

CONSTRUCTION ENGINEERING & TECHNOLOGY: EMV APPROACH AS AN EFFECTIVE TOOL

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ABSTRACT

There are many risks events that adversely affect the timely completion, cost, quality and scope of construction projects. Therefore it is important to have understanding about risks that occur during planning, execution and maintenance of these construction projects, their probability of occurrence as well as consequences of their occurrence and probability of consequences.

A simple yet an effective system for risk quantification in construction projects based on Expected Monetary Value (EMV) analysis is proposed in this paper. This system is developed using guidelines available in literature in the area of risk management. The system is checked for practicability and can be used by client as well as contractor's organization who are engaged in construction projects.

Key words: Risk, Consequences, EMV, Risk Management, construction projects.

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INTRODUCTION

Construction industry has a wide horizon, wide scope and there is a need for successful risk management. Many construction projects to meet dead line and cost target due to various inherent risks. Too often, risks are either ignored or are dealt in a completely arbitrary way resulting in an expensive delays, litigations and even bankruptcy (Ross 1986). Structured approach to risk management includes identification of risks, their classification, analysis, deciding upon risk response strategies and monitoring as well as controlling of the implemented risk response strategies.

The researchers aim to present a simple yet useful system for getting a primary estimation of total risks that a construction project may face in terms of cost and provides a rational basis to make decisions related to risk response strategies. The system developed for risk quantification in construction projects is an outcome of extensive study of Literature and guidelines on risk management .The basic concepts and principles related to risks and its management are discussed first, followed by the description of proposed risk quantification system. Scope of proposed paper is restricted to quantification of risks in construction projects .

RISK AND ITS MANAGEMENT: A BRIEF REVIEW

In the literature, the word ‘Risk’ has been used in many different meanings with many different words such as hazard or uncertainty (Boodman 1977, Faber 1979, Lifson and Shaifer 1982, Hertz and Thomas 1983). Risk has been defined in variety of ways. The Webster’s dictionary defines risk as ‘The possibility of loss, injury, disadvantage or destruction’. Businesses would like to quantify risks for many reasons. Knowing how much risk is involved will help decide if costly measures to reduce the level of risk are justifiable (Jannadi and Alamshari 2003).

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Symbolically, we could write Risk as

Risk = f (Uncertainty of event, Potential loss/gain from event) (Jamal and Keith 2003).

The concept of risk varies according to viewpoint, attitudes and experience of an individual and thus risk has a different meaning to different people. Engineers, designers, and contractors view risk from the technological perspective, Lenders and developers tend to view it from economical and financial side, and health professionals, environmentalists, chemical engineers take a safety and environmental perspective. Risk is, therefore, generally seen as an abstract concept whose measurement is very difficult (Baloi and Pence 1977).

Risk management is the critical part of project management as ‘unmanaged or unmitigated risks are one of the primary causes of project failure’ (Royer 2000). The risk management process aims to identify and assess risks in order to enable the risks to be clearly understood and managed effectively (Hillson 2002 b). The term ‘risk management’ has multiple meanings. Many use this term synonymously with risk identification. For many others, it is synonymous to risk analysis, risk monitoring and /or risk control. In fact, these all are the phases of risk management. According to PMBOK (PMI 2004), project risk management is defined as ‘the process concerted with identifying, analyzing and responding to uncertainty throughout the project life cycle’.

The general consensus in current literature, available in the field of risk management, incorporates four steps in the process of risk management. These are Risk identification, Risk Analysis, Risk Response planning and Risk Monitoring and control (Thevendran and Mawdesley 2004).

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Risk identification is a process of identifying risks that shall help further in analyzing, monitoring and controlling risks. For a construction project, risk identification consists of defining which risks most likely affect the project and documenting characteristics of each. Risk identification process is to be performed on regular basis throughout the project and should address both internal and external risks (Turnbaughs 2005). A large number of techniques exist for risk identification, such as, brainstorming and workshops, checklist and prompt List, questionnaires and interviews, Delphi group or normal group techniques and various diagrammatic techniques like cause effect diagram, influence diagrams etc. (Hillson 2002 a).

