Using The MACBETH Method To Solve The Construction Site Manager Selection Problem

Murat Anbarcı, Ekrem Manisalı, Ömer Giran and
Osman Hürol Türkakın

July 27, 2020

6th International Project and Construction Management Conference (IPCMC 2020), 12 – 14 November 2020,Istanbul,Turkey

Using The MACBETH Method To Solve The Construction Site Manager Selection Problem

M.Anbarcı,E.Manisalı,O.Giran,O.H.Türkakın
muratanbarci@gmail.com

Abstract

Construction site manager is one of key personnel staffs to serve in construction projects in order to satisfy several required criteria such as project duration, cost and quality. In construction sector, personnel contracting depends on project. And after project termination, the contract with personnel may be not continued unless there is another project is planned to be started. So that before each project start, a new construction manager is required. In this study, a generic selection methodology based on MACBETH multi-criteria method is proposed with a case study that includes selection of a construction manager from four civil engineer candidates who have applied to a construction company.

Key words: *MACBETH, Multiple Criteria Decision Making, Construction Management.*

Introduction

Construction companies are increasingly adopting project management skills in their design and build processes to their projects. A key issue for the management of the construction projects is to ensure skilled individuals are allocated as effectively as possible to cope with the other construction companies' projects. A construction manager is a key personnel that companies the use of the construction management project requirements on a construction project. Selection of a site manager for construction projects and hiring the right candidate is a multi-criteria decision making problem (Ceran and Dorman 1995).

In literature, some of the Multi Criteria Decision Making Techniques have been applicated to solve many problems also recruitment problem of a company. Afshari (2017) profosed a method combines the Delphi method and the fuzzy liguistic evaluation to enhance the selection of construction project manager. Ensslin et al .(2013) identify human resource allocation in a project management model, based on knowledge demand and using a multi-criteria decision aiding method as an intervention instrument. Torfi and Rashidi (2011) select project managers of a construction company by implementing AHP and Fuzzy TOPSIS decision making methods. Balentis et al.(2012) proposed a model by using Fuzzy MULTIMOORA decision making method to solve project manager problem.Sadeghi et al.(2014) improved goal programming and TOPSIS decision making method to select a project manager.

Multicriteria Decision Making (MCDM)

The complexity of real-world problems, which involve the achievement of multiple and often conflicting objectives (criteria), is raised with the use of MCDM methods to guarantee the validity and reliability of the final decision (Figueira et al. 2009). The advantages of MCDM methods include their ability to take into consideration conflicting criteria, structure the management problem, provide a model for discussion, and lead to rational and explainable decisions (Belton and Stewart 2002).

The main steps of multi-criteria decision making methods are (Anbarcı et al.2016):

(1) Problem identification,
(2) Establishment of evaluation criteria
(3) Development of alternative systems
(4) Evaluation of alternatives according to criteria
(5) Application of a normative multi-criteria analysis method
(6) Acceptance of an alternative as highly favored
(7) If the final solution is not accepted, to collect new information to the next iteration for multi-criteria optimization.
(8) Model building and use,
(9) Development of action plans.

MACBETH Method

MACBETH is an approach to multicriteria decision aid whose development was set in motion in the early 1990's by C.A. Bana e Costa and J.-C. Vansnick. MACBETH, the name (Measuring Attractiveness by a Categorical Based Evaluation Technique) is :

i. User-friendly for decision-makers to discuss their value systems and preferences.
ii. Interactive from a practical viewpoint, this suggests that such interaction would greatly benefit from an extremely efficient decision support system, as it is actually the case of the M-MACBETH software.
iii. Constructive because MACBETH rests on the idea that full-bodied convictions about the kind of decision to make do not (pre-)exist in the mind of the decision maker, nor in the mind of each of the members of a decision advising group (Bana e Costa et al.2002).

