Risk Quantification Model for Construction Projects using Score Model and EV Analysis approach

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Abstract
Combining in itself the potential for employment and providing critical infrastructure for practically any economic activity, construction industry plays a decisive role in healthy development of any nation. Not only large but even small construction projects have an abundance of risks and need effective Risk Management. Intuition, expert skills and judgment always influences decision making process in Risk Management. A set of tools is needed which shall enable Risk Management to be used effectively in practice in construction industry. In any Risk Management Program, it is necessary to pay serious attention to Risk Quantification. Risk Quantification leads to an estimate of risk exposure for the project, and aids in risk response planning i.e. determining which risk events warrant response and the size of cost and schedule contingency reserves. In this paper, a model for Risk Quantification has been proposed for construction projects, using score model and EV analysis approach.

Key Words: Risk, Risk Management, Score model, EV Analysis

1. INTRODUCTION
Over the world, construction activity is regarded as the principle sign of growing economic activity. Risk and uncertainty are inherent in all construction works, no matter what is the size of the project. Although size of project is one of the major causes of risk, other factors that carry risk within them include speed of construction, location of project, technology being used and familiarity with the work. A construction project is also vulnerable to Political, Economic, Social and Environmental conditions. Project objectives tend to change, as well as there are changes in design, work methods, responsibilities of parties etc. which result in an increased vagueness of conditions. The participants in the industry have been agonizing outcomes of failure in the form of unusual delays in the project completion with cost overruns and many times, something failing to meet quality standards and operational requirements. An effective analysis and management of construction associated risks remain a big challenge to industry practitioners (Syed and Azhar, 2004).Thus, construction industry demands systematic risk management approach. All too often, risks are either ignored, or dealt with in a completely arbitrary way. In a business as complex as construction, such an approach is often inadequate (Hayes, R W, Perry J G, Thompson P A and Willmer, G.,1986).Failure to perform effective risk management can cause projects to exceed budget, fall behind schedule, miss critical performance targets, or exhibit any combination of this troubles (Barney B. Roberts and Louis Fussell,1999).
In any Risk Management Program (RMP), it is necessary to pay serious attention to risk quantification. Risk quantification is the process of evaluating risks and determining the effects of these risks on the project. It is primarily concerned with determining which risk events warrant response. In this paper, a model for Risk quantification for construction projects has been proposed.

2. LITERATURE REVIEW
A broad definition of risk is the probability that an adverse event occurs during a stated period of time (Royal Society, 1991). However, Al-Bahar and Keith (1990); Porter (1981); Perry and Hayes (1986) defined risk as the exposure to the chance of occurrences of events adversely or favourably affecting project objectives as a consequence of uncertainty.

Risk management is defined as “the systematic process of identifying, analysing, and responding to project risk” (PMI, 2000). According to Flanagan and Norman (1993), Risk Management (RM) is a discipline for living with the possibility that future events may cause adverse effects. Dikmen, Birgönül,M Talat and Arikan, A E (2004);

Turner, 1999 and Chapman, 1997 have all presented the wider perspective of RM and have stated that RM is one of the most critical project management practices to be followed for successful project completion.

PMI (2000) proposes six major processes for risk management i.e., risk management planning, risk identification, qualitative risk analysis, quantitative risk analysis, risk response planning, and risk monitoring and control. Although detail of each RMP suggested by various researchers (Al-Bahar and Crandall 1990; Flanagan and Norman 1993; Kahkonen and Huovila, 1996; Chapman 1997; ICE 1998; and PMI 2000) is different in term of scope and number of processes, generally, they can be divided into three main processes i.e. risk identification, risk analysis and risk response.

Risk identification aims to identify all risks to which a business or project is exposed, so that conscious decisions can be taken on how to manage risks. Documentation review, brain storming, interviews, Questionnaire surveys, SWOT analysis, PEST analysis, Check list, Assumption analysis, Delphi technique, influence diagram, cause and effect diagrams or fishbone diagrams, failure mode and effect analysis (FEMA), hazard and operability study (HAZOP), case studies, expert judgment and risk register are the tools and techniques used to identify risks (Cross, 2001; Russel and Taylor, 2000; Kunanoto and Henley, 1996; Williams, 1996 and Turner, 1999).

The risk analysis process evaluates the consequences associated with risks by using risk analysis and measurement techniques. Risk can be assessed by using qualitative or quantitative analysis or both.

