Tamap Journal of Engineering

Volume 2018, Article ID

Research Article

Risk Analysis of Road Construction Projects: A Case Study from Erbil

Khattab Qadir Darwish[1], Zeynep Isik[2,*], Hande Aladağ[3] and Gökhan Demirdöğen[4]

[1] Faculty of Engineering, Hasan Kalyoncu University, Gaziantep, Turkey
[2] Faculty of Civil Engineering, Yildiz Technical University, İstanbul, Turkey
[3] Faculty of Civil Engineering, Yildiz Technical University, İstanbul, Turkey
[4] Faculty of Civil Engineering, Yildiz Technical University, İstanbul, Turkey

* Corresponding author, e-mail: zeynep@yildiz.edu.tr

Received: / Accepted:

Abstract: Construction firms need to identify and mitigate the possible risk factors that can occur in projects to increase their performance considering the increasing competitiveness in the construction industry. Taken into account of huge demand for infrastructure services allied to Iraq's reconstruction, road projects become prominent ones among required infrastructure projects. In this context, identifying risks and developing a risk analysis model for the road construction projects in Erbil constitutes the aim of the study. In this context, a total number of 67 risks that affects road construction projects were identified with a comprehensive literature review. Then, a survey questionnaire was used for data collection with the participation of 56 respondents to perform qualitative risk analysis. Gathered data was analyzed by using probability-impact matrix to prioritize identified risks. After then, Monte Carlo Simulation was used as a quantitative risk analysis method. According to the result of qualitative analysis, a total number of 46 risk factors out of a total number of 67 risk factor were found out as the prominent risk factors for road construction projects in Erbil. The results of Monte Carlo simulation also show that the technical risks are the most significant risks considering their effect on the total project cost.

Keywords: construction industry, Monte Carlo simulation, risk analysis, road construction projects.

INTRODUCTION

Recently, necessity for risk analysis of infrastructural projects such as roads, bridges etc. increased due to high rework costs, deadline limits and the quality expectations of the public and private clients in the construction industry. The road construction in northern Iraq, for the last decade had witnessed a great development due to reconstruction of the region. However all the road projects in in Iraq especially in Erbil, are suffering from cost overrun, time delay, and insufficient quality. Taken into account of huge demand for road projects in Erbil, the risk management process become crucial because risks can cause cost increases, time delays, and lack of quality of projects. As it is known, the risk management process has an important role in project management and therefore, it should be developed to achieve additional improvement in the projects. Project risks can be defined as an uncertain event or condition that has a positive or negative effect on project objectives, such as time, cost, and quality (Ashley et al. 2007; PMBOK 2008). Thus, there is a need for a risk management process to manage all types of risks in projects. Risk management includes the processes of conducting risk management planning, identification, analysis, response planning, monitoring, and control on a road project. The risk analysis process in road projects can be complex because of the complexity of the modeling requirements and the subjective nature of the data for conducting the analysis. However, there is an enormous number of study concentrated on risk management in road construction projects. For example, Sato et al. (2005) conducted quantitative risk analysis based on real data in road projects in Japan and based on the obtained data, the frequency and the impact of each event were analyzed and summarized in a risk ranking matrix. In addition, arrow diagrams were built to represent the sequence of project steps. By translating the arrow diagrams to Monte Carlo simulation system, some model projects were simulated. Mousavi et al (2011) used jackknife technique in highway risk analysis. At first risks were ranked with a common technique, and then those risks ranked with the jackknife technique. Zayed et al (2008) studied risk and uncertainty analysis in highway projects in China by using R index model with Analytic Hierarchy Process (AHP). McGoey-Smith et al (2007) used Monte Carlo capability of @RISK in quantitative risk analysis of a large transportation project. Khazaeni et al (2012) used a fuzzy adaptive decision making model for selection of balanced risk allocation which transforms the linguistic principles and experiential expert knowledge into a more usable and systematic quantitative-based analysis by using the fuzzy logic. Diab and Nassar (2012) used risk analysis to improve highway construction project performance. The study was to analyze and evaluate the different risk drivers in highway construction projects in the US. In the mentioned above studies, the researchers considered a large sample data in a parametric statistical framework and it was found out that risk management plays significant role in the accomplishment and completion of road construction projects. In addition, the risk management of road projects in the developing countries, such as Erbil, has not been received sufficient attention from researchers. Based on the information gathered from the Road Sector Development Program, execution of most of the road projects in Erbil resulted in cost and time overruns. In this context, this research examines whether such risks contribute to cost and time overruns based on the road construction projects in Erbil.

RISK MANAGEMENT IN CONSTRUCTION

Risks have a significant impact on a construction project‘s performance in terms of cost, time and quality. As the size and complexity of the projects have increased, an ability to manage risks throughout the construction process has become a central element preventing unwanted consequences. The need for project risk management has been widely recognized. The objectives of project risk management are to increase the likelihood and impact of positive events, and decrease the likelihood and impact of negative events in the project. It involves processes, tools, and techniques that will help the project manager maximize the probability and results of positive events and minimize the probability and consequences of negative events as indicated and appropriate within the context of risk to the overall project objectives of cost, time, scope and quality. Project risk management is most effective when first performed early in the life of the project and is a continuing responsibility throughout the project‘s life cycle. Risk management includes the processes of 1) risk management planning, 2) risk identification, 3) qualitative/quantitative analysis of risks, 4) response planning, and 5) risk monitoring and control (PMBOK, 2018). In this context, study will adopt those processes presented by PMBOK.

Identification of Risk Factors Affecting Road Construction Projects

In the study, for identifying risk factors affecting road construction projects, a comprehensive literature review was conducted. According to literature review, risk factors were separated into two groups, namely internal and external risks. Internal risks consist of "technical risks, environmental risks, organizational risks, project management risks, right of way risks and construction risks". In external risks, "political risks, social and cultural risks, economical/financial risks and natural risk" were identified from the literature review. Also, every identified risk groups involve sub-risks. Risk groups and their sub-risks were given below.