MACBETH has been applied to solve problems in different subjects for instance (Demesouka at al.2016);

- Research and development
- Human resources management
- Career choice problems
- Portfolio management
- Natural phenomena
- Medical science
- Drinking water utilities
- Public investments
- Politics
- Project development

The steps of the MACBETH method are as follows (Bana e Costa et al. 2002):

1. Step: The Decision Maker has to select carefully the decision criteria, according to which the alternatives' performance is to be measured, forming the problem's value tree and the Decision Maker has to define the upper reference level and the lower reference level for each criterion.
2. Step: For mesauring the attractiveness of alternatives belonging to a finite Set A to create of quantitative models
3. Step: Establishing cardinal value functions based on a questioning procedure.
4. Step: To ask Decision Makers' to verbally express differences in the attractiveness of two actions (criteria and/or alternatives), based on the seven semantic categories shown in Table 1, forming a (n× n) matrix in case of n actions by achieving the quantification process.

Table 1. Attractiveness Scale.

Semantic Categories	Quantitive Scale
No	0
Very Weak	1
Weak	2
Moderate	3
Strong	4
Very Strong	5
Extreme	6

5. Step: Arranging the consistent judgements in decreasing order according to the preferences of the Decision Makers.
6. Considering p_i^k the performance of the alternative k to the criterion i, and the fact that the Decision Makers' prefer the alternative k to the alternative l for this criterion, they should denote the level of strength of performance (h) between these two alternatives according to the predefined scale of Table 1 as follows:

$$p_i^k - p_i^l = h\alpha \qquad (1)$$

where $\alpha = coefficient$ necessary to meet the condition that p_i^k,$p_i^l \in [0,100]$,and $h \in \{0,1,2,3,4,5,6\}$.

7. Step: Evaluation of the alternatives is obtained by applying the additive aggregation model [Eq. (2)], where $V(a)$ measures the overall attractiveness of $a \in A$; $v_j(a)$ quantifies the per-criterion local attractiveness of the actions of A; and wj is the scaling constant (weight) of the ith criterion for the k criteria of the analysis (Demesouka at al.2016);

$$V(a) = \sum_{i=1}^{k} w_i x v_i(a) \qquad (2)$$

with

$$\sum_{i=1}^{k} w_i = 1 \; and \; w_i > 0 \; (i = 1, \dots, k)$$

Case Study

In this study, a generic selection methodology based on MACBETH multi-criteria method is proposed with a case study that includes selection of a construction manager from four civil engineer candidates who have applied to a construction company.

The experience, their performance in the job interview and references of the candidates were taken into account in the selection of the most suitable candidate among the four civil engineer candidates who applied for the construction manager position of the company.

At first, the value tree of the determined criteria has been created as shown in Figure 1.

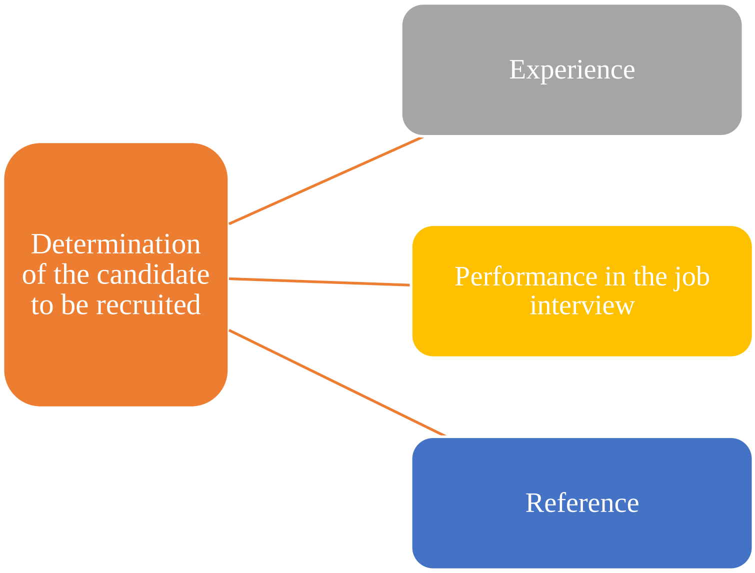

Figure 1. Value tree of the determined criteria.

