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Research Article

Evaluation of Risk Indicators and Techniques in Construction Project Management

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Abstract: In this study, the authors illustrate the need to establish select key risk indicators which are required to define the appropriate risk measurement technique used in the analysis involved in the life cycle of a construction project. Data were collected from 34 recently completed projects using a questionnaire based survey aimed to identify the most commonly occurring risks in construction projects. The data was collected through one to one interviews since that helped to account in an accurate manner the differences in profession and experience between various participants. The data from this study indicate that "documentations review" is the most popular technique used to mitigate risks. In addition the highest risks in these types of project are the ones related to the client such as changing demands and payment delays, followed by poor performance of subcontractors.

Keywords: Construction management, project risk indicators, risk management, risk measurement techniques

INTRODUCTION

Construction projects are some of the most complex projects in the world. This is mainly due to the many factors or risks that can affect these projects. If these risks are not managed properly, they may lead to project failure. Project risk management is the process of maximizing the effect of positive events and minimizing the consequences of negative risks that may affect the overall project objectives. Risk management planning describes all the work to be performed in the risk management process, in order to help the project teams to carry out the next steps effectively and more efficiently.

Risk identification is a crucial part of the risk management system. It is impossible to maintain a project or control risks adequately without first identifying the risks. Risk analysis is used to determine how safe the project is and also can be used to determine the various trade-off alternatives to lower the risk. Risk analysis studies the cause and consequence relation of the problem potential in a project. It promotes actions that increase opportunities of success, reduce threats of risks and distribute responsibilities among project teams. Risk monitoring and control is the last step of project risk management, which is the process of identifying new risks and developing strategies to minimize their impact.

The objective of this study is to identify the risk management techniques commonly used by project managers and to spot the most frequently occurring risks in Lebanese construction projects.

LITERATURE REVIEW

The construction industry represents one of the most complex and dynamic industrial environments (Abderisak and Lindahl, 2015). This industry and its related projects highly are highly dependent on the efficiency and competence of the people as well as the suitability of the equipment used. It also depends on the weather, policy, site conditions and on the attitude and influence of numerous stakeholders (Gladysz *et al*., 2015). Thus it is highly exposed to many risks that may affect the objectives of the projects.

Serpella *et al*. (2014) indicated that risk management is frequently not a problem of lack of information, but rather is the problem with the lack of knowledge. It is impossible to identify all the risks in a project, also the effort required to consider every single risk is unpractical, time consuming and also could be counter-productive in its effect (Goh and Abdul-Rahman, 2013). Therefore the list of identified risks should be limited to the critical ones.

Researchers in Malaysia indicated that client changing demands, late payment by clients, inflation, tight project schedule, inappropriate time allocation, defective design, unprofessional personnel, safety risks, low competency of subcontractors and inaccurate schedule are in the top ten important risks identified in

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Table 1: The selected nine critical risks indicators

Risk indicators	Mentioned by
1) Client payment delays	Baghdadi and Kishk (2015), Goh and Abdul-Rahman (2013) and Iqbal *et al*. (2015)
2) Changing demands of client	Baghdadi and Kishk (2015) and Omran *et al*. (2015)
3) Tight project schedule	Goh and Abdul-Rahman (2013), Iqbal *et al*. (2015) and Omran *et al*. (2015)
4) Unclear scope of work	Baghdadi and Kishk (2015) and Iqbal *et al*. (2015)
5) Defective design	Goh and Abdul-Rahman (2013) and Iqbal *et al*. (2015)
6) Accidents/safety	Goh and Abdul-Rahman (2013) and Iqbal *et al*. (2015)
7) Inflation	Goh and Abdul-Rahman (2013) and Iqbal *et al*. (2015)
8) Unskilled labor	Goh and Abdul-Rahman (2013) and Omran *et al*. (2015)
9) Poor performance of subcontractors	Iqbal *et al*. (2015) and Omran *et al*. (2015)

