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Selection of risk response actions with consideration of secondary risks

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Abstract

Secondary risk in project risk management refers to the risk that arises as a direct result of implementing a risk response action (RRA). It is important for project managers (PMs) to consider the effects caused by the secondary risks in the process of RRA selection. The purpose of this paper is to propose an optimization method to address the problem of selecting risk response actions (RRAs) with consideration of secondary risk which is seldom considered in the existing studies. The optimization model aims to minimize the total risk costs with time constraint being placed on the project makespan. By solving the model, an optimal set of RRAs along with the earliest start time for each activity can both be obtained. The results show that secondary risk plays an important role in the process of RRA selection. Project managers should allocate more budget for responding the project risk when the secondary risk is considered, and consider all factors relating to both time and cost so as to select appropriate RRAs to mitigate primary risk and secondary risk.

Keywords: Project risk management (PRM); Risk response action (RRA) selection; Secondary risk; Optimization; Project scheduling

1. Introduction

Project risk is defined as an uncertain event causing damage or loss, which is considered to be threatening in project management due to the fact that it exerts effects on project objectives such as schedule, cost and quality (Degn Eskesen et al., 2004; ISO, 2009; Muriana and Vizzini, 2017; PMBOK, 2013). Particularly, in project scheduling, project managers (PMs) have little knowledge of the risks involved in each activity of a project which may to a certain extent give rise to delays in duration, and thus overruns in budget and degradation in quality will be incurred correspondingly (Wang and Yuan, 2016; Zhang and Fan, 2014; Zwikael and Ahn, 2011). For instance, in a subway project, the malfunctions of a critical equipment such as Tunnel Boring Machine (TBM) will postpone the excavation by days or even weeks, which if responded by investing in a new one, more time will be consumed. As a result, a time delay of the activity will be caused. However, if the backup plan such as preparing an alternative equipment is made in advance, then the time delays will be controlled to an acceptable level. Therefore, when scheduling a project, it is of vital importance to identify and evaluate the possible risks, and deal with them by determining and performing RRA so as to reduce their negative impact on the project (Creemers et al., 2014; Herroelen and Leus, 2005; Kılıç et al., 2008; Nguyen et al., 2013; Zafra-Cabeza et al., 2008).

According to Hillson (1999), the effect of risk identification and risk evaluation will be diminished if risk response is not properly performed. However, in practice, risk response does not receive enough attention in comparison with risk identification or risk analysis that it lacks a widely accepted model or tool for selecting appropriate response strategies, and that it does not have a standard process for PMs to follow (Fan et al., 2008; Hillson,

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1999; Ben-David and Raz, 2001). In the stage of risk response, four strategies are commonly used to cope with risks, which are risk avoidance, risk transference, risk mitigation and risk acceptance (PMBOK, 2013). With different purposes, these four strategies are selected by PMs in accordance with different situations or projects with consideration of the severity of risks, the availability of resources and other factors that are related to the project objectives. To be specific, in confrontation with a risk evaluated as insignificant, options for PMs can either be accepting its loss without further actions or transferring it to a third party through insurance. On the contrary, if a risk is critical to the success of activity execution or even the achievement of project objectives, then strategies such as risk avoidance and risk mitigation need to be adopted. In particular, risk avoidance refers to the elimination of the threats brought by risks, while risk mitigation aims to reduce risk probability or impact to an acceptable level. In order to completely prevent the risk, risk avoidance is always applied by removing the whole activity related to that risk from the original plan. Such a move, though effective, may result in certain complexity in managing the project, since new risks will be incurred by the newly adopted activity. In contrast, risk mitigation, which seems to be more practical, reduces the risk associated with the activity by selecting and implementing a new set of RRAs. Therefore, selecting RRAs to mitigate the risks within the project is the main job in the stage of risk response (Aqlan and Lam, 2015; Zhang and Fan, 2014). This paper intends to propose a method for selecting an optimal set of RRAs to mitigate the risks and to guarantee that the project will reach its objectives.