Risk analysis is an evaluation process of uncertainty associated with occurrence of internal and external risks, as well as consequences of occurrence of these risks on the basis of best available information. Certain risks affect the project performance negligibly. Such risks can be very well ignored and their impact on project need not be quantified. While certain risks have potential to adversely affect the project objectives to large extent. These risks are to be quantified. Risks analysis can be subjective as well as objective. Risk analysis involves the Qualitative and quantitative assessment of the identified risks. Project management has to estimate the probability of occurrence of the risks as well as their potential consequences. The risk management database can then be updated with the new information (Schatteman 2008).

Qualitative risk analysis is to determine the likelihood and potential effect of identified risks on project objectives. It helps in prioritizing risks for further attention. Techniques like Fault tree analysis, Event tree analysis, Sensitivity analysis and probability impact grid are used for qualitative risk analysis (Ammar 2007).

Quantification of risks involves evaluating risks and risk interactions to assess the range of possible project outcomes (PMI 2004). It is primarily concerned with which risk events warrants

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response. Statistical sums, Expected monetary value, expert judgment etc. are some of the tools used for quantification of risks.

Risk response planning is a process of determining appropriate response to the risks that are screened and analyzed quantitatively. Having identified the risk exposure and having quantified its potential consequences, it is time to deploy well known suitable strategies such as risk avoidance, risk probability reduction, risk impact reduction and risk transfer (Schatteman 2008). The PMBOK (PMI 2004) gives four response strategies. These are Risk avoidance, Risk transfer, Risk mitigation and Risk Acceptance.

Risk Monitoring and Control is a process where effectiveness of the responses is monitored and controlled. At the same time, identification and analysis of newly arising risks is done at this stage.

PROPOSED RISK QUANTIFICATION SYSTEM

For the purpose of this paper, risk management is defined as a systematic process of identifying, classifying, analyzing, responding and monitoring and controlling of risk events throughout the life cycle of a construction project in order to eliminate or control risk exposure to the project. To carry out risk management work of construction project a 'Risk Management Team' shall be formed. This team shall consist of not more than 3-5 members (Stake holders or their representatives). This team shall work on the proposed risk quantification system. The effectiveness of risk management shall be clearly dependent to a substantial degree on the capability and experience of the team members undertaking risk management (Ward 1999).

Proposed System consists of three step framework as below :

- a. Identification and Classification of identified risks
- b. Qualitative analysis of risks

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c. Quantification of risks

Every step of the proposed system is detailed below:

Identification and Classification of Risks

In the context of this paper and for the proposed system, risk management is defined as a systematic and continuously identifying the significance of risks associated with a construction project under consideration. Team members of Risk Management Team shall identify risks in the project using Brainstorming session. Expert opinion may be taken, if needed. This shall generate a check list of risks in the project.

Classification of risks shall help in dividing identified risks in different categories for analysis purpose. This is important because one may not be interested in analysis of all risks, but in a particular category, for various reasons. One of the better ways is to break up the entire project in its phases and classify the variables in different categories. Many researchers have suggested the different ways of risk classification. Names of some of these authors include Ross 1986, Shen 2001, Baloi 2003 and Flanagan and Norman 1993.

For the proposed system, classification of risks exclusively for construction Projects are considered as below :

- a. Political Risks
- b. Environmental Risks
- c. Physical Risks
- d. Legal and contractual Risks
- e. Design Risks
- f. Construction Risks
- g. Financial Risks

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h. Procurement risks

Qualitative Analysis of Risks

In the proposed system, for qualitative risk analysis, probabilities and consequences are assessed on subjective basis using following tools.

- a. QRA sheet (Qualitative Risk Analysis sheet)
- b. P-C Matrix (Probability – Consequences Matrix)

a. QRA sheet

This is designed, in particular, to evaluate individual risk responses subjectively (Table 1). It has a list of identified risks and classification of these risks. It shall ask for probability and consequences of each risk in a subjective way. For probability assessment, a probability scale shall be used. This scale shall be used respectively for the probability range like rare, unlikely, possible, likely and almost certain. In the context of consequences the same scale shall be used. Here the scale shall be used respectively for insignificant, minor, moderate, major and catastrophic consequences.