Table 2: Respondents according to their profession

Position of the respondent	Number of respondents	Percentage of respondents
Civil Engineer (site engineer)-CE	14	41.2%
Project Engineer (electrical or mechanical site engineer)-PE	8	23.5%
Project Manager-PM	7	20.6%
Architectural Engineer (site engineer)-ARCH	5	14.7%

Table 3: Respondents according to their working experience

Experience of the respondent	Number of respondents	Percentage of respondents
More than 5 years	8	22.8%
3 to 5 years	10	31.4%
Less than 3 years	16	45.7%

the construction industry (Goh and Abdul-Rahman, 2013; Omran *et al*., 2015). Furthermore, payment delays, safety related risks, defective design, inaccurate schedule, poor performance of subcontractors, inflation and improper scope of work definition were amongst the ten most critical risks in Pakistan (Iqbal *et al*., 2015).

Baghdadi and Kishk (2015) highlighted 54 identified risks; however, inadequate scope, payment delays and client changing demands were classed as the most critical risks. This finding has been mirrored by the other researchers (Goh and Abdul-Rahman, 2013; Omran *et al*., 2015; Iqbal *et al*., 2015).

At the beginning of this study, the various risks reported in the above mentioned publications were tabulated and nine of them were selected. The selection was based on the classification of these risks as critical or highly important by more than one research group. These risks are listed in Table 1.

MATERIALS AND METHODS

Survey's questionnaire: The questionnaire survey conducted in this study sought to explore the risks occurring in construction projects in Lebanon and the techniques used to solve them. Hence, a questionnaire is composed of two parts. The first part of the questionnaire distinguished the most occurring risks faced by the construction industry. The participants were requested to rank each risk (refer to Table 1) according to the frequency of occurrence, where 1 would be the most frequently occurring risk and 9 would be the least occurring risk.

The second part of the questionnaire was used to enquire about the different risk management techniques utilized through the phases of the risk management process (Project Management Institute, 2008). The techniques listed in the questionnaire: documentation review, brainstorming, checklist analysis, fishbone diagrams, SWOT analysis, probability and impact models, risk categorization and finally probability distributions. The respondents' answers were rated according to a five-point Lickert scale, thus allowing a neutral opinion.

Method of data collection: A survey based on one to one interviews was used as the method of data collection. The selection of professionals (respondents) was limited only to engineers working in the construction industry. In order to obtain a practical and convincing analysis, the profession and working experience of the respondents were also taken into consideration. Table 2 presents the profession of the participants, while Table 3 presents their working experience.

Tool for analysis: Responses were collected from projects executed in different sites in Lebanon. The t-test was performed by using SPSS™ to prioritize the risk management techniques based on the scores of the respondents. To identify the techniques, one sample t-test was computed at a 95% confidence interval with a statistical significant mean score of 3.0 as a cut point value. The value of mean score was fixed at '3.0', which corresponded to the moderate value in the five point Likert scale used in this research. The population means of all change issues which are greater than 3.0 represent the opinion of respondents that are in the range of 'neutral', 'agree' and 'strongly agree'.

The null hypothesis (H_0) is rejected when the t-value obtained is less than the 0.05 level of significance. The research interest is one-tailed where we look for only sample mean values greater than the population mean. Therefore, for each of the eight risk

Table 4: Statistical results of the most occurring risk in the Lebanese construction projects

