2011 2nd International Conference on Construction and Project Management
IPEDR vol.15 (2011) © (2011) IACSIT Press, Singapore

Evaluating Projects Based on Safety Criteria; Using TOPSIS

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Abstract. Undoubtedly, one of the vital activities in managing projects is the evaluation of projects' performance. Thus, it is important for organizations to recognize their strengths and weaknesses. Different methods and criteria have been proposed for this issue, but a few researches have considered projects' performance concerning safety aspects. In order to effectively improve safety in organizations, different factors that may influence its implementation need to be studied. Therefore, this study considers 16 critical success factors (CSFs) related to a safety program in order to evaluate projects' performance. To prioritize CSFs and projects Entropy and TOPSIS methods are exploited respectively. This study was conducted through questionnaire surveys in 5 different projects. Findings of this study denote that clear and realistic goals and program evaluation are the most important CSFs.

Keywords: Projects, Entropy, Safety, TOPSIS, Critical Success Factors (CSFs)

1. Introduction

One of the main problems of organizations is the frequent occurrences of accidents at the workplace [1]. Safety programs as a proactive approach are one of the best ways in improving projects' performance in a way that a suitable safety program can substantially decline accidents since it can aids managers to provide a safe environment for employees [2]. It is clear that a project's performance can be improved in this condition. In addition, an effective safety program can develop safety culture due to its mutual cooperation between management and workers in organizations. The question of how to successfully implement safety programs has been discussed by scholars [3]. Since a safety program is interrelated with different dimensions of a project, it is crucial to consider various factors that are significantly important in safety programs.

Grassi et al. [4] applied an integrated approach based on fuzzy logic theory and TOPSIS in order to rank hazardous activities. They proposed a fuzzy multi-attribute model for risk evaluation in workplaces. Findings of this study revealed that injury magnitude and occurrence probability are the most critical factors from analyst points of view. Yang et al. [5] developed a hybrid methodology to explain the role of Bayesian Networks in multiple utility techniques in safety management. The proposed methodology suitably represents the risk results and avoids the arguments resulting from exclusive states expressed by linguistic variables.

In this paper, critical success factors of safety are considered as criteria for evaluating projects. Data are gathered through a questionnaire based on 16 critical success factors in five different projects. To evaluate projects and to prioritize CSFs, TOPSIS and Entropy method is used respectively. Finally, a case study is presented to prove the capability of proposed approach. Findings of this study reveal that clear and realistic goals and program evaluation have the highest weights

2. Critical Success Factors in Safety

Critical success factors can be defined as items that if they are satisfactory, they will ensure successful implementation of a safety program [6]. Rungasamy et al. [7] stated that CSFs are necessary to the success of any program in a way that if organizations' goals are not compatible with the current condition, their programs will fail catastrophically. It is also believed that the success of safety programs can be increased if

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the required conditions are provided. Aksorn and Hadikusumo [8] proposed a comprehensive list of critical success factors which may influence successful implementation of a safety program.

Table1- CSFs in safety implementation [8]

Code	Factor	Code	Factor
C1	Clear and realistic goals	C9	Personal competency
C2	Good communication	C10	Teamwork
C3	Delegation of authority and Responsibility	C11	Positive group norms
C4	Sufficient resource Allocation	C12	Personal attitude
C5	Management support	C13	Effective enforcement scheme
C6	Program evaluation	C14	Safety equipment acquisition and maintenance
C7	Continuing participation of Employees	C15	Appropriate Supervision
C8	Personal Motivation	C16	Appropriate safety education and training

3. Shannon Entropy and Objective Weights

Shannon and Weaver [9] proposed the entropy concept, which is a measure of uncertainty in information formulated in terms of probability theory. Since the entropy concept is well sui ted for measuring the relative contrast intensities of criteria to represent the average intrinsic information transmitted to the decision maker, [10], conveniently it would be a proper option for our purpose.

Shannon developed measure H that satisfied the following properties for all p_i within the estimated joint probability distribution P [11]:

It is proved that the only function that satisfied these properties is:

$$H_{Shannon} = -\sum_i p_i \log(p_i)$$

Shannon's concept is capable of being deployed as a weighting calculation method [12], through the following steps:

Step 1: Normalize the evaluation index as:

$$P_{ij} = \frac{X_{ij}}{\sum_j X_{ij}}$$

Step 2: Calculate entropy measure of every index using the following equation:

$$e_j = -k \sum_{j=1}^{n} P_{ij} \ln(P_{ij})$$

Where $k = (\ln(m))^{-1}$

Step 3: Define the divergence through:

$$div_j = 1 - e_j$$

The more the div_j is the more important the criterion $j_{th.}$

Step 4: Obtain the normalized weights of indexes as:

$$w_j = \frac{div_j}{\sum_j div_j}$$

4. TOPSIS

TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) method is demonstrated by Chen and Hwang [13]. The basic principle is that the chosen alternative must have the shortest distance from the ideal solution and the farthest distance from the negative-ideal solution.