Internal Risks:

- ***Technical Risks:*** Technical risks can be listed as "TR1- Incorrect assumptions in planning stage on technical issues, TR2- Incorrect traffic volume account, TR3- Insufficient information on geotechnical and groundwater ,TR4- Uncertainty of hydrogeology study, TR5- Incorrect/ Insufficient survey data, TR6- Insufficient or poor specifications, TR7- Defective design, TR8- Incomplete structural designs, TR9- Lack of design exceptions, TR10- Consultant designs not according to department standards, TR11- Changes in design required by the owner, TR12- Changes in design required by the engineer, and TR13- Incorrect quantity and cost estimation" (Kim, 1985; Guo, 2002; Lambert et al., 2002; Moolenaar et al., 2004;Caltrans, 2007; Trinh et al., 2007; Blasier,2008; El-Sayegh,2008; NYSDOT, 2008; Perera et al., 2009; Dai, 2009; Tsegaye, 2009; Alavi and Taavares, 2009; D'Ignazio et al., 2011; Mousavi et al., 2011; Diab and Nassar, 2012; San Santoso et al. 2012; Khazaeni et al., 2012; Gupta et al., 2013; Mahamid, 2013; Wrahadikusumah et al., 2014).
- ***Environmental Risks:*** Environmental risks can be listed as "ER1- Inadequate environmental analysis, ER2- Changes in design require additional environmental analysis, and ER3- Pollution level (Gas emissions, noise level)" (Lambert et al., 2002; Moolenaar et al., 2004; Caltrans, 2007; Trinh et al., 2007; NYSDOT, 2008; Alavi and Taavares, 2009).
- ***Organizational Risks:*** Organizational risks can be listed as "OR1- Changes in the scope of work required by the owner, OR2- Inadequate time to plan, OR3- Changeable cost, time, and quality objectives, OR4- Pressing to decrease time and base design, OR5- Absence of transparency in tendering process, OR6- Lack of competition for tender, OR7- Delaying payment by the owner to contractor, OR8- Too much routines from government for decision and approval, OR9- Unskilled staff employment, OR10- Losing critical staff at very important time of the project, and OR11- Shortage of specialized staff (geotechnical, archeology, etc.)" (Kim, 1985; Askar and Gab-Allah, 2002; Guo, 2002; Moolenaar et al., 2004; McGoey-Smith, 2006; Caltrans, 2007; TRINH et al., 2007; El-Sayegh,2008; NYSDOT, 2008; Alavi and Taavares, 2009; Dai, 2009; Perera et al., 2009; Xu et al., 2010;

D'Ignazio et al., 2011; Mousavi et al., 2011; Khazaeni et al., 2012; San Santoso et al. 2012; Gupta et al., 2013; Mahamid, 2013; Wrahadikusumah et al., 2014).

- ***Project Management Risks:*** Project management risks can be listed as "PMR1- Incorrect project need evaluation, PMR2- Delays from consultant or contractor, PMR3- Unstudied work that must be accommodated, PMR4- Insufficient support from upper management, PMR5- Delays in project in decision making, approvals and permits, and PMR6- Changes in priorities on existing program" (Kim, 1985; Moolenaar et al., 2004; Caltrans, 2007; TRINH et al., 2007; Blasier, 2008; El-Sayegh,2008; NYSDOT, 2008; Dai, 2009; Perera et al., 2009; Xu et al., 2010; Mousavi et al., 2011; Khazaeni et al., 2012; San Santoso et al. 2012; Diab and Nassar, 2012; Mahamid, 2013).
- ***Right of Way Risks:*** Right of way risks can be listed as "RWR1- Landowners disagreeing to sell their lands, and RWR2- Changeable price for land acquisition" (Moolenaar et al., 2004; Caltrans, 2007; TRINH et al., 2007; NYSDOT, 2008; Alavi and Taavares, 2009; Xu et al., 2010; Mousavi et al., 2011; San Santoso et al. 2012; Gupta et al., 2013; Wrahadikusumah et al., 2014).
- ***Construction Risks:*** Construction risks can be listed as "CR1- Change requirement due to variance site conditions, CR2- Contractor required earlier site investigation before to bidding, CR3- Surveys problems, CR4- Absence of construction safety, CR5- Lack of equipment, material and labor availability, CR6- Lack of productive equipment, CR7- Labor disputes, CR8- Delaying payment by the contractor to subcontractors, CR9- Absence of communication between central and site offices, CR10- Changes during construction stage require further coordination with resource agencies, and CR11- Buried manmade objects" (Kim, 1985; Guo, 2002; Moolenaar et al., 2004; McGoey-Smith, 2006; Caltrans, 2007; TRINH et al., 2007; Blasier, 2008; El-Sayegh,2008; NYSDOT, 2008; Alavi and Taavares, 2009; Dai, 2009; Perera et al., 2009; Tsegaye, 2009; Xu et al., 2010; D'Ignazio et al., 2011; Mousavi et al., 2011; Diab and Nassar, 2012; Khazaeni et al., 2012; San Santoso et al. 2012; Gupta et al., 2013; Mahamid, 2013; Wrahadikusumah et al., 2014).

External Risks:

- ***Political Risks:*** Political risks can be listed as "POR1- Political force majeure (war and riot), POR2- Relationship with the neighborhoods, POR3- Public security and safety, POR4- Changes in regulations and laws, POR5- Corruption, bribes, nepotism and collusion, POR6- Vandalism, and POR7- Labor strikes" (Kim, 1985; Guo, 2002; Moolenaar et al., 2004; McGoey-Smith, 2006; Caltrans, 2007; TRINH et al., 2007; El-Sayegh, 2008; NYSDOT, 2008; Dai, 2009; Perera et al., 2009; Xu et al., 2010; D'Ignazio et al., 2011; Mousavi et al., 2011; San Santoso et al. 2012; Gupta et al., 2013; Mahamid, 2013; Wrahadikusumah et al., 2014).
- ***Social & Cultural Risks:*** Social & Cultural risks can be listed as "SCR1- Objections from local communities, and SCR2- Public awareness" (Moolenaar et al., 2004; Caltrans, 2007; TRINH et al., 2007; El-Sayegh, 2008; NYSDOT, 2008; Alavi and Taavares, 2009; Perera et al., 2009; Xu et al., 2010; Mousavi et al., 2011; San Santoso et al. 2012; Mahamid, 2013).
- ***Economical/Financial Risks:*** Economical/Financial risks can be listed as "EFR1- Inflation, EFR2- Fluctuation in money exchange rate, EFR3- Variation in interest rate, EFR4- Change in economic conditions of state, EFR5- Absence of bank loans availability/ Funding

availability, EFR6- Incorrect market study, and EFR7- Changeable price of machine, materials, labor, fuel and land" (Kim, 1985; Askar and Gab-Allah, 2002; Guo, 2002; McGoey-Smith, 2006; Caltrans, 2007; TRINH et al., 2007; Blasier, 2008; El-Sayegh, 2008; Alavi and Taavares, 2009; Perera et al., 2009; Dai, 2009; Xu et al., 2010; Mousavi et al., 2011; Khazaeni et al., 2012; Lambert et al., 2012; San Santoso et al. 2012; Gupta et al., 2013; Mahamid, 2013; Wrahadikusumah et al., 2014).

