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A Model to Estimate Information System Project Contingency Budget

[1]Junwei Zeng, [1]Fajie Wei and [2]Haitao Xiong
[1]School of Economics and Management, Beihang University, Beijing, 100191, China
[2]School of Computer and Information Engineering, Beijing Technology and Business University, Beijing, 100048, China

Abstract: Development of an information system is a complex process, which expose to a great number of risks. Hence, the high failure rates long associated with information system projects, despite advances in techniques for information technology development, suggest that organizations need to improve their ability to identify and to manage associated risks. To improve the risk management in information system development projects, a pragmatic procedure is suggested to determine the size of a project's contingency plan budget at any specified level of certainty. Considering the interaction among risk factors, a method based on common risk factors and copula functions is used to model and quantify positive dependence between risks.

Key words: Information extraction, copula, information system development project, contingency plan budget, risk dependency

INTRODUCTION

Even before the widespread use of “the mythical man-month” (Brooks, 1975), Information System (IS) project failure was described as a common phenomenon and many development projects did not achieve previously cost, schedule and performance goals. It has been continuing to the present. Over last three decades, there has been considerable interest in exploring and explaining the reasons for the abnormal high failure rates. McFarlan (1981) points out that failure to assess individual project risk is a major source of the IS development problem. Then, many researchers, therefore, try to identify the various risks associated with the IS development (Jiang and Klein, 2000). Jiang *et al*. (2001) argue that the high failure rates associated with IS projects suggest that organizations need to improve not only their ability to identify, but also to manage the associated risks.

A contingency plan is designed for the identified uncertainty, which means that people can have a relatively controllable environmental setting. This feature is very meaningful for the IS development projects because most of the changes can be predictable and project managers have a lots of alternative technological tools to reduce or constraint the impact of those predictable changes. Some project managers try to use a fixed deterministic percentage of project budget to capture and quantify the degree of confidence that the contingency plan should cover. Touran (2003) criticizes the use of this approach.

Budgeting for project contingency plan, an efficient way to reserve resources, has been studied by scholars (Ranasinghe, 1994; Touran, 2003; Yeo, 1990). Recently, Khamooshi and Cioffi (2009) propose a pragmatic procedure to determine the size of contingency plan budget for a project, a programs, or a system at any specified level of certainty confidence. That method, like many other risk management approaches, considers risks as independent events.

In this research, the combination of risk tolerance and statistical dependence will be analyzed and then be used to allocate the contingency plan budget in IS development projects. A applied procedure is proposed to manage the contingency plan budget of IS development projects, considering dependencies among risk events in IS projects. The procedure demonstrates how to formulate a project contingency plan and to allocate contingency plan budget for risks defined over the duration of an IS development project. Taking the coupling of blocks in an information system into account, the copula is introduced to model relationship between dependent risks to make the estimation more practical. The Monte Carlo methods are also used in the calculation of the joint distribution of risk events.

In the rest of this study, a statistical dependence model for IS projects is firstly described. And then, a framework that enable project managers to work better with inevitable risks in projects is presented. The last section is the conclusion.

A MODEL FOR IS PROJECTS RISK ESTIMATION

The important of relaxing the independent assumption has been clearly recognized by scholars. The copula approach is used to solve this issue by many

Corresponding Author: Junwei Zeng, School of Economics and Management, Beihang University, Beijing 100191, China

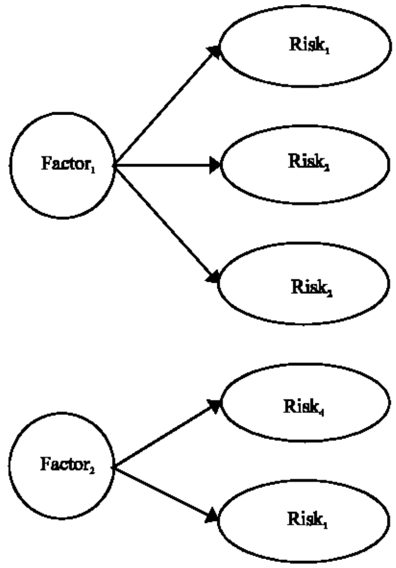

Fig. 1: A model for statistical dependence of risks due to common risk factors

researchers (Van Dorp, 2005). A copula is a function that links the marginal distributions to the joint distribution, which is a statistical concept that relates random variables. Van Dorp and Duffey (1999) discusses a simulation-based model to quantify positive dependence between uncertainty distributions of activities in a project network. Their model can provide a less cumbersome method to elicit dependency information from experts. Their research is useful in uncertainty analysis where dependence between random variables with a bounded support is present due to common factors. Later, Van Dorp (2005) puts forward a model for building statistical dependence between marginal distribution.