Team members shall discuss together to decide the level of probability and consequences of individual risk. A QRA sheet shall be filled after reaching consensus, where only tick marks shall be put in appropriate boxes in QRA sheet, against individual risks.

b. Probability consequence Matrix

Response in QRA sheet shall be further analyzed using probability - Consequence Matrix. It consists of vertical column for probability and horizontal column for consequences using the scale, same as that is used in QRA sheet. This matrix shall give combined effect of probability

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and consequences associated with each risk. This combined effect shall be expressed as very low, low, significant and high, dividing PC Matrix into four Zones (Table2).

The combined effect of probability and consequences of each risk (as obtained in QRA sheet) is assessed against PC Matrix. Risks falling in low and very low zones of PC matrix shall be eliminated from quantification, as these risks have negligible effect on project performance in term of cost. Risks falling in “Significant” and “high zones” of PC Matrix shall have potential Consequences on project objectives in terms of cost and thus shall be considered for quantification.

Table -1

QRA (Qualitative Risk Analysis Sheet)

Identified and classified risk	Probability						Consequences				
	Rare	Unlikely	Possible	Likely	Almost certain	Insignificant	Minor	Moderate	Major	Catastrophic	
A). Political Risk											
R1											
R2											
R3											
B). Contractual Risk											
R1											
R2											
R3											
R4											

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Table-2

Probability – Consequence Matrix (Hillson 2002 a)

P \ C	In significant	Minor	Moderate	Major	Cates tropic
Rare	Very Low	Very Low	Low	Low	Significant
Unlikely	Very Low	Low	Low	Significant	Significant
Possible	Low	Low	Significant	Significant	High
Likely	Low	Significant	Significant	High	High
Almost Certain	Significant	Significant	High	High	High

Quantification of Risks

In this step of proposed system, risks which actually may cause substantial cost increase shall be quantified to get an idea about total project risks in term of cost. A quantification format is proposed for this purpose, which shall be used to gather the data related to probability and consequences of the “significant” and high” exposure risks in term of cost. The effect of time factor i.e. cost related to delay shall also to be included in each risk.

Team members shall discuss together and after reaching consensus, shall fill details about individual risks as well as about their interdependency, if exists, in quantification format.

Basic occurrence probability of selected risks – Team members shall decide about the probability of occurrence of risks i.e. chance of risks actually occurring, after discussing,

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brainstorming and reaching consensus. For example, the basic occurrence probability of a particular risk can be decided as 70% by the Team members after reaching consensus. This means that there are 70% chances of occurrence of that particular risk and there shall be 30% chance of non occurrence of that particular risk.

Scale for probabilities for different cost consequences– In the proposed system, scale for cost consequences shall be used where a range of cost consequences in terms percentage of the total project cost shall be given and associated probabilities shall be filled by team members after reaching consensus. This scale is shown below in Table 3.

Table 3

Scale with a Range of Cost Consequences and associated Probabilities

Cost Consequences	0-1%(specify)	1%-2% of the project cost(specify)	3% -5 % of the project cost(specify)	5%-10 % of the project cost(specify)	10 % and above (specify)
Probability					

(Here it means: What is the probability that consequences due to a particular risk will lead to 0-1% increase the total project cost, 1 to 2% increase in total project cost and so on).

Note: Above classes being mutually exclusive, sum of the probabilities for all the ranges of consequences should be 100%.

Experience shall influence the responses while filling the above table. The scale for cost-consequences and associated probabilities is subjected to modification, considering various factors like total project cost, completion period, importance of the project etc.

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Interdependence and cost consequences

It is not that all risks in the project are independent. Many risks have interdependency relations with other risks, i.e. occurrence of one risk can lead to some effect on the cost consequences due to other risk. The quantification format made for this purpose shall be used to get these details. There may be an increase or decrease in the cost consequences but these values are needed for the calculations proposed in this framework for risk quantification. The format for obtaining cost consequences due to independencies is presented below in Table 4.