- ***Natural Risks:*** Natural risks can be listed as "NR1- Unexpected severe weather, NR2- Unexpected natural disasters in project area, NR3- Unforeseen site condition, NR4- Impact of subsurface conditions (e.g., water table level, soil, etc.), NR5- Unsuitable sub-grade material" (Kim, 1985; Lambert et al., 2002; Guo, 2002; McGoey-Smith, 2006; TRINH et al., 2007; Blasier, 2008; El-Sayegh,2008; Perera et al., 2009; Dai, 2009; Alavi and Tavares, 2009; Xu et al., 2010; D'Ignazio et al., 2011; Mousavi et al., 2011; Khazaeni et al., 2012; San Santoso et al. 2012; Gupta et al., 2013; Mahamid, 2013; Wrahadikusumah et al., 2014).

Case Study: Road Construction Projects in Erbil

In this study, road construction projects in Erbil were investigated and a qualitative and quantitative risk analysis with a Monte Carlo Analysis was conducted to analyse and illustrate the prominent risk factors.

Qualitative Risk Analysis

Qualitative risk analysis is the process of prioritizing risks for further analysis or action by assessing and combining their probability of occurrence and impact. The key benefit of this process is that it enables project managers to reduce the level of uncertainty and to focus on high-priority risks. In the study, probability and impact matrixes were developed for each risk factor. Required data for the probability-impact matrixes were gathered from a total of 56 participants (the project team members of the road projects in and the professionals in road construction). Participants were selected for their familiarity with the risk categories on the agenda.

Before performing probability-impact matrixes (P-I matrixes), a draft questionnaire was sent to two supervisor and five expertise in road construction industry for analysis and correction. This led to a review of the identified risk factors. All experts reach a consensus that the identified risk factor are valid for road construction projects in Erbil. After the validation of the identified risks was gathered the final questionnaire was subsequently produced. The final questionnaire was designed to gather information from professionals working in road construction sector in Erbil. As Biggam (2015) indicates there are a few number of sampling techniques that can be used such as random sampling, stratified sampling, cluster sampling, systematic sampling, quota sampling, and convenience sampling. In this study, convenience sampling was used to select respondents in the road sector because of easy access to research subjects.

The questionnaire that includes P-I matrixes were sent out to a total number of 80 professionals by e-mail. Both e-mail and telephone calls were used as a reminder to those who did not return the questionnaires within the specified period. The total number of 56 responses (70%) was returned. The response rate was deemed adequate for the data analysis hence the response rate of 20–30% for postal questionnaires of the construction industry was indicated as a sufficient amount.

In P-I matrixes, both the probability and impacts of each risk factor were assessed from very low (VL) to very high (VH) by their rates according to Table 1 and combined through the P-I matrix as shown in the Figure 1 to classify risks as low, moderate, or high priority. The matrix method is the commonly used to classify risks according to their seriousness. The matrix has two dimensions; probability on the vertical axis and impact on the horizontal axis, both ranged from very low (VL) to very high (VH). P-I matrixes can be classified into following three zones:

- Low (Green): risks in this zone are characterized as low risks, and can be usually ignored or eliminated from further analysis.
- Moderate (Yellow): risks in this zone are of moderate importance, and different approaches can be required. Additional management attention may be needed.
- High (Red): risks in this zone are unacceptable, and different approaches are required. Priority management attention is required.

Table 1 Ranking and rates of probability and impact

Ranking	Rates of Probability	Rates of Impact
Very Low (VL)	<=10%	<=5%
Low (L)	11-30%	6-10%
Moderate (M)	31-50%	11-20%
High (H)	51-70%	21-40%
Very High (VH)	>70%	>40%

Probability						
	VH	M	M	H	H	H
	H	L	M	M	H	H
	M	L	L	M	M	H
	L	L	L	L	M	M
	VL	L	L	L	L	M
		VL	L	M	H	VH
	Impact					

Figure 1 Probability- Impact Matrix (Adapted from Shane, et al, (2012)

In the questionnaire the respondents were asked to rate the probability of occurrence for each risk factor and their impacts on time, cost and quality in the road construction projects in Erbil. Then average values were calculated for each risk factor. The probability of occurrence and impacts of each risk factor on the project objectives (qualitative analysis of risk factors) is shown in the Table 2.