In order to determine the effect levels in the preference to be made after the decision criteria are determined, a comparison matrix that shows the importance levels among themselves should be created. The decision maker is expected to make binary comparisons between the criteria, creating a non-dispute comparison matrix. It is proposed to use the semantic categories specified in Table 1 in the creation of comparison matrices. Experience was the most important criterion for decision makers in this study, while the least important w the reference. The comparison matrix was determined for the solution of the problem is as in Table 2.

Table 2. Comparison Matrix.

	Reference	Performance in the job interview	Experience
Reference	No	Very Weak	Very Strong
Performance in the job interview		No	Strong
Experience			No

After the preparation of the comparison matrix, a linear programming model has been used for the determination of the criterion weights. The purpose of the linear programming model created was to minimize the largest of the specified criteria. It is necessary to establish the required linear programming to create the constraints. Ordinal conditions ensure the accuracy of the preference ranks of the specified criteria, while semantic conditions ensure that preference levels are appropriate. Ordinal conditions and semantic conditions are shown in Table 3.

Table 3. Constraints.

Constraints
Ordinal Conditions
Experience (Very Weak) Job Interview Performance
Experience (Very Strong) Reference
Job Interview Performance (Strong) Reference
Semantic Conditions
(Experience-Job Interview Performance)<(Experience-Reference)
(Experience-Job Interview Performance)<(Job Interview Performance-Reference)
(Experience-Reference)>(Job Interview Performance-Reference)

After entering the related constraints into the Solver add-in of Microsoft Excel program, linear programming problem has been solved. When the Solver plug-in was run, the values to be taken by other criteria were determined so that the criterion with the lowest score is "1". The results are shown in Table 4.

Table 4. Calculation and Results of the Linear Programming.

	Results/Calculations		
Aim: Minimizing the highest option	6		
Criteria			
Experience	6	0,5	
Job Interview Performance	5	0,42	
Reference	1	0,08	
Constraints			
Ordinal Conditions			
Experience (Very Weak) Job Interview Performance	6	≥	6
Experience (Very Strong) Reference	6	≥	6
Job Interview Performance (Strong) Reference	5	≥	5
Semantic Conditions			
(Experience-Job Interview Performance)<(Experience-Reference)	-4	≤	-4
(Experience-Job Interview Performance)<(Job Interview Performance-Reference)	-3	≤	-3
(Experience-Reference)>(Job Interview Performance-Reference)	1	≤	1
Reference	1	=	1

The results prior to use in deciding by the decision-maker has been checked whether satisfies all specified limitations. Failure to achieve any one of these conditions is indicative of a mismatch in the comparison matrix. The decision maker should make the necessary corrections in the comparison matrix based on the constraint not provided. As a result of the model, “6”, “5” and “1” values were found for experience, job interview performance and reference criteria, respectively. After these values are found, they are proportioned to have a total of "1" to determine the weight of the criteria in percent. Thus, the weight of the experience criterion was calculated as "0.50", the weight of the job interview performance criterion was "0.42" and the weight of the reference criterion was "0.08". The results showed that the experience and job interview performance were significantly effective in recruitment, while the reference was of low importance. After the criteria have been determined, the relative preference levels of the candidates have been determined for each criterion. Comparison matrices for each criterion has been created. The comparison matrices of the criteria are shown in the Table 5 below.

Table 5. Comparison matrix for criteria.

Experience	1.Candidate	2.Candidate	3.Candidate	4.Candidate
1.Candidate	No		Very Weak	Weak
2.Candidate	Very Weak	No	Weak	Moderete
3.Candidate			No	Weak
4.Candidate				No
Job Interview Performance	1.Candidate	2.Candidate	3.Candidate	4.Candidate
1.Candidate	No			
2.Candidate	Strong	No	Moderate	
3.Candidate	Strong		No	
4.Candidate	Very Strong	Weak		No
Reference	1.Candidate	2.Candidate	3.Candidate	4.Candidate
1.Candidate	No	Very Strong		Very Strong
2.Candidate		No		
3.Candidate			No	
4.Candidate				No

After the comparison matrices were created, the scores of the alternatives were calculated according to the criteria. One of the issues that should be considered before establishing the Model is to equalize the candidate with the least preferability according to the criteria to the value of "0". The MACBETH method scores the least preferred option in the criteria so that it equates to "0". As a result of calculations using the Solver plug-in of Microsoft Excel, the values obtained for the preference of candidates were 3,4,2 and 0, respectively. Values were extended to the maximum value of 100. Candidates ' scores according to criteria are shown in Table 6.