The core idea of using copula method to cope with dependency is the procedure to calculate the multivariate distributions between subsets of uncertainty distributions. After analyzing the methods to deal with two extremes caused by assuming the marginal distributions to be specified separately, the multivariate can be constructed by an intermediate method. The method assumes independence between marginal distributions and allows to use joint distributions for subsets of uncertainty distributions which share common risk factors. Actually, the ideal of latent variable models has been used when specifying the independence (Bartholomew *et al*., 2011; Holland and Rosenbaum, 1986). People can use many skills, e.g. brainstorming sessions, to identify the common risk factors in a specific project. The dependence diagrams can also be introduced into project risk analysis. Considering the construction of a rank correlation by project experts is impractical.

The Diagonal Band distribution introduced by Cooke and Waij (1986) is suggested to be used under this environment (Van Dorp and Duffey, 1999). A bivariate Diagonal Band distribution D (U, V) of two uniform on [0,1] distributed random variables U and V is shown in Fig. 1. To model the statistical dependence between risk events in a specific project, a multivariate distribution of risk events need to be modeled. A copula-based statistical dependence model is proposed in this study.

In Fig. 1, $Risk_i$ is used to denote a specific risk event whose potential loss follows some kinds of distribution and $Factor_j$ represents a common factor that can impact on several risk events in a IS development project.

To estimate the potential loss of a IS project, a multivariate joint distribution, F_0 (•), can be specified between $Risk_1$, $Risk_2$, $Risk_3$, $Risk_4$ and $Risk_5$. In most case, the marginal distributions, denoted by $F_{ri}(Risk_i)$, of $Risk_1$, $Risk_2$, $Risk_3$, $Risk_4$ and $Risk_5$ are available (from estimation of project engineers and experts). By introducing new common influential factors (common risk factors or so-called latent variables), the independent common risk factor $Factor_1$ and $Factor_2$, (whose marginal distribution can be denoted by F_{fj} ($Factor_j$), joint distribution of five risk events, F_0 (•), can be simplified.

It can be represented by F_{123} ($Risk_1$, $Risk_2$, $Risk_3$) which means the joint distribution for $Risk_1$, $Risk_2$, $Risk_3$ and F_{45}($Risk_4$, $Risk_5$) which means the joint distribution for $Risk_4$ and $Risk_5$. So, to get the two joint distributions, F_{123} ($Risk_1$, $Risk_2$, $Risk_3$) and F_{45} ($Risk_4$, $Risk_5$), the joint distribution between $Factor_j$ and $Risk_i$ (j = 1, i = 1, 2, 3 or j = 2, i = 4, 5) should be specified. The conditional independence can be used to simplify the joint distribution to a combination of several bivariate distributions (Duffey and Van Dorp, 1998). According to the definition of copula, the joint distribution between $Factor_j$ and $Risk_i$ such as $Factor_1$ and $Risk_1$ can be uniquely determined by its associated copula.

In (Van Dorp and Duffey, 1999), the DB copula, D (U, V), is a bivariate Diagonal Band distribution of two uniform on [0, 1] distributed random variables (U and V) with one parameter (θ). The DB copula can be used to describe the relationships of risk events in (Van Dorp and Duffey, 1999). Uncertainty information can be elicited and the marginal cumulative distribution function of $Factor_j$, F_{fj} ($Factor_j$) and the marginal distribution function of $Risk_i$, F_{ri} ($Risk_i$) also can be figured out. F_{fj} ($Facotr_j$) and F_{ri} ($Risk_i$) contain all information on the marginal distribution. From standard distribution theory, all marginal distribution which is absolute continuous may be derived from the uniform marginal by an appropriate transformation. So, both F_{fj} (Factor$_j$) and F_{ri}(Risk$_i$) are related to uniform random variables on [0, 1]. Hence, in (Van Dorp and Duffey, 1999), U can be associated with F_{fj} (Factor$_j$) and V can represent F_{ri} (Risk$_i$).

Generally speaking, if considering the dependence of risks, the joint distribution of risk events, Risk$_i$, should be obtained. The problem can be simplified by introducing some independent common risk factors, Factor$_j$ and using a theory called conditional independence (Musolino *et al*., 2011). So, only the bivariate distributions of Factor$_j$ and Risk$_i$ need to be considered.

The Monte Carlo method for assessing variability and uncertainty in project risk analysis has become more common. The reverse of procedure deriving copulas can be used to generate pseudo-random samples from general classes of multivariate probability distributions. That is, given a procedure to generate a sample from the copula distribution, the required sample can be constructed. More details can be found in (Durante and Sempi, 2010).

NEW FRAMEWORK FOR BUDGETING

The procedure proposed in this study inherits the theoretically sound foundations of the rank correlation method allowing the marginal distributions to be specified separately and is practical enough to be used by IS project analysts. It contains five steps, as shown in Fig. 2.

