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Research paper

Risk Assessment of Time and Cost Overrun Factors throughout Construction Project Lifecycle: Pilot Study

, Ismail Abdul Rahman[1], Ismaaini Binti Ismail[1], Mustafa Musa Jaber[1,2]

[1]*Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Johor, Malaysia.*
[2]*Nabu Research Academy, Baghdad, Iraq*

Abstract

Construction industry is one of the important contributors to economic development of a country. However, this industry has being facing serious problems such as failure to complete projects within stipulated time and cost. Hence, this paper presents a study on assessing the risk of various factors in causing time and cost overruns throughout the construction life cycle**.** A pilot study which involved 5 construction experts was conducted to validate the factors and its location in the life cycle. Data collection was carried out using two round Delphi technique with 15 selected respondents. The study found that construction phase is having highest numbers of high risk factors of time and cost overruns.

1. Introduction

In the construction industry, the aim of project control is to ensure that projects finish on time, within cost and achieve other project objectives. Unfortunately, time overrun is a very frequent phenomenon and is associated with nearly all projects in the construction industry [1]. Similarly, cost overrun is a major problem in project development and is a regular feature in construction industry. The situation of a construction project in which budgetary estimate exceeds estimation, budget exceeds budgetary estimate, and settlement exceeds budget is a universal phenomenon [2]. This trend is more severe in developing countries where time and cost overruns sometimes exceed 100% of the anticipated cost of the project ([3]; [4]). The projects that had faced time and cost overruns problem were reported in numerous countries.

According to [5], time and cost overruns were major problem in the construction industry of Portugal where the project had experienced time overrun of around 40% of the contract time. While, average cost overrun was recorded as 12% of the contract cost. In Nigeria, [6] found that average escalation for the time and cost overruns were 188% and 14% respectively. Similarly in Malaysia, several studies have been carried out toinvestigate the performance and factors of time and cost overruns in construction industry. As reported by [7], about 17.3% of 417 government contract projects in Malaysia were considered sick and abandoned in the year 2005. Besides that, a study conducted in Klang Valley found that most of construction projects were affected by cost overrun due to inaccurate or poor estimation of original cost [2]. Thus, it is very important to address the issues of time and cost overruns to ensure the success of construction projects.

2. Aim and Objectives

The aim of this study is to assess the risk of various factors that cause time and cost overruns throughout the life cycle of construction projects in Malaysia. In order to achieve this aim, the following objectives are set as follow:

i. Identifying time and cost overrun factors throughout the project life cycle.
ii. Determining the occurrence of the factors throughout the project life cycle.
iii. Assessing the risk level of the factors of time and cost overruns.

3. Data Collection

Data collection was carried out using Delphi technique on identifying and determining the risk factors that caused time and cost overrun in construction projects in Malaysia. The collected data was analysed using average index (AI) score to find out its risk level which then applied to risk matrix to classify the risk level for each factor.

3.1. Pilot Study

Pilot study is used as preliminary study to test the acceptability of the identified factors and its positioning within the life cycle phases. In this study, a pilot study was conducted by interviewing with five experts in the field of construction. Thus, it allowed the necessary adjustment before actual survey was implemented.

3.2. Actual Survey (Delphi Method)

Survey for this study was conducted by adopting Delphi method. Delphi method was developed by the Rand Corporation in the 1950s [9]. It is a qualitative research method which uses questionnaire survey among the selected panel of the experts. This panel is asked to provide feedback and answers on selected questions. It involves several rounds to achieve consensus [11]. However, the number of the experts in the panel and rounds are selected based on level and complexity of the particular project. Various researchers used Delphi method in their studies by selecting different number of experts and rounds as summarizedin Table 1.

Table 1: Implementation of the Delphi Method

References	Field of study	Sample requirement	Round
This study	Construction projects	15	2
(Jordan & Javernick-will, 2013)	Disaster recovery	11	3
(Xia & Chan, 2010)	Design and build project	20	2
(Yeung, Chan, & Chan, 2009)	Construction project	22	4
(Hyun, Cho, Koo, Hong, & Moon, 2008)	Design and build project	7	3
(Manoliadis, Tsolas, & Nakou, 2006)	Sustainable construction	20	2
(Rowe and Wright, 1999)	Forecasting tool	3-15	2

For this study, a total of 15 experts involved in managing construction project were selected for data collection purpose. The experts were selected based on their expertise in handling construction project. They were assessed based on their working experience, involvement in managing project and also academic qualification [12]. Besides that, the results of the study are considered to achieve the consensus when it reaches an agreement of at least 70 percent of the respondents [13]. These criteria are very important to ensure that a quality data can be gathered. This survey was conducted in two rounds and the processes which involved Delphi method are illustrated in Figure 1.