Risk Indicators	Mean
Changing demands of clients	3.50
Client payment delays	4.08
Unclear scope of work	4.33
Poor performance of subcontractors	4.63
Tight project schedule	5.04
Defective design	5.17
Changes in material prices	5.38
Unskilled labor	5.42
Labor accidents	7.46

management techniques considered in this study, two hypotheses were set. The first hypothesis (H_0) is that the technique is rarely being used (Mean ($\bar{x}$) $\leq$3) and the second hypothesis (H_1) is that the technique is being used significantly (Mean ($\bar{x}$) >3). T-test method would be used to know which hypothesis is accepted and which one is rejected. The first hypothesis (H_0) would be rejected if T-test is more than $t_{0.05}$, n-1 (Mendenhall, 2013):

$$\text{T-test} = (\bar{x} - 3) / (\sigma/\sqrt{n})$$

$t_{0.05}$, n-1 will be figured using the t distribution table

RESULTS AND DISCUSSION

Most occurring risk in construction projects: The first part of the questionnaire was set to find out the most occurring risk in construction projects. Each respondent ranked the risks from the most occurring to the least occurring in their projects. Responses were averaged for each risk and presented in Table 4. It can be seen from the data in this table, that the most commonly occurring risk (lowest mean) in the Lebanese construction projects is the changing demands of the client (mean = 3.50) and the least commonly occurring risk is the labor accidents (mean = 7.46).

The changing demands of client are usually the result of failure to set clear expectations at the beginning of the project. Traditionally, the clients are not certain of the things they wants and they do not see things from the same perspective as the contractor, so they keep requesting changes during the execution of the project, this action usually increases the cost of the project and often leads to schedule overrun.

The second most occurring risk in the Lebanese construction industry is also related to the client (Table 4), which is client payment delays. Some respondents said that the financial status of the client is the main factor that keeps the project going and payment delays are a big problem that also leads to project schedule overrun and sometimes in extreme cases may cause project termination.

Unclear scope of work is the third most occurring risk. This is usually due to un-clarified specifications and details set by the client. This initial ambiguity may lead to increases in the cost of the project and could delays other important works or even deleting them. In addition, once the specifications are clarified at a later stage in the project, it may force the contractor to accelerate the work to catch up with the plan and this would lead up to further increase the cost of the project.

Poor performance of subcontractors is another important risk, it may affect the work of other subcontractors and may lead to delays to the project plan. The remaining risks were not frequently occurring according to the respondents. Perhaps this is due to good planning that anticipate the uncertainties which might affect the project schedule and design. However, it is clear that the risk related to accidents was least occurring due to the high safety standards undertaken at the sites.

Risk management techniques: The analysis of the data collected from the second part of the questionnaire is focused on finding out the most popular risk management techniques used in construction projects. Table 5 presents the results of the analysis of the second part of the questionnaire.

The hypothesis H_0 which is the technique is rarely used was tested using a T-test method. T-test results were computed as shown in Table 6 and compared with the value of $t_{0.05}$, n-1 in the t distribution table which was equal to 1.69 for n = 34. This Hypothesis was accepted for four of the eight techniques and it was rejected for the rest.

Table 6 shows that, the risk management technique most used in Lebanon is documentations review. In this technique, risks are identified by reviewing old projects with similar conditions. This technique is useful for dealing with risks that had been identified in the past, but it would not help to detect new risks that may occur. This technique is simple but it needs a lot of work, the engineer has to document everything that takes place during the project in order to be able to identify the source and nature of the risks and to eliminate them in the future.

The second most used technique is brain storming (Table 6), which is used by setting up meeting sessions to obtain a comprehensive list of project risks. This technique is also simple but it requires experience and creative thinking. The third most popular technique is risk categorization, which is used to analyze risks and to determine the areas that are most exposed to these uncertainties. Also grouping risks by common root can produce effective risk responses. This technique may help to understand the source of some risks and can guide to eliminate a few risks in a single response action. Finally SWOT analysis is an important technique that can examines the capability of the company to overcome the weaknesses and threats faced, while focusing on the strengths of the company to benefit from the opportunities of the project.

According to the results presented in Table 6, the last four techniques are rarely used. This could be due to their complexity and the lack of appreciation of their benefits.