Risk quantification involves the process of evaluating risks and determining the effect of risk on the project. Many analytical models developed by different researchers can be used quantify risks i.e.to estimate or evaluate the risk exposure to the project. These models have a serious drawback of their analytical complexity. Complexities of these models require more time and data to work upon it. Because of the analytical complexity of these models, either the number of variables is limited or the project application is limited. It is possible to explore risk and uncertainties using these analytical models, by limiting the variables in the solution but the techniques become unreliable. Also, the risks encountered in the flow of information are not modelled. With the background of limitations to various models used in risk quantification, there is a scope for developing other model or system for risks quantification.

3. PROPOSED RISK QUANTIFICATION MODEL (RQM)

The proposed RQM consists of following steps in the process leading to risk quantification:
. Formation of Risk Quantification Team (RQT)
. Identification of important Project success parameters
. Assessing importance of Project success parameters relative to each other
. Identification and categorization of risks with their primary consequence class
. Rating relevance of every risk with all selected success parameters
. Computation of risk score
. Risks screening for selection of critical/ significant risks
. Determination of interdependency between risks
. Determination of the probability of occurrence for risks
. Determination of the consequences of risks with the probability of consequences
. Calculations for Expected value of Risks
. Documentation of the entire process of risk quantification using RQM.

These steps are explained below:

Step - 1

The first step in the risk quantification process of RQM is formation of Risk Quantification Team (RQT) which shall work on risk quantification of the project. Not only project participants but the other key players in the project, like designers and users, who can offer necessary information for identification and quantification, also can be part of RQT. Team leader (TL) shall be chosen or selected by RQT members, considering his/her the knowledge, experience as well as thorough study and understanding of risk quantification process in the RQM.

(Step – 2 to Step – 6 are part of Score Model)

Step - 2

Identification of important Project success parameters is a very crucial and important step in the risk quantification process by RQM. PMBoK (1996) considers cost, time; quality, scope and participant's satisfaction as the important project objectives. In the proposed model for risk quantification, these five parameters are considered as success parameters for developing an understanding of the proposed model (RQM).

Step - 3

In this step of the risk quantification process of RQM, an assessment of the importance of the selected project success parameters relative to each other is done. In the proposed RQM, use of Paired Comparison Analysis is recommended to assess relative importance of the project success parameters. Using Paired Comparison Analysis, RQT gets a list of success parameters with a weight (score) that describes parameter's relative importance.

Step - 4

This step of risk quantification model is to identify the project risks and classify them in appropriate categorization and also to mention about their primary consequence class. Studying Project Data is important for identification and classification of risks. It is recommended that for risk identification purpose, the entire project should be decomposed and divided into different work packages (Work Breakdown Structure – WBS), either by considering scope or the difference in achieving time target or cost involved or the techniques used. To avoid unstructured list of risks which may deviate focus of RQT, it is recommended to use Risk Group Structure (RGS) in combination with WBS. RGS is a grouping of project risks in different categories in order to understand the risks faced by the project and thus can be used to structure and guide the risk identification process. A preliminary check list of potential risks by Perry and Hayes (1985) is recommended as a starting point for identifying and classifying the risk by the RQT. Group decision making tools like Delphi Technique, Brainstorming, Nominal Group technique are recommended for identification of risks. An Identification, Categorisation and Primary Consequence Matrix (ICPC Matrix) is proposed in this RQM, that shall be used by RQT to list identified risks in different logical and formal categories and according to their primary consequence class

Step - 5

This step in the model is rating relevance of every risk with all selected success parameters. **A**ll identified risks, belonging to different categories, shall be rated in terms of their level of relevance (in context to their consequences) with every success parameter selected by RQT, i.e. Cost, Time, Quality, Scope and Participant's satisfaction. A verbal scale of 0-9 is proposed here that shall be used by RQT for rating the level of relevance as shown in **Table 3. 1** on page 7. This exercise shall be carried out by RQT for the entire list of risks and shall be tabulated.

Step - 6

This step in the proposed RQM shall be computation of risks score. In this step, score of each of the success parameter arrived using paired comparison analysis shall be multiplied with the score for the level of relevance of each risk with reference to the success parameter.

In the proposed RQM, computation for the Risk Score for individual risks shall be done using following equation:

$S_j = \sum w_i \, r_{ij}$ .... (Anderson D., Sweeny and Williams T., 2003)

Where,

S_j = Score of risk $_j$

w_i = the weight (score) of the success parameter i

r_{ij} = the rating for the relevance of risk j with respect to success parameter i

Using this equation for calculation, the RQT shall do the calculations and it shall be tabulated. Exercise of computation of risk score shall result in identified and categorized list of risks having different risk score.