Most existing methods of RRA selection mainly focus on mitigating the primary risks with no perception of the secondary risks which might occur during the implementation of the selected RRAs (Fan et al., 2015; Marmier et al., 2014; Zhang and Fan, 2014; Zhang and Zuo, 2016). According to PMBOK, the occurrence of secondary risk can be regarded as a direct outcome of implementing an action that responds to a primary risk. Take a risk occurs in the context of offshore pipeline for instance. When there occurs buckle in the pipeline, a feasible action is to send a Pipeline Intervention Gadget (PIG) through the pipeline in order to do the cleanup. However, if the gadget is stuck in the middle of the pipeline, then a secondary risk is realized (Chapman, 1990). Similar to primary risk, secondary risk is also capable of bringing about a negative impact to the whole project. Therefore, PMs need to decide which primary mitigation actions should not be implemented to avoid the occurrence of secondary risks, and how to deal with the secondary risks if they are incurred by primary mitigation actions. In the case of the "PIG" stuck risk, a secondary RRA which is to increase the hydrostatic pressure needs to be taken, given the fact that otherwise pipe bursting or even environmental damage will be incurred (Dey et al., 2004).

It can be seen that determining the appropriate set of RRAs plays an important role in PRM, and is critical to the success of project. Besides, secondary risk which is incurred during the implementation of primary RRA should also be considered in the process of RRA selection because secondary risk, similar to primary risk, has negative effect on project performance and should be handled appropriately. However, most existing RRA selection methods fail to determine the RRAs of secondary risk, nor investigate the effect of secondary risk on project objectives, such as time and cost. Therefore, this paper aims to address this research gap and answer the following research questions: What is the difference in managing secondary risk and primary risk? How to determine the optimal set of RRAs with consideration of secondary risk and how does the secondary risk influence project makespan and cost?

In this study, an optimization model for selecting RRAs for both primary risks and secondary risks is proposed. In the construction of the model, the objective function is to minimize the sum of the total risk costs and the costs of crashing with time constraints being imposed on the precedence relationships between every two activities. Then by setting a reasonable due date for the whole project and solving the model, an optimal set of RRAs along with the earliest start time for each activity can both be obtained.

The outline of this paper is as follows: in the next section, the related literature on the selection of RRAs is reviewed. After that, the concepts of primary risk and secondary risk and the differences in managing these two kinds risks are given in Section 3. Next, the problems of selecting RRAs in the case of project scheduling are elaborated in Section 4. Then, in Section 5, a mathematical model for selecting an optimal set of RRAs is constructed. Section 6 takes a metro project as an example to illustrate the effectiveness of the proposed method. After obtaining the results by solving the mathematical model, the result analysis and managerial implications are given in this section. Finally, conclusions and future directions are presented in Section 7.

2. Literature review

2.1. Literature on RRA selection

It can be seen that the selection of appropriate RRA has received much attention from different perspectives (Hatefi and Seyedhoseini, 2012). According to the classification proposed by Zhang and Fan (2014), the zonal-based approach, the trade-off approach, the WBS-based approach and the optimization-model approach are considered as the four primary methods used to analyze and determine the RRAs. In addition to these four methods, the decision tree method (Dey, 2012; Marmier et al., 2014; Nguyen et al., 2013) and case-based method (Fan et al., 2015; Lam et al., 2013; Oztekin and Luxhøj, 2010) are also used for selecting the RRAs in recent years. Among the above methods, optimization method is the most relevant to our study. Therefore, the brief descriptions and comments about the optimization-model approaches will be given as follows.

Ben-David and Raz (2001) first propose that the selection of RRAs can be modeled as an optimization problem. With an aim to minimize the total risk costs, their model is able to generate the most cost-effective solutions for the selection of RRA sets. Kayis et al. (2007) develop a new RRA selection method to provide PMs with the optimal set of RRAs in view of the limited budget and risk magnitude. In their model, a cost effectiveness approach is used as an objective, which is to minimize the difference between the upper bound mitigation cost/risk ratio and the mitigation cost/risk ratio generated from the project.