Table 5: Statistical results of the risk management techniques

Questions	Techniques	Mean	SD
The project information and work is documented for later review.	Documentations review	4.38	1.03
The potential risks that may occur in the project are identified using brainstorming.	Brainstorming	3.71	1.18
A checklist of potential risks is prepared to help you identify risks.	Checklist analysis	3.18	1.12
Fish bone diagrams are used in risk identification.	Fishbone diagram	2.06	1.24
The strengths and weaknesses and the opportunities and threats that may affect the project are being considered while identifying risks.	SWOT analysis	3.59	1.03
Probability and impact models are used to determine the impact and the probability of occurrence of a risk.	PI models	2.74	1.44
Risks are categorized based on the area of their effect in the project, the project phase etc.	Risk categorization	3.69	1.16
Risks are analyzed using probability distributions.	Probability distribution	2.38	1.11

Table 6: Statistical results of the risk management techniques

Techniques	T-test result	Comparison	Hypothesis H_0
Documentations review	7.83	T-test > $t_{0.05}$, n-1	Rejected
Brainstorming	3.50	T-test > $t_{0.05}$, n-1	Rejected
Risk categorization	3.36	T-test > $t_{0.05}$, n-1	Rejected
SWOT analysis	3.32	T-test > $t_{0.05}$, n-1	Rejected
Checklist analysis	0.92	T-test < $t_{0.05}$, n-1	Accepted
PI models	-1.07	T-test < $t_{0.05}$, n-1	Accepted
Probability distribution	-3.24	T-test < $t_{0.05}$, n-1	Accepted
Fishbone diagram	-4.44	T-test < $t_{0.05}$, n-1	Accepted

Table 7: Risk management techniques used by different professions

Techniques	CE	PE	PM	ARCH	Average
Documentations review	4.71	3.38	4.57	4.80	4.365
Brainstorming	3.71	3.38	3.57	4.40	3.765
Checklist analysis	3.57	2.63	3.43	2.60	3.0575
Fishbone diagram	2.14	1.38	1.86	3.20	2.145
SWOT analysis	3.79	2.75	4.00	3.60	3.535
PI models	3.14	2.25	1.86	3.60	2.7125
Risk categorization	4.14	3.25	3.43	3.20	3.505
Probability distribution	2.64	1.88	1.86	3.20	2.395

Table 8: Risks indicators occurrences by different professions

Risk Indicators	CE	PE	PM	ARCH
Client payment delays	4.27	3.67	4.33	3
Changing demands of client	3.45	4.50	2.83	2
Tight project schedule	5.45	4.33	5.67	1
Unclear scope of work	3.27	2.83	7.83	4
Defective design	4.91	5.17	5.67	5
Labor accidents	7.55	8.33	6.50	7
Changes in material prices	5.09	6.50	4.83	6
Unskilled labor	6.09	4.83	4.17	8

Analysis according to the profession of respondents: Table 7 describes the usage of risk management technique by different professions. It can be noticed that different groups use different combinations of two main risk management techniques to different degree. However, it is clear that documentations review is the first choice for all these groups. Civil engineers use risk categorization as the second technique. This may be due to the fact that civil engineers are usually needed throughout the whole project phases and areas and that is why they need to categorize risks to help them to choose the best responses to these risks.

Project engineers (electrical and mechanical engineers) are the group that use risk management techniques the least, none of the techniques got a score more than 4, maybe that is because they are not familiar with these techniques.

SWOT analysis is a technique often used by project managers, which is logical due to the nature of their work and also because they are more familiar with policies and transact with all other employees and subcontractors.

Architectural engineers are the group that uses brainstorming the most. This may be due to the fact that they try to add something different in their project and as such they could not rely solely on any of the other techniques but instead they need creative thinking to identify potential new risks.