Table 2 Qualitative analysis of risk factors

Code	Probability (P)	Impact (I)	(P x I)	Impact Levels

		Time (IT)	Cost (IC)	Quality (IQ)	P x IT	P x IC	P x IQ	Time	Cost	Quality
TR1	0.41	0.26	0.23	0.26	M x H	M x H	M x H	Moderate	Moderate	Moderate
TR2	0.43	0.21	0.23	0.29	M x H	M x H	M x H	Moderate	Moderate	Moderate
TR3	0.39	0.29	0.32	0.30	M x H	M x H	M x H	Moderate	Moderate	Moderate
TR4	0.30	0.15	0.18	0.21	L x M	L x M	L x H	Low	Low	Moderate
TR5	0.43	0.30	0.31	0.26	M x H	M x H	M x H	Moderate	Moderate	Moderate
TR6	0.36	0.18	0.23	0.37	M x M	M x H	M x H	Moderate	Moderate	Moderate
TR7	0.44	0.35	0.36	0.36	M x H	M x H	M x H	Moderate	Moderate	Moderate
TR8	0.37	0.27	0.28	0.26	M x H	M x H	M x H	Moderate	Moderate	Moderate
TR9	0.29	0.18	0.18	0.17	L x M	L x M	L x M	Low	Low	Low
TR10	0.29	0.19	0.20	0.22	L x M	L x M	L x H	Low	Low	Moderate
TR11	0.33	0.24	0.25	0.18	M x H	M x H	M x M	Moderate	Moderate	Moderate
TR12	0.30	0.19	0.19	0.18	L x M	L x M	L x M	Low	Low	Low
TR13	0.45	0.29	0.33	0.20	M x H	M x H	M x M	Moderate	Moderate	Moderate
ER1	0.35	0.18	0.20	0.21	M x M	M x M	M x H	Moderate	Moderate	Moderate
ER2	0.27	0.15	0.16	0.14	L x M	L x M	L x M	Low	Low	Low
ER3	0.28	0.12	0.13	0.15	L x M	L x M	L x M	Low	Low	Low
OR1	0.25	0.13	0.14	0.10	L x M	L x M	L x L	Low	Low	Low
OR2	0.36	0.24	0.20	0.21	M x H	M x M	M x H	Moderate	Moderate	Moderate
OR3	0.34	0.23	0.22	0.22	M x H	M x H	M x H	Moderate	Moderate	Moderate
OR4	0.32	0.19	0.21	0.26	L x M	L x H	L x M	Low	Moderate	Low
OR5	0.35	0.21	0.30	0.29	M x H	M x H	M x H	Moderate	Moderate	Moderate
OR6	0.36	0.22	0.29	0.28	M x M	M x H	M x M	Moderate	Moderate	Moderate
OR7	0.53	0.44	0.29	0.36	H x VH	H x H	H x H	High	High	High
OR8	0.50	0.33	0.23	0.23	M x H	M x H	M x H	Moderate	Moderate	Moderate
OR9	0.44	0.24	0.25	0.42	L x H	L x H	L x VH	Moderate	Moderate	Moderate
OR10	0.35	0.21	0.17	0.27	L x H	L x M	L x H	Moderate	Low	Moderate
OR11	0.40	0.16	0.17	0.27	M x M	M x M	M x H	Moderate	Moderate	Moderate
PMR1	0.34	0.18	0.23	0.20	M x M	M x H	M x M	Moderate	Moderate	Moderate
PMR2	0.44	0.31	0.23	0.26	M x H	M x H	M x H	Moderate	Moderate	Moderate
PMR3	0.33	0.19	0.20	0.20	M x M	M x M	M x M	Moderate	Moderate	Moderate
PMR4	0.34	0.19	0.16	0.19	M x M	M x M	M x M	Moderate	Moderate	Moderate
PMR5	0.41	0.28	0.21	0.21	M x H	M x H	M x H	Moderate	Moderate	Moderate
PMR6	0.28	0.17	0.17	0.14	L x M	L x M	L x M	Low	Low	Low
RWR1	0.46	0.35	0.27	0.16	M x H	M x H	M x M	Moderate	Moderate	Moderate
RWR2	0.33	0.21	0.24	0.14	M x H	M x H	M x M	Moderate	Moderate	Moderate
CR1	0.31	0.22	0.21	0.15	M x H	M x H	M x M	Moderate	Moderate	Moderate
CR2	0.37	0.17	0.22	0.17	M x M	M x H	M x M	Moderate	Moderate	Moderate
CR3	0.40	0.25	0.25	0.20	M x H	M x H	M x M	Moderate	Moderate	Moderate
CR4	0.43	0.14	0.13	0.17	L x M	L x M	L x M	Low	Low	Low
CR5	0.37	0.29	0.23	0.27	M x H	M x H	M x H	Moderate	Moderate	Moderate
CR6	0.35	0.23	0.20	0.24	M x H	M x M	M x H	Moderate	Moderate	Moderate
CR7	0.27	0.18	0.14	0.19	L x M	L x M	L x M	Low	Low	Low
CR8	0.48	0.31	0.20	0.25	M x H	M x M	M x H	Moderate	Moderate	Moderate
CR9	0.27	0.19	0.15	0.20	L x M	L x M	L x M	Low	Low	Low
CR10	0.30	0.20	0.18	0.15	M x M	M x M	M x M	Moderate	Moderate	Moderate
CR11	0.22	0.12	0.11	0.12	L x M	L x M	L x M	Low	Low	Low

Table 2 Qualitative analysis of risk factors (Continued)

Code	Probability (P)	Impact (I)			(P x I)			Impact Levels		
		Time (IT)	Cost (IC)	Quality (IQ)	P x IT	P x IC	P x IQ	Time	Cost	Quality
PR1	**0.41**	**0.48**	**0.35**	**0.31**	**M x VH**	**M x H**	**M x H**	**High**	**Moderate**	**Moderate**
PR2	0.32	0.20	0.19	0.17	M x M	M x M	M x M	Moderate	Moderate	Moderate
PR3	0.31	0.24	0.20	0.17	M x H	M x M	M x M	Moderate	Moderate	Moderate
PR4	0.27	0.19	0.19	0.16	L x M	L x M	L x M	Low	Low	Low
PR5	0.40	0.21	0.28	0.33	M x H	M x H	M x H	Moderate	Moderate	Moderate
PR6	0.22	0.17	0.19	0.20	L x M	L x M	L x M	Low	Low	Low
PR7	0.21	0.21	0.19	0.16	L x H	L x M	L x M	Moderate	Low	Low
SCR1	0.28	0.18	0.16	0.14	L x M	L x M	L x M	Low	Low	Low
SCR2	0.29	0.15	0.12	0.14	L x M	L x M	L x M	Low	Low	Low
EFR1	0.33	0.19	0.20	0.14	M x M	M x M	M x M	Moderate	Moderate	Moderate
EFR2	0.36	0.22	0.29	0.20	M x H	M x H	M x M	Moderate	Moderate	Moderate
EFR3	0.29	0.15	0.19	0.17	L x M	L x M	L x M	Low	Low	Low
EFR4	0.42	0.30	0.26	0.22	M x H	M x H	M x H	Moderate	Moderate	Moderate
EFR5	0.51	0.28	0.28	0.22	H x H	H x H	H x H	High	High	High
EFR6	0.42	0.22	0.26	0.19	M x H	M x H	M x M	Moderate	Moderate	Moderate
EFR7	0.41	0.19	0.23	0.19	M x M	M x H	M x M	Moderate	Moderate	Moderate
NR1	0.30	0.22	0.21	0.19	L x H	L x H	L x M	Moderate	Moderate	Low
NR2	0.22	0.27	0.25	0.20	L x H	L x H	L x M	Moderate	Moderate	Low
NR3	0.31	0.16	0.18	0.15	M x M	M x M	M x M	Moderate	Moderate	Moderate
NR4	0.36	0.26	0.26	0.22	M x H	M x H	M x H	Moderate	Moderate	Moderate
NR5	0.34	0.21	0.25	0.25	M x H	M x H	M x H	Moderate	Moderate	Moderate

