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A mathematical Model to select the Risk Response Strategies of the Construction Projects: Case Study of Saba Tower

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Abstract

Uncertainties and risks are always associated with large real world projects and may obstacle and threaten projects in some ways. Failure in accurately identifying the project risks increases the total cost and may cause social and environmental damages as well as casualties during project execution. The aim of this study is to develop a mathematical programming model for selecting risk response strategies for construction projects. All risk response strategies for the analysed project have been identified and a mathematical model is presented based on project iron triangle; time, cost and quality to obtain the optimal risk response strategy for the construction project.

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Keywords: risk management, optimization, risk identification, risk response

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1. Introduction & literature review

Uncertainties and risks are the inherent characteristics of the real world construction projects. The project risk management deals with identifying and controlling the risks before they occur [1]. Various risks happen in project execution phase which may reduce the performance efficiency and even cause the project failure. Therefore, the application of project risk management is essential in order to achieve optimal performance in construction projects [2].

Risk identification is the first step of risk management process where the potential risks are identified. It is a crucial process to guarantee the project success and meet the project time, cost, quality and safety. Appropriate strategies should be performed for responding to risks, when the project risks are identified and analyzed [3]. One of the first places to start identifying risks is the project itself. Some of the planning processes can help you with the risk identification task. The project constraints, WBS, task list, and critical success factors can uncover risks regarding the project itself [3,4]. Risk management identifies potential project obstacles early in the process and develops plans and strategies to reduce or avoid their impacts [5,6].

ISO 31000 method and Failure Mode and Effects Analysis (FMEA) approach have been the most effective and applicable methods to evaluate risks for complex projects. Shafiee and Dinmohammadi (2014) used the FMEA approach to assess technical risks of wind-mill plants [7]. Recently, Chanamool and Naenna (2016) applied Fuzzy FMEA to evaluate critical risks of emergency department of a hospital [8]. In another studies, Fuzzy FMEA method was used to measure the technical risks of complex construction projects [9,10]. Kumru and Kumru (2013) implemented Fuzzy FMEA technique to improve the purchase process of a public hospital [11].

Chanamool and Naenna (2016) applied Fuzzy FMEA method to prioritization and assessment of failures of an emergency department [12]. The other researchers proposed modified FMEA method based on fuzzy set theory and fuzzy Analytic Hierarchy Process (FAHP) by analyzing the limitations of the traditional FMEA [13-17].

Different models of project risk management were proposed since 1990 to manage the risks of the projects in order to increase the success of the projects [18,19]. Responding to the risks is one of the vital steps of the most proposed models by different scholars over the past decades. Some models included some simple steps and some others consisted of more sophisticated details. In recent years, various methods have been used to evaluate the project risks and different studies conducted on the area of risk management in more detail. Analysis checklists, SWOT approach, Delphi technique and multi-criteria decision-making techniques such as AHP are some examples of the techniques used in this field [20]. Also, the Fuzzy Inference, Decision Support Systems and Expert Systems were proposed as newer methods [21]. Recent studies remarkably show that the application of Fuzzy Logic in risk management has become a popular topic among scholars due to its compatibility with the nature of uncertainty and risks [22]. The effects of risks can be evaluated by two main parameters: the probability of risk occurrence and the severity of risk. The severity of risk depends on many factors regarding human resource, workplace, materials, and equipment which cannot be easily quantified based on the traditional methods [23].

In this study, a hybrid FMEA and ISO 31000 approach is used to evaluate and identify the risks of the construction project. Then, an optimization model is proposed for selecting the risk response strategies that clearly relate the work breakdown structure, risk events, risk mitigation actions and their effects to each other. In other words, work breakdown structure is an important tool for integrating the comprehensive project management with the other risk management sub-systems.

To the best of our knowledge, we are introducing the selection method of risk response strategies for the first time and there is no previous study in the literature. In this paper, a mathematical programming model for selecting the risk response strategies is proposed with its application in a real world construction project.

2. The mathematical model and problem description

After identifying the risks by using the standard ISO 31000 based on the FMEA method, the risk response