Table 8 presents the different perspectives of risks by different professions. Changing demands of the client is the most occurring risk according to project managers and that it because the project manager is the one who arranges the work and time schedules so these changes affect his work directly. Others may not be

Table 9: Most risks indicator occurrences-average of the responses according to their experience

Risks Indicators	More than 5 years	3 to 5 years	Less than 3 years
Client payment delays	2.60	3.14	3.58
Changing demands of client	2.40	3.57	3.92
Tight project schedule	5.20	7.14	3.75
Unclear scope of work	7.40	6.00	3.75
Defective design	6.40	5.00	4.75
Labor accidents	8.00	6.43	7.83
Changes in material prices	6.00	4.71	5.58
Unskilled labor	4.00	5.14	6.08

Table 10: Most risk techniques used-average of the responses according to their experience

Techniques	More than 5 years	3 to 5 years	Less than 3 years	Average
Documentations review	4.13	4.40	4.50	4.343
Brainstorming	3.88	3.70	3.63	3.737
Checklist analysis	3.63	3.20	2.94	3.257
Fishbone diagram	2.25	2.30	1.81	2.120
SWOT Analysis	4.13	3.60	3.25	3.660
PI models	2.50	2.90	2.75	2.717
Risk categorization	3.13	4.00	3.69	3.607
Probability distribution	2.13	2.40	2.50	2.343

impacted by these risks the way project managers are. This is because one of the project managers roles is to address the changing demands of the clients before passing down the tasks.

Both civil and project engineers have "the unclear scope of work" as the most occurring risk. On the other hand, the same risk is considered to be minimal by the project managers. This could be, due to the lack of access to the overall picture of the project by the engineers, who are more focused on technical aspect while project managers have clear view of that whole picture.

Poor performance of subcontractors is much more rated by the project managers comparing to the other engineers; this is because the project manager is the one that transact with subcontractors the most. There is not much difference in the ranking of the other risks by the groups and as such they are not included in this discussion.

Analysis according to the experience of respondents: The collected data are analyzed from the perspective of the experience of the respondents. Table 9 presents the results of the analysis. It is clear that, changing demands of clients and clients' payment delays are the most occurring risks in Lebanese construction projects and it is clear these two risks are related to the client. Unclear scope of work and tight project schedule are more of a concern for the less experienced participants in comparison to the others. This is definitely due to their lack of knowledge in project management. However, this can be solved by good planning and guidance from the senior manager involved in the project.

According to the results presented in Table 10, it can be noticed that "documentations review" is most used techniques by the respondents with experience less than three years. On other hand, respondents with more than 5 years of experience are the least group to use it. This is probably because the experienced respondents rely more on their knowledge and experience so they do not have to check the historical reviews. However the "documentation review" is still the most used technique along side with SWOT analysis for this group. Brainstorming, checklist analysis and SWOT analysis are techniques often used by experienced respondents, which is logical due to their benefits in identifying risks.

The resulting data presented in Table 7 and 10 show four main risk management techniques used in Lebanese construction projects, in which, three of them used for risk identification and one used for risk analysis. The technique most used is documentations review, which is confirmed by both analysis done relating to the profession and the experience of respondents. The second most used technique is brainstorming and the analysis related to this technique showed clearly that architectural engineers are those who use it most. In addition, this analysis showed that respondents with high experience tend to use this technique more than others.

The next most used technique is risk categorization. It is mostly used by civil engineers due to the nature of their job, which oblige them to be heavily involved in all the implementation phases of the project. This is the reason that makes this technique so important and useful for them. The fourth technique used is SWOT analysis; this technique is used mainly by experienced project managers and civil engineers due to its complexity.

CONCLUSION

One of the biggest problems when evaluating risk management is to identify key risk indicators and to select the appropriate risk management techniques. The proposed techniques and indicators, based on the literature review and on the results obtained from this analytical study, are strong enough to achieve our objectives. The outcome of this study represents an

approach towards the identification of key risk indicators and their usage in construction projects. In addition, obtaining the information from different professions in charge of the projects is essential in order to find common techniques used in risk management.

This study offers a platform for researchers in the area of construction project management, where once the techniques and indicators used for risk management analysis are identified, they can be used to implement a project successfully.

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