Step - 7

RQT shall decide upon the cut off criteria for screening the risks obtained in hierarchical order. Pareto Principal or Dot Diagrams is proposed and suggested here for the use by RQT to decide upon cut off criteria. This cut off criteria may vary from project to project depending upon nature, complexity and size of the project. Risks having score above cut off criteria shall be selected for quantification.

Step - 8

Determination of interdependency among screened risks is taken into consideration as dependencies can have an influence on calculation of the probabilities as well as consequences of particular project risks.

Step 9

This step of RQM deals with the process of determination of risk probabilities. In the proposed RQM, ordinal scale is recommended for relative ranking of probability of occurrence. The range of an ordinal scale chosen here represents relative probability values from "Very Low" to "Very High". Numerical ranges for this ordinal scale to assess risk probability falls between 0.0 (no probability) and 1.0 (Certainty). For each of the ordinal scale ranges, a corresponding probability description is provided. RQT shall assign probability after reaching consensus. In case consensus is not reached, responses by team members can be analysed using a measure of central tendency.

Step - 10

This step deals with is sizing of screened Risk, which involves assessing the range of possible consequences of the risks in terms of cost and time and quality, and, the associated probabilities of these consequences. This shall be done by RQT after reaching consensus. RQT may seek expert opinion to make the process of sizing effective. High, Medium, Low (HML) Scenario Approach shall be used by team members for sizing the risks. When it comes to the aspect of quality, it is bit more difficult to assign a criterion for expressing the consequence of the risk. In such case, the degree to which a risk is capable of doing harm to specified quality requirement (for example, life span, capacity, and durability) is used as a standard. As far as success parameter 'Scope' and 'Participants Satisfaction' is concerned, the RQT members shall decide upon the consequences resulting out of change in scope as well as low level of participant's satisfaction. These consequences could be in terms of increase in cost, in terms of delay as well as in terms of reduced quality. In all these cases, the appropriate scales shall be used by RQT to describe the range of consequences.

Step - 11

This step is for the calculations for Expected values of risks. In the proposed system, Expected Value Theory is used to quantify risk and expected consequences are taken in terms of delay and financial magnitude of risk as well as decrease in the life span of project under consideration. Methodology to calculate Expected values of risks shall be as below:

a. Select a risk to be quantified

b. Assign basic occurrence probability to this risk (Say B1)

c. Using High, Medium, Low (HML) scenario, assign consequences in terms of cost/Delay/Decrease in life span (Say H1, M1 and L1).

d. Assign probabilities to these consequences (Say P1 for H1, P2 for M1 and P3 for L3)

e. Calculate value (V1) of these consequences as below:

$$(H1 \times P1) + (M1 \times P2) + (L1 \times P3) = V1$$

f. Calculate Expected Value (EV1) of the Risk as below:

(B1 x V1) = EV1

Using this methodology, Expected Value for all the risks under consideration shall be calculated.

Step - 12

This step is for result documentation. It is necessary that entire risk quantification process with its outcome be documented. The detailed process followed in this model can be used by an organization for risk quantification in future projects.

4. CONCLUSION

Proposed Risk Quantification Model provides a flexible and easily understood way of quantifying project risks. The proposed risk quantification model shall help in estimating the probable consequences in terms of cost, schedule and quality, thereby providing incentives to the project team to repair these short comings. It provides an efficient and effective approach towards quantification of risks. It allows the active participation of decision makers in reaching agreement and a rational basis on which to make decisions. It provides an improved effectiveness for decision making in context to risk response planning. Time spent for doing risk response planning is reduced. It provides inputs to other process of risk management. The RQM is aligned with the standard terminology and can be applied to numerous types of construction projects. This RQM is adaptable to different types of projects and different types of construction organizations
Considering all these benefits, researchers are strongly recommending use of this Risk Quantification Model for risk quantification in construction projects. Further research is recommended for development of a computer based Risk Quantification Model.

Table 3.1

Rating for Level of Relevance with respect to consequences

Sr. No.	Level of Relevance	Rating
1	Extremely High Relevance	9
2	Very High Relevance	8
3	High Relevance	7
4	Slightly High Relevance	6
5	Average Relevance	5
6	Slightly Low Relevance	4
7	Low Relevance	3
8	Very Low Relevance	2
9	Extremely Low Relevance	1

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