

# An optimization method for selecting project risk response strategies

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## Abstract

There is wide agreement that the risk response strategy selection is an important issue in project risk management (PRM). Some academic researchers have paid attention to this issue. This paper proposes a novel method for solving the risk response strategy selection problem in PRM. In the method, an optimization model is developed, which integrates three critical elements that are the project cost, project schedule and project quality. By solving the model, the optimal solution could be obtained so that the most desirable risk response strategies to cope with the risk events can be determined. If the optimal solution is not found or project managers are not satisfied with the solution, another pathway can be used to support the managers to get the desirable strategies. The pathway is based on an iterative process which involves making trade-offs between the project budget, time and quality according to objective requirements and managers' judgments. The iterative process comes to an end if the objectives predefined by the managers are reached. A simple example project is also provided to illustrate the practicality and usefulness of the proposed method.

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*Keywords:* Risk response strategy; Optimization; Trade-off; Project scope; Work breakdown structure (WBS)

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## 1. Introduction

Risk can appear in any aspect of a project in practice. It may cause cost overruns, schedule delays and even poor quality if it is not dealt with effectively in the process of project management. Therefore, project risk management (PRM) is an important topic for practitioners and academic scholars. In general, PRM consists of three phases (Buchan, 1994): risk identification, risk assessment and risk response. Risk identification refers to recognizing and documenting associated risks. Risk assessment refers to examining the identified risks, refining the description of the risks, and estimating their respective probabilities and impacts. Risk response refers to identifying, evaluating, selecting, and implementing actions in order to reduce the likelihood of occurrence of risk events and/or lower the negative impact of those risks. The risk response plays a proactive role in mitigating the negative impact of project risks (Miller and Lessard, 2001). Once risks of a project

have been identified and analyzed, appropriate risk response strategies must be adopted to cope with the risks in the project implementation (Zou et al., 2007). Therefore, there is wide agreement that the risk response strategy selection is an important issue in PRM (Ben-David and Raz, 2001), but study on selecting risk response strategies is the weakest part of the PRM process so that many organizations fail to gain the full benefits from PRM (Hillson, 1999). In practice, project managers can recall similar projects or risk events that they have experienced before when confronting the problem of selecting risk response strategies for the current project. They try to utilize previous knowledge through lessons learned, case studies and best practices in their memory to choose right strategies from a pool of potential risk response strategies. However, managers often fail to do this because they are short of quantitative models as a reference for evaluating and selecting risk response strategies (Jaafari, 2001) to achieve the project objectives in cost, schedule, quality, etc.

The aim of the study is to propose a decision analysis method which combines quantitative model and qualitative analysis to select desirable project risk response strategies. In the method, an integer programming model is constructed based on analysis of the

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project work breakdown structure (WBS) and project risks previously identified. The model can help project managers select risk response strategies by maximizing risk response effects of implementing the strategies while considering project cost of performing the strategies, project schedule and project quality. By solving the model, the optimal solution could be obtained so that the most desirable risk response strategies can be determined. If the optimal solution is not found or project managers are not satisfied with the solution, another pathway can be used to support the managers to get the desirable strategies. The pathway is based on an iterative process to make trade-offs between the three mentioned critical factors: cost, schedule and quality. The iterative process comes to an end if the objectives predefined by the managers are reached.

The remainder of this paper starts from reviewing the previous studies related to project risk response strategy selection. Then it moves to an introduction of some basic concepts associated with project risk response strategy selection. Subsequently, an optimization method for selecting risk response strategies is presented. In the method, a mathematical model is constructed and a resolution process for obtaining the most desirable strategies is given. Thereafter, a simple example project is demonstrated to illustrate the effectiveness and practicability of the proposed method. Conclusions and future developments appear in the last section.

## 2. Literature review

It can be seen that studies pertinent to project risk response strategy selection have aroused attention by some scholars from different perspectives. A summary of related literature on project risk response strategy selection is as shown in Table 1. The approaches involved in the existing studies can be mainly classified into four categories: the zonal-based approach, the

trade-off approach, the WBS-based approach and the optimization-model approach. In the following, the brief descriptions and comments on these approaches will be given.

In the zonal-based approach, two selected criteria with respect to risks are mapped to the horizontal axis and vertical axis, respectively. The two selected criteria are the weighted probability of immediate project risk and that of external project risk (Datta and Mukherjee, 2001), the extent to which risks are controllable and degree to which risks are specific to the project (Miller and Lessard, 2001), etc. According to different values of the two criteria, a two-axis graph composed of multiple zones is formed. Different strategies are placed in their corresponding zones. Thus, appropriate strategies can be selected according to the zones in which the coordinates constituted of the two criterion values are located. The two-dimensional zonal-based approach can be considered as approximate tools for selecting risk response strategies (Hatefi et al., 2007). It has a limitation that only two criteria can be considered.

In the trade-off approach, in order to obtain candidate risk response strategies, trade-offs are made considering objective requirements of the project and managers' subjective preferences between criteria associated with risk such as cost, probability of success, percentage of work losses, duration, quality, and so on. Then the desirable strategies can be selected among the candidate ones according to efficient frontier rule (Kujawski, 2002; Pipattanapiwong and Watanabe, 2000), pareto optimal solution (Haimes, 2005) and decision maker's preference (Klein, 1993). But, this approaches either consider only two factors or make trade-offs based on qualitative analysis.

The WBS-based approach is regarded as the one based on risk management and the project management process. It relates risk response strategy selection to work activities based on project WBS analysis. When the analyzed activity is the actual one, risks are identified and strategies can be formulated directly associated

Table 1  
Literature on project risk response strategy selection.

Authors	Focus of analysis	Approaches
Flanagan and Norman (1993)	The likelihood of occurrence and severity of the risks	The zonal-based approach
Elkjaer and Felding (1999)	The degree of influence and degree of predictability of the risks	
Datta and Mukherjee (2001)	The weighted probability of immediate project risk and that of external project risk	
Piney (2002)	The acceptability of impact and probability of risks	The trade-off approach
Miller and Lessard (2001)	The extent to which risks are controllable and degree to which risks are specific to the project	
Chapman and Ward (1997)	The expected costs of risk response strategies and uncertainty factors of the expected costs	
Pipattanapiwong and Watanabe (2000)	The expected cost of risk after applying the risk response strategy and degree of risk to access the risk response strategy	
Kujawski (2002)	The probability of success for a given total project cost and the total project cost for a given probability of success	
Haimes (2005)	The cost of risk response strategy and percentage of work losses associated with the risk response strategy	The WBS-based approach
Klein (1993)	Uncertainties in project duration, cost and quality	
Chapman (1979)	Work activities, and risks and risk response activities associated with the work activities	
Klein et al. (1994)	A variation on Chapman based on the analysis of a prototype activity	
Seyedhoseini et al. (2009)	Selecting a set of response actions that minimizes the undesirable deviation from achieving the project scope.	
Ben-David and Raz (2001)	Project work contents, risk events, and risk reduction actions and their effects	The optimization-model approach
Ben-David et al. (2002)	Interactions among work packages in respect to risks and risk abatement efforts	
Fan et al. (2008)	The risk-handling strategy and relevant project characteristics	
Kayis et al. (2007)	The available mitigation budget and strategic objectives of the project	

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