Tablo 6. Candidates ' scores according to criteria.

	1.Candidate	**2.Candidate**	**3.Candidate**	**4.Candidate**
Reference	82,41	0,00	100,00	13,41
Experience	72,00	100,00	50,00	0,00
Performance in the job interview	0,00	80,55	52,78	100,00

After the scores of the candidates were calculated for each criterion, the general scores of the alternatives were calculated using the weights of the criteria. Candidates' scores are shown below Table 7.

Tablo 7. Candidates' overall scores.

Weights	0,08	0,50	0,42	
Alternatives	Reference	Experience	Performance in the job interview	Total Score
1.Candidate	82,41	72	0	41,12
2.Candidate	0	100	80,55	76,29
3.Candidate	100	50	52,78	52,81
4.Candidate	13,41	0	100	41,86

As seen in Table 7, the second candidate got the highest score with 76,29 points. Thus, second candidate is the most suitable from four civil engineer candidates who have applied to work as a construction manager of the construction company.

Results

In this study, MACBETH method, which is one of the Multiple Criteria Decision Making techniques, was applied in the construction manager selection problem and a solution was presented for decision makers. Also this study clearly demonstrated that selection of construction manager can be improved in several ways by implementing the decision making MACBETH method.

References

Ceran, T., and Dorman, A. A. (1995). “The complete project manager.” J. Archit. Eng., 10.1061/(ASCE)1076-0431(1995)1:2(67), 67–72.

Afshari, A.R. (2017).”Methods for selection of construction project manager:Case Study” J.Constr.Eng.Manage, 143(12):06017003.

Ensslin,S.R., Ensslin,L., Back,F., Lacerda,R.(2013).” Improved decision aiding in human resource management” International Journal of Productivity and Performance Management, Vol. 62 No. 7,pp. 735-757.

Torfi, F., and Rashidi, A. (2011). “Selection of project managers in construction firms using analytic hierarchy process (AHP) and fuzzy TOPSIS: A case study.” J. Constr. Dev. Countries, 16(1),69–89.

Balentis, A., Balentis, T., and Brauers, W. K. M. (2012). “Personnel selection based on computing with words and fuzzy MULTIMOORA.” Expert Syst. Appl., 39(9), 7961–7967.

Sadeghi, H., Mousakhani, M., Yazdani, M., and Delavari, M. (2014). “Evaluating project managers by an interval decision-making method based on a new project manager competency model.” Arabian J. Sci. Eng., 39(2), 1417–1430.

Figueira, J. R., Greco, S., and Slowinski, R. (2009). “Building a set of additive value functions representing a reference preorder and intensities of preference: Grip method.” Eur. J. Oper. Res., 195(2), 460–486.

Belton,V.,and Stewart,T.J. (2002). Multiplecriteria decisionanalysis:An integrated approach, Kluwer Academic, Boston.

Anbarcı,M., Türkakın,O.H., Manisalı,E. (2016). İnşaat Yönetiminde Çok Ölçütlü Bir Karar Verme Yöntemi VIKOR ile İş Makinesi Seçimi, 4. Proje ve Yapım Yönetimi Kongresi, Eskişehir.

Bana e Costa, C.A.,Vansnick, J.C.,De Corte, J.M. (2002). MACBETH (Overview of MACBETH Multicriteria Decision Analysis Approach), Technical Report, International Journal of Information Technology and Decision Making 11(2):359-387.

Demesouka, O. E., Vavatsikos, A. P., and Anagnostopoulos, K. P.(2016), Using MACBETH Multicriteria Technique for GIS-Based Landfill Suitability Analysis, Journal of Environmental Engineering, 04016042.