Table 4
Interdependency Format

Effect on(say) Risk R1	% Increase	% Decrease
Due to occurrence of Risk R2		
Due to occurrence of Risk R3		
Due to occurrence of Risk R4		

Team members shall write the percentage increase or decrease in cost consequence of risks in term of total project cost. For example, as shown in Table 4, influence of risks R2, R3 and R4 on risk R1 can be filled by Team members. This Format (Table 4) shall be used for interdependent risks in project to find changes in cost consequences.

Calculations for Risk Quantification

In the proposed approach, Expected Monetary Value (EMV) analysis is used as a tool to carry out risk quantification. EMV is a product of risk event probability and risk event consequences. Risk event probability is an estimate of probability that a given risk will occur (Basic Occurrence probability).

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The calculations using EMV analysis in the proposed risk quantification system are as below :

1. The lowest and highest cost consequences related to each risk are considered as “Low1” and “High 1” values. As the consequences are described in scales, the mid-point of each class is taken as cost consequences for calculation.

Example – For class 1-2% - 1.5% taken for calculations

Similarly, For class 3-5% - 4% is taken for calculations

Expected Monetary Value 1 is calculated for every risk using following formula

Expected Monetary Value 1 = Cost consequence of a risk x Probability of this cost consequence

(Eqn-1)

2. Next step is to consider basic occurrence probability of each risk and multiply it with its Expected Monetary Value 1. This shall give Expected Monetary Value 2 for a particular risk. Thus,

Expected Monetary Value 2=Basic occurrence Probability x Expected Monetary Value 1

(Eqn-2)

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Modification is also applied to Expected Monetary Value 2 for interdependencies, in order to get Final Expected Monetary Value. Low 2, High 2 and Final Expected Monetary Value is determined using following formula.(Refer Table 4 for clarity of this formula)

Low 2 = Low 1+ [(Low 1 x % change in a particular risk say R1 due to occurrence of another risk say R2) x Basic occurrence probability of risk R2] + [(Low 1 x %change in a particular risk say R1 due to occurrence of another risk say R3) x Basic Occurrence Probability of Risk R3] + [(Low 1 x %change in a particular risk say R1, due to occurrence of another risk say R4) x Basic occurrence probability of risk R4]

(Eqn-3)

High 2 = High 1+ [(High 1 x %change in a particular risk say R1 due to occurrence of another risk say R2) x Basic occurrence probability of another risk R2] + [(High 1 x %change in a particular risk say R1 due to occurrence of another risk say R3) x Basic Occurrence Probability of Risk R3] + [(High 1 x %change in a particular risk say R1 due to occurrence of another risk say R4) x Basic occurrence probability of another risk R4]

(Eqn-4)

Final Expected Monetary Value = Expected Monetary Value 2 + [(Expected Monetary Value 2 x %change in a particular risk say R1 due to occurrence of another risk say R2) x Basic Occurrence Probability of R2] + [(Expected Monetary Value 2 x %change in a particular risk say R1 due to occurrence of another risk say R3) x Basic Occurrence Probability of R3] + [(Expected Monetary Value 2 x %change in a particular risk say R1 due to occurrence of another risk say R4) x Basic Occurrence Probability of R4]

(Eqn5)

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The total project risk, in terms of cost, varies between the sum of Low 2 values and sum of High 2 values, for all the risks considered for quantification. Proposed System also gives the sum of Expected Monetary Value of all the project risks, which is calculated in a proposed system as **‘Final Expected Monetary Value’**.

Discussion and Conclusion

Proposed risk quantification system is a simple and effective tool to understand and quantify risks in terms of cost. It has a potential to contribute in a great way in a power construction project risk management process . The system can be used to find:

1. Range within which the individual risk (in terms of cost) may vary
2. Range within which the risk of total project (in terms of cost) may vary
3. Expected monetary value of the total project risk

The system can be used by the clients as well as contractors for bidding on power construction projects and for deciding upon risk response strategies. Though the system does not give a very detailed quantitative analysis of the risks, it can be used fairly for decision making at the starting point of every phase of the construction project. It helps in identifying the high risk areas which need to be controlled and monitored for the achievement of project objectives in terms of cost. This approach can be made suitable for incorporating and implementing with a computer aided decision support system, provided precise data is made available for the proposed risk quantification system.

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