Risks can be prioritized based on their risk ranking for further quantitative analysis and planning risk responses by reducing the probability of their occurrence or the risks negative impact. Table 2 shows final prioritized risk factors according to their impacts on time, cost and quality in road construction projects in Erbil. According to the result of qualitative risk analysis two risk factors were found out as the prominent risk factors considering the project objectives (time, cost and quality). These risk factors are "delaying payment by the owner to contractor" and "absence of bank loans availability/funding availability". Besides, political force majeure (war and riot) was found out as the most significant risk considering the project success based on time dimension. A total number of 46 risk factors were found as having moderate importance from the view of cost dimension. The impact of the rest risk factors were found out as low and can be eliminated from further analysis.

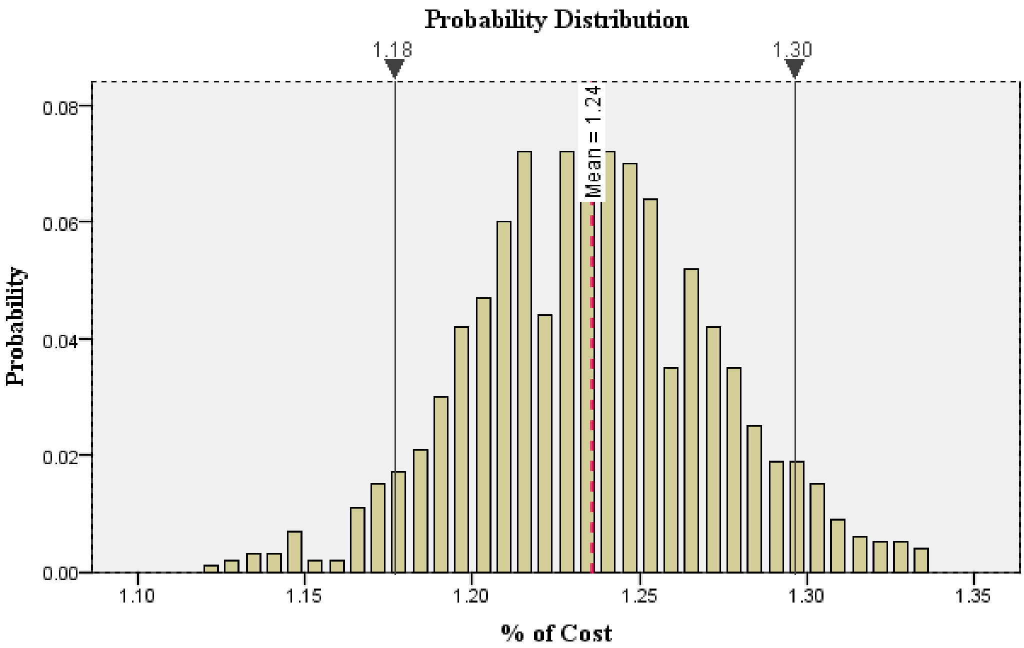
Quantitative Risk Analysis

Quantitative risk analysis is the process of numerically analyzing the effect of identified risks on overall project objectives. The key benefit of this process is that it produces quantitative risk information to support decision making in order to reduce project uncertainty. It is used mostly to evaluate the aggregate effect of all risks affecting the project. Quantitative risk analysis should be repeated, as needed, as part of the control risks process to determine if the overall project risk has been satisfactorily decreased.

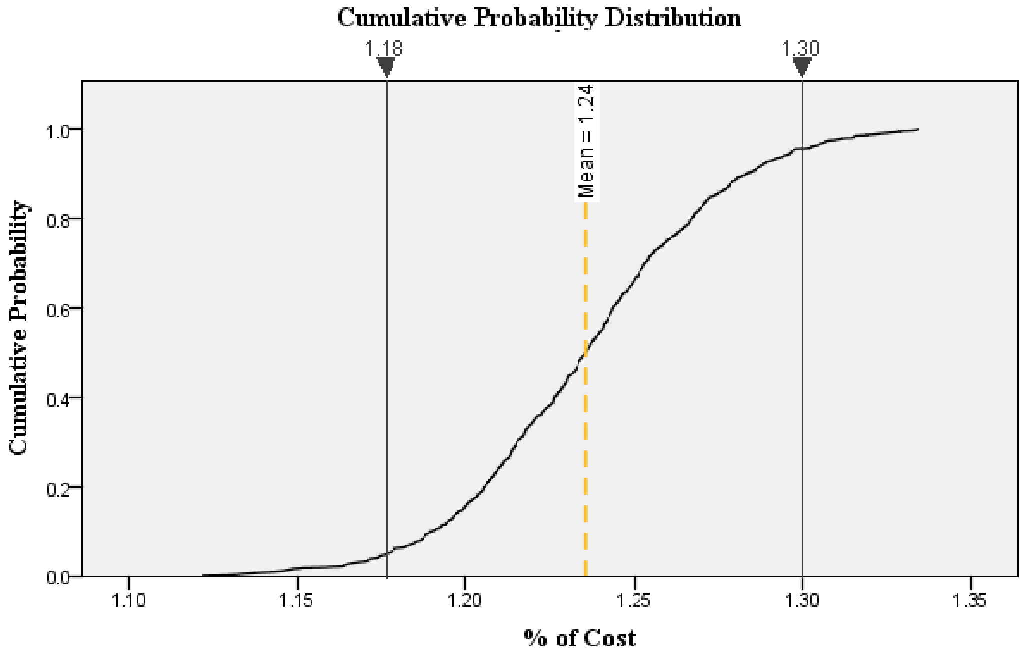
Quantitative risk analyses are commonly modeled through simulation methods. The simulation uses a model that translates the specified detailed uncertainties of the project into their potential impact on project objectives. Simulations are typically performed using the Monte Carlo technique that uses random number generators to draw samples from probability distributions. In Monte Carlo simulation, the project model is computed many times (iterated), with the input values (e.g., cost estimates or activity durations) chosen at random for each iteration from the probability distributions of these variables to generate a distribution for the total cost or schedule. A histogram (e.g., total cost or completion date) is calculated from the iterations. In the study, quantitative risk analysis was carried out through the Monte Carlo simulation with SPSS statics to develop a risk analysis model. Monte Carlo simulation was chosen because of its common use in risk management literature and it is the most effective way to compute probability distributions for overall cost and schedule considering the large number of risk events, project activities and their interconnectivity.

