their criteria and the “Acceptable” performance, a joint discussion is facilitated to present the advantages considered in reference to the contract or strategic values. Then, alignment between similar criteria is performed to have a focused criteria list. In practice, 30%-40% of criteria will be combined or incorporated in other criteria especially when there are quantitative performance references. The discussion led not only to develop an assessment criteria system, but it improved understanding interfaces between disciplines and what is considered “important” for each aspect. This could not happen with traditional quantitative assessment systems or even several of MCDA methodologies.

6.3 Phase Three: Group CBA

With a clear list of assessment criteria, inspired by contractual requirements and integrated between different disciplines, a group review session involving all disciplines and management to confirm the validity of each criterion and ensure the list covers all project portfolio aspects and scope. Checks are done for practicality of assessment and accuracy of scores to reflect a holistic and fair project performance status.

7 Outcomes

This approach led to developing a robust multi-criteria tool to evaluate more than 40 infrastructure projects portfolio, then extended to include more than 160 projects with different scope of work that requires customization of a new list of criteria extracted from the first edition.

The new structured assessment system helped mitigate an existing bias usually driven by projects ahead of schedule while they have a low performance in other aspects. This biases free assessment is appreciated by different discipline leads as it helps them address non-compliance in a combined perspective.

Following a successful practice over 6 months, the scoring scale has been edited to reflect the contractual aspect of the assessment Table 2.

Table 2: Revised Scoring Scale

Score	Criteria
1	Not at required level
2	Partially in place or no proactive approach
3	Meets minimum standard; room for improvement
4	Proactively managed and exceeds requirements

The CBA mechanism practiced for a portfolio of projects in construction phase helped managers understand better the performance of supply chain, different sections, and different contractors.

While the scoring scale is a value-based assessment system, it is considered as qualitative rather than quantitative, as it is linked to a contractual requirement compliance description. However, the researcher utilized equations Eq. (1a – c) to evaluate the importance of advantages for implementation of Lean construction and related portfolio in construction projects.

8 Conclusion

Traditional selection models neglected the provided equations to quantify the percentage benefits for quantitative and qualitative parameters. This technique's main strength is approach, which quantifies important advantages using known significance indices for variables and equations for computing percentage advantages for quantitative and qualitative components, minimising subjectivity. The key addition to knowledge is a selection approach that calculates the percentage benefit of each factor of quantitative variables, qualitative elements with grades or rankings, and qualitative factors with yes/no foundation. The author believes this method will help industry practitioners pick the best option. Grouping the most relevant criteria that contribute to existing knowledge and offering the instruments (equations) to quantify each factor's percentage advantage for both quantitative and qualitative aspects achieves this.

CBA gives decision makers independence, unlike other existing methods. Due to intuitive component weights and scoring scales, ranking methods are more subjective. This study's innovative CBA approach compensates for extensive training. This is due to extracting many equations to express the percentage benefits for qualitative elements with n grades basis. The research will assist construction professionals by utilizing the CBA framework in understanding the relevance of multicriteria decision-making in construction project management. As construction is a highly opinionated sector, construction practitioners must recognise the necessity of making smart judgements. Due to the fact that CBA is predicated on value-adding benefits, it will facilitate effective decision-making. The collaborative aspects of CBA improve communication between team members and enhance understanding of interfaces. Managers found that CBA is essential for future strategy development as it can include different categories ranging from values to specifications. CBA consistency helped deliver a bias free qualitative assessment tool that supported decision-making with fairness. With the emergence of sustainability norms, CBA is a useful mechanism to consider sustainable advantages and environment friendly benefits while assessing options in any disciplines as future studies.

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