The TOPSIS procedure consists of the following steps: [14]

Compute the normalized decision matrix. The normalized value rij is calculated as:

$$r_{ij} = \frac{f_{ij}}{\sqrt{\sum_{j=1}^{J} f_{ij}^2}} \quad j = 1,\ldots,J \quad i = 1,\ldots,n$$

(1) Calculate the weighted normalized decision matrix. The weighted normalized value vij is calculated as:

$$V_{ij} = w_i r_{ij} \qquad j = 1,\ldots,J \quad i = 1,\ldots,n$$

Where wi is the weight of the ith attribute or criterion, and $\sum_{i=1}^{n} w_i = 1$

(2) Determine the ideal and negative-ideal solution.

$$A^+ = \left\{ v_i^+,\ldots.,v_n^+ \right\} = \left\{ \left(\max v_{ij} \middle| i \in I^{'} \right), \left(\min v_{ij} \middle| i \in I^{''} \right) \right\}$$

$$A^- = \left\{ v_i^-,\ldots.,v_n^- \right\} = \left\{ \left(\min v_{ij} \middle| i \in I^{'} \right), \left(\max v_{ij} \middle| i \in I^{''} \right) \right\}$$

Where $I^{'}$ is associated with advantage criteria, and $I^{''}$ is associated with cost criteria.

(3) Calculate the separation measures, using the n-dimensional Euclidean distance. The separation of each alternative from the ideal solution is given as:

$$D_j^+ = \sqrt{\sum_{i=1}^{n} (v_{ij} - v_i^+)^2} \qquad j = 1,\ldots,J$$

Similarly, the separation from the negative-ideal solution is given as:

$$D_j^- = \sqrt{\sum_{i=1}^{n} (v_{ij} - v_i^-)^2} \qquad j = 1,\ldots,J$$

(4) Calculate the relative closeness to the ideal solution. The relative closeness of the alternative aj with respect to A^* is defined as:

$$C_j^+ = \frac{D_j^-}{\left(D_j^+ + D_j^-\right)} \qquad j = 1,\ldots..,J$$

(5) Rank the preference order.

5. Evaluating Project Based on Safety Criteria

In this study a questionnaire including 39 questions was designed and distributed into five different industrial projects. Questions were designed based on the 16 CSFs in Table 2 in order to measure perceptions of respondents from the condition of factors in each project. Questionnaires were submitted to all the managers and supervisors of projects. To measure the condition of CSFs in projects, respondents were asked to rate on a five-point Likert scale varying from "very bad" (1) to "very good" (5). Collected data are represented in table 2.

Table2- Data of five projects on 16 critical success factors

	C1	C2	C3	C4	C5	C6	C7	C8
Project1	3.73	4.08	3.91	4.08	4.28	3.27	3.74	4.31
Project2	4.12	4.23	3.82	4.32	3.75	3.68	3.85	4.21
Project3	3.81	3.95	3.75	4.28	3.86	3.54	3.88	4.07
Project4	4.16	3.78	4.17	3.97	4.21	3.72	4.06	3.92
Project5	3.58	4.10	4.02	3.95	4.32	3.36	3.92	4.16
	C9	C10	C11	C12	C13	C14	C15	C16
Project1	3.52	4.17	3.17	3.73	4.37	3.50	4.32	3.67
Project2	3.89	4.05	3.25	3.62	4.41	3.66	4.16	3.92
Project3	3.72	4.22	3.73	3.57	4.21	3.54	4.37	3.77
Project4	3.67	4.12	3.42	3.81	4.17	3.72	4.09	3.81
Project5	3.92	4.35	3.37	3.88	4.41	3.23	4.14	3.75

The weight of each criterion is calculated by Shannon Entropy method. As considerable in table 3, the highest rank refers to clear and realistic goals and management support.

Table3- Weight of criteria by Entropy

Criteria	C1	C2	C3	C4	C5	C6	C7	C8
Weight%	13.21	5.66	5.59	5.48	12.90	9.83	2.80	4.03
Criteria	C9	C10	C11	C12	C13	C14	C15	C16
Weight%	6.10	2.29	12.48	3.76	2.25	9.19	2.61	1.83

To prioritize projects, TOPSIS method is applied. As considerable in table 4, project 4 and 2 have the highest rank respectively.

Table4- Projects' ranking

Item	TOPSIS Index	Rank
Project1	0.3486	5
Project2	0.5687	2
Project3	0.4907	3
Project4	0.8691	1
Project5	0.3843	4

6. Conclusion

During the past decade, great number of accidents has prompted scholars to investigate into the factors which may influence successful implementation of a safety program. Since a safety program involve different aspects of a project, it is important to distinguish the most important factors which may influence successful implementation of a safety program.

This research presented a practical methodology for identifying the main reasons of success in safety programs implementation and ranking projects based on 16 critical success factors of safety. The methodology of this research provides an appropriate and simple way for determining the main factors which may improve projects' performance.

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