Monte Carlo simulation is a computerized mathematical technique that is commonly used to evaluate the risk and uncertainty that would affect the outcome of different decision options. Monte Carlo simulation furnishes the decision-maker with a range of possible outcomes and the probabilities they will occur for any choice of action. It shows the extreme possibilities along with all possible consequences for middle-of-the-road decisions. Monte Carlo simulation performs risk analysis by building models of possible results by substituting a range of values -a probability distribution- for any factor that has inherent uncertainty. It then calculates results over and over, each time using a different set of random values from the probability functions. Depending upon the number of uncertainties and the ranges specified for them, a Monte Carlo simulation could involve thousands or tens of thousands of recalculations before it is complete. Monte Carlo simulation produces distributions of possible outcome values. By using probability distributions, variables can have different probabilities of different outcomes occurring. Probability distributions are a much more realistic way of describing uncertainty in variables of a risk analysis (Palisade, 2018). Monte Carlo methods are widely used in construction management area to incorporate the total effects of uncertainty in variables like cost estimation, option pricing, project schedules, as well as the effect of distinct risk events like the cancellation of a contract or the change of a tax law (Zhong et al., 2015; Salling and Leleur, 2015). In this study, Monte Carlo simulation was used as a quantitative risk analysis method for generating a distribution for the total cost of identified risk factors for road construction projects.

In the data collection process for Monte Carlo Simulations, the projects were taken into consideration and the prices were taken as a percentage of the total cost, but if there is an individual project the total cost and all items cost should be taken for calculation, all the impacts on cost must transfer to price instead of percent. The results of Monte Carlo analysis are generally represented with probability distributions that reveal the uncertainty in values (Ashley et al, 2007). Figure 2 illustrates probability outputs of Monte Carlo analysis for of identified risk factors for road construction projects.



<1.18	1.18 - 1.30	>1.30
5%	90%	5%



<1.18	1.18 - 1.30	>1.30
5%	90%	5%

Figure 2 Probability outputs from a Monte Carlo analysis for total costs

An additional output for the Monte Carlo analysis is Tornado Diagram that is also shown in Figure 3. The tornado diagram is a graphic depiction of a sensitivity analysis. The tornado diagram is useful to know which risks (input) will have the greatest influence on project cost (output). The length of the bars in the diagram represents the rank order correlation between the risks and the overall cost. The risk factors that have higher correlation will have a high influence on the total project cost.

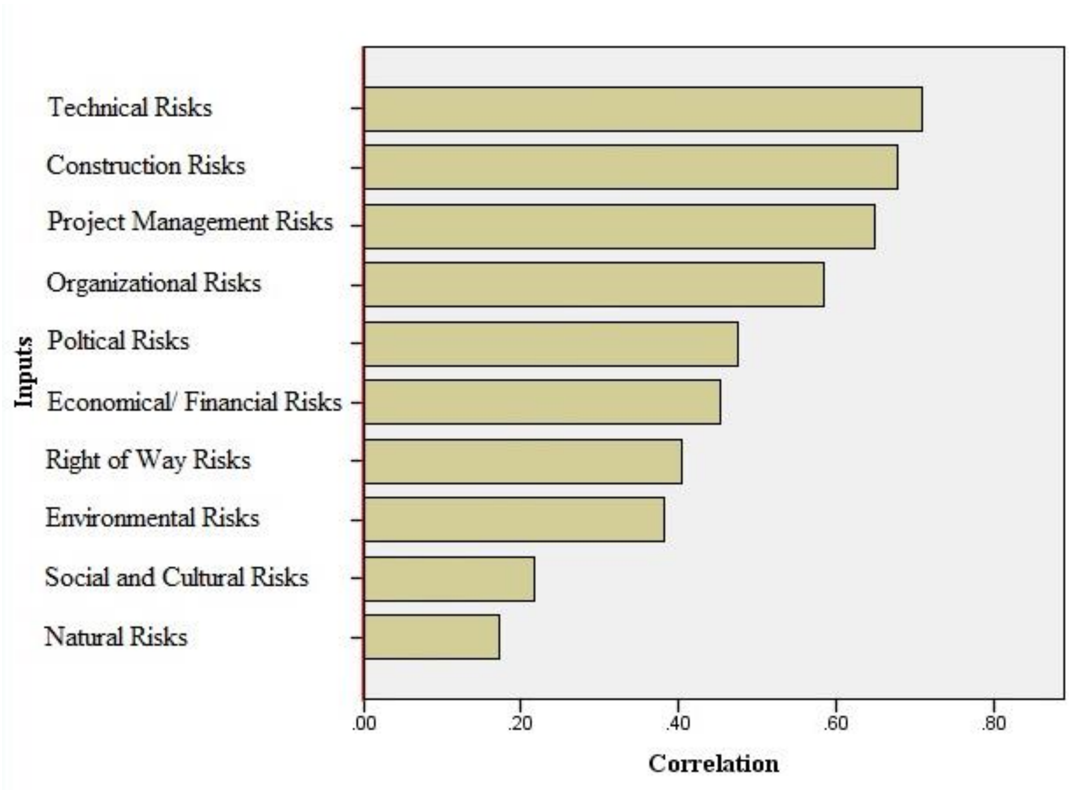


Figure 3 Tornado diagram output from a Monte Carlo analysis

Figure 3 illustrates the rank order correlation between risk factors and their effect on the total project cost. The technical risks take place on the top because they have the greatest influence on the total project cost. Construction risks, project management risks, organizational risks, political risks, economical & financial risks, right of way risks, environmental risks, and social & cultural risks are one of the important risk groups respectively considering their effect on the total project cost whereas natural risks have the lowest influence on the total project costs.

RESULTS AND DISCUSSION

Within the scope of the study, questions concerning the risk management attitude in road construction projects in Erbil were addressed to the respondents. The questions can be found below:

- Is the risk identification process carried out systematically in road construction projects in Erbil? If yes, in which phase?
- Is the risk analysis process carried out systematically in road construction projects in Erbil? If yes, in which phase?
- Is the risk response carried out systematically in road construction projects in Erbil? If yes, in which phase?
- When is the risk analysis most effective in road construction process?
- What are the risk management approaches?
- What are the common risk groups for road construction projects in Erbil?

According to the result of the survey questionnaire that was conducted with the professionals in road construction sector in Erbil; risk management (identification & analysis and response planning) was not carried out systematically in road construction projects in Erbil. Besides, majority of the respondents (42.9%) indicated that risk analysis should be carried out at the beginning of the planning phase throughout the project life-cycle. In risk analysis the most important issue is the timing according to the project life-cycle to be most beneficial. According to the PMBOK Guide (2018) project risk management is most effective when first performed early in the life of the project. In the context of risk management approaches, majority of the respondents (30.4%) adding a percent to cost and time would be efficient managerial approach to cope with the risks whereas a total of 7.1% indicated that various mathematical tools such as sensitivity analysis, present value, etc. should be chosen as a risk management approach. However, the method by adding a percent to cost and time to cope with the risks is ordinary followed by the organizations that lacks from risk management knowledge and is a traditional method, which is not so effective, it depends on the experiences. According to the survey results, in road construction projects in Erbil, employment a team for the risk analysis (73.2%) was commonly chosen rather than employment a manager for the risk analysis (26.8%). In the context of risk groups effecting the road construction projects in Erbil, technical risks were received the most significant concentration by the respondents. The followings were on the economical/ financial risks (14.4%), construction risks (13.8%), project management risks (12.3%), and environmental risks (10.3%), political risks (7.2%), social and cultural risks (7.2%), natural risks (5.6%), organizational risks (5.1%) and right of way risks (4.6%).

In the context of risk identification and analysis, respondents rated the probability of occurrence for each risk factor and their impacts on time, cost and quality in the road construction projects in Erbil using P-I matrixes. According to the qualitative risk analysis of risk factors for road construction projects in Erbil, technical risks were also found out as the most significant risk group considering their probability and impact. The results of the qualitative risk analysis also reveals that risk group of right of way was the least important risk group whereas the other ones had moderate significant importance.

Also, as it is seen from the tornado diagram that was shown in Figure 3, the technical risks are the most significant risks considering their effect on the total project cost. Construction risks, project management risks, organizational risks, political risks, economical & financial risks, right of way risks, environmental risks, and social & cultural risks are the successive risk groups whereas natural risks are least important risk factors considering their effect on the total project cost.

From comparison between the two results; technical risks, construction risks and project management risks are the most significant ones that should be paid more attention in order to reduce their probability of occurrence or impacts.

CONCLUSIONS

The overall aim of this research was to increase the understanding of risk management in the road construction projects in Erbil in order to contribute effective implementation of the country‘s road infrastructure development program. Besides, preparing a potential check list for possible risk factors and developing a risk analysis model that can be used by the road construction project managers constitutes the main aim of the study. Therefore, risk factors affecting road construction projects in Erbil were identified with a comprehensive literature review. Identified risk factors were then prioritized based on their effect on cost, time and quality using probability-impact matrixes. According to the result of probability-impact matrixes, “delaying payment by the owner to contractor” and “absence of bank loans availability/funding availability” were found as the most important risk factors considering their impact on time, cost and quality for the road construction projects in Erbil. Also, a total number of 46 risk factors were found out as having a moderate importance. Qualitative risk analysis of risk factors shows that additional analysis is required for those 46 risk factors in order to sustain success in road construction projects in Erbil. In this context, Monte Carlo simulation was used as a quantitative risk analyses method. Monte Carlo Analysis (quantitative analysis) was used after qualitative analysis (P-I matrix) with the aim of reducing probability of occurrence or impact of the high and moderate risks later reapplying the quantitative analysis till an acceptable amount of the total cost of the project was obtained. Results of Monte Carlo simulation also shows that the technical risks are the most significant risks considering their effect on the total project cost.

The findings of the study provide a comprehensive systematic approach in risk identification and risk analysis for the authorities in Erbil who are responsible on road construction projects. The study focuses on the risk identification and analysis processes of risk management. Thus, the research opens to future evaluations in response planning and risk monitoring processes. The study can also be used as a guideline in order to perform risk analysis in different kind of construction projects. It is also possible to use this study as a base in order to compare if there exist any difference in road construction projects in different countries.

REFERENCES

Alavi, S., and Tavares, M. P., “Highway Project Cost Estimating and Management”, The State of Montana Department of Transportation, **2009**.

Ashley, D. B., Diekmann, J. E., and MOLENAR, K., “Guide to Risk Analysis and Allocation for Highway Construction Management”, **2007**, http://santafempo.org/wp-content/uploads/2010/01/FHWA+-+Risk+Analysis+and+Allocation.pdf (Accessed: June 2018)

Askar, M. M., and Gab-Allah, A. A. “Problems facing parties involved in build, operate, and transport projects in Egypt”, Journal of Management in Engineering, **2002**, 18(4), 173- 178.

Biggam, J. “Succeeding with your master's dissertation: a step-by-step handbook”, McGraw-Hill Education, UK, **2015**.

Blasier, K. “Risk Misallocation on Highway Transportation Projects”, Midwest Regional University Transportation Center College of Engineering Department of Civil and Environmental Engineering University of Wisconsin, **2008**, Madison, USA.