Risk identification: It has become the consensus that the requirement of risk identification is to determine which risk events are likely to affect the project and to document the characteristics of each potential risk event. Beside the normal requirements, the common risk factors, e.g., common code blocks, development framework *et al*., are also needed to be identified by experts and then risk events are grouped according to the common risk factors. The final result of this step can be illustrated by figures similar to Fig. 1.

Risk quantification: In this stage, risks and interactions among them need to be evaluated to assess the range of possible project outcomes. The potential impact and the probability of occurrence of each risk should be evaluated. Usually, a risk events can cause damage at several different levels with corresponding probabilities. The more scenarios with probabilities can be listed in this step, the more accurate the final result can be.

Risk fitting: It is noticeable that, in this new procedure, people can take all uncertainty factors into consideration instead of dealing with impact and occurrence separately and deterministically. In other words, this procedure can eliminate the second drawback of the currently used method mentioned in previous sections. Based on the scenarios from previous step, the distributions of the risk events can be simulated. There are a lots of tools can help people to translate the scenarios of a risk event into a suitable distribution. The uniform, triangular, binomial, Poisson, exponential, Student's t and normal are very popular distributions in project management and most of project managers are familiar with these distributions. The Quality Assurance (QA) teams in most of IT companies are using some efficient bug management software which can help to generate the reliable assessment of the distributions.

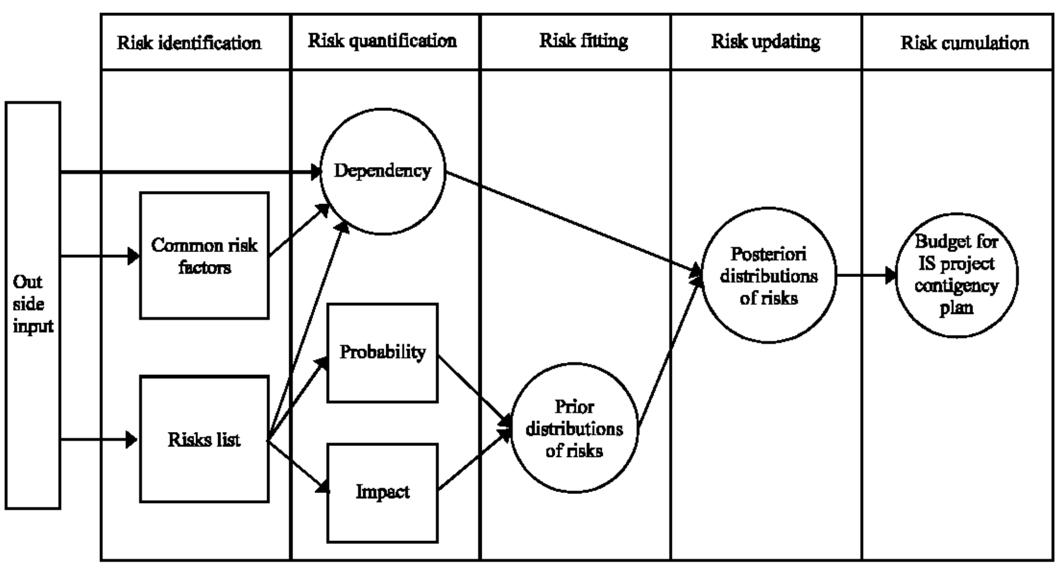

Fig. 2: Procedure for getting contingency plan budget

Risk updating: This step is used to update the distribution of each risk in a IS project. The information extraction and the fitting of risk events do not contain the quantifiable dependency information. This design is reasonable because the impact of common risk factors are not easy to be accurately valued and the best practice of this work is to build a special team with experts in many fields. With the model in section 2, the description of distributions of the common risk factors can be avoided. So, the joint distribution of each risk events group can be calculated by considering the dependency structure.

Risk cumulation: The amount of damage that the IS project will experience depends on risk events that will occur, which people cannot know specifically in advance. But, the expectation or a specific value given any level of certainty, e.g., 99\% confidence, can be calculated after analyzing the joint distribution of all risk events. This procedure is very pragmatic. It simplifies the extraction process of expert opinion without loss of accuracy.

CONCLUSION

Failures of IS development projects (cost overruns, schedule delays, poor quality) can cause enormous losses. Unfortunately, the rate of occurrence of failures is still high. Many scholars try to solve this problem by software engineering and project risk management. At the same time, contingency plan budget for IS development project, which is a very import tool for project managers to reduce the risk exposure, attracts more and more researchers. However, there are two weak points in existing methods: (1) The assumption about independence of risk events, which is obviously counterintuitive, (2) The deterministic description of risk events, which may cause data loss. The statistical model and procedure proposed in this study can improve the accuracy of the estimation of contingency plan budget for IS development projects by overcoming the above two disadvantages. The five steps can help stakeholder to grab and extract information about risk events in the IS projects and translate them into a specific number when given a level of certainty. Diagonal Band distribution and Monte Carlo methods are used to quantify the dependency among risks.

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