Caltrans, “Project Risk Management Handbook: Threats and Opportunities”, Second Edition, Caltrans Office of Statewide Project Management Improvement, **2007**, California, USA.

D‘Ignazio, J., Hallowell, M., and Molenaar, K., “Executive Strategies for Risk Management by State Departments of Transportation”, NCHRP project, **2011**, pp. 20-24.

Dai, P., “Contract Management for International EPC Projects”, *PhD Thesis*, **2009**, Southeast University, China.

Diab, M. F., and Nassar, K., “Using risk analysis to improve highway construction project performance”, In The Proceedings of the ASC Annual 48th Annual International Conference, **2012**, Birmingham, England.

El-Sayegh, S. M., “Risk analysis and allocation in the UAE construction industry”, International Journal of Project Management, **2008**, 26(4), 431-438.

Guo, W., “Development of a framework for preliminary risk analysis in transportation projects”, *MSc Thesis*, **2004**, Worcester Polytechnic Institute, USA.

Gupta, A. K., Trivedi, M. K., and Kansal, R., “Risk Variation Analysis of Indian Road PPP Projects”, International Journal of Science, Environment and Technology, **2013**, 2, pp. 1017-1026.

Khazaeni, G., Khanzadi, M., and Afshar, A., “Fuzzy adaptive decision making model for selection balanced risk allocation”, International Journal of Project Management, **2012**, 30(4), 511-522.

Kim, D. H., “Risk treatment methods in the construction contracts and building process”, *PhD Thesis*, **1985**, Sydney, University of Syney.

Lambert, J. H., Kaplan, S., Pikus, I., and Leung, F., “A risk analysis methodology for critical transportation infrastructure”, Richmond, VA: Virginia Transportation Research Council, **2002**.

Mahamid, I., “Common risks affecting time overrun in road construction projects in Palestine: Contractors' perspective”, Construction Economics and Building, **2013**, 13(2), pp. 45-53.

McGoey-Smith, A., Poschmann, A., and Campbell, L., “Quantitative Risk Analysis and Risk Management of a Large Transportation Project”, In Transport Association of Canada, Annual Meeting, **2007**, Saskatoon, Canada.

Molenaar, K. R., Ashley, D. B., and Diekmann, J. E., “Guide to risk analysis and allocation for highway construction management”, Federal Highway Administration, **2006**.

Mousavi, S. M., Tavakkoli-Moghaddam, R., Azaron, A., Mojtahedi, S. M. H., and Hashemi, H., “Risk analysis for highway projects using jackknife technique”, Expert Systems with Applications, **2011**, 38(5), 5514-5524.

Mousavi, S. M., Raissi, S., Vahdani, B., and Hossein, S. M., “A fuzzy decision-making methodology for risk response planning in large-scale projects”, Journal of Optimization in Industrial Engineering, **2011**, pp. 57-70.

New York State Department Of Transportation (NYSDOT), “Risk management guide for project development, **2008**, https://www.dot.ny.gov/content/delivery/region11/projects/X72977-Home/X72977-Repository/Draft_Risk_Mgmnt_Guide_ProjDev.pdf (Accessed: June 2018)

Palisade, “Monte Carlo Simulation”, **2018**, http://www.palisade.com/risk/monte_carlo_simulation.asp (Accessed: June 2018)

Perera, B. A. K. S., Dhanasinghe, I., and Rameezdeen, R., “Risk management in road construction: the case of Sri Lanka. International Journal of Strategic Property Management”, **2009**,13(2), 87-102.

Project Management Institute (PMI), “A Guide to the Project Management Body of Knowledge”, fourth ed., Project Management Institute (PMI), **2008**.

Project Management Institute (PMI), "A Guide to the Project Management Body of Knowledge", sixth ed., Project Management Institute (PMI), **2018**.

Salling, K. B., and Leleur, S. "Accounting for the inaccuracies in demand forecasts and construction cost estimations in transport project evaluation", Transport Policy, **2015**, 38, pp. 8-18.

San Santoso, D., Joewono, T. B., Wibowo, A., Sinaga, H. P., and Santosa, W., "Publicprivate partnerships for Toll way construction and operation: Risk analysis and allocation from the perspective of investors", Journal of Construction in Developing Countries, **2012**, 17(2), pp. 45–66

Sato, Y., Kitazume, K., and Miyamoto, K., "Quantitative risk analysis of road projects based on empirical data in Japan", Journal of the Eastern Asia Society for Transportation Studies, **2005**, 6, 3971-3984.

Shane, J. S., Kandil, A. A., and Schexnayder, C. J., "A guidebook for nighttime construction: Impacts on safety, quality, and productivity", Transportation Research Board, **2012**, 726.

Trinh, A. T., Trinh, A. T., Tran, H. T., and Bui, Q. H., "Project Risk Management In Transport Projects In Vietnam", In Proceedings of the Eastern Asia Society for Transportation Studies, Eastern Asia Society for Transportation Studies, **2007**, pp. 42-42

Tsegaye, G., "Design Risk Management in Ethiopian Federal Road Projects", *MSc Thesis*, **2009**, Addis Ababa Institute of Technology, Addis Ababa University.

Wirahadikusumah, R. D., Sapitri, B. S., and Soemardi, B. "Risk Inclusion in the Reserve Price Estimation for Toll Road Concession Award", Journal of Traffic and Logistics Engineering, 2014, 2(1).

Zayed, T., Amer, M., and Pan, J., "Assessing risk and uncertainty inherent in Chinese highway projects using AHP", International Journal of Project Management, **2008**, 26(4), 408-419.

Zhong, D., Yang, S., Chang, H., Yu, J., and Yan, F., "Construction schedule risk analysis of high roller-compacted concrete dams based on improved CSRAM", Science China Technological Sciences, **2015**, 58(6), pp. 1021-1030.

Xu, Y., Yeung, J. F., Chan, A. P., Chan, D. W., Wang, S. Q., and Ke, Y., "Developing a risk analysis model for PPP projects in China—a fuzzy synthetic evaluation approach", Automation in Construction, **2010**, 19(7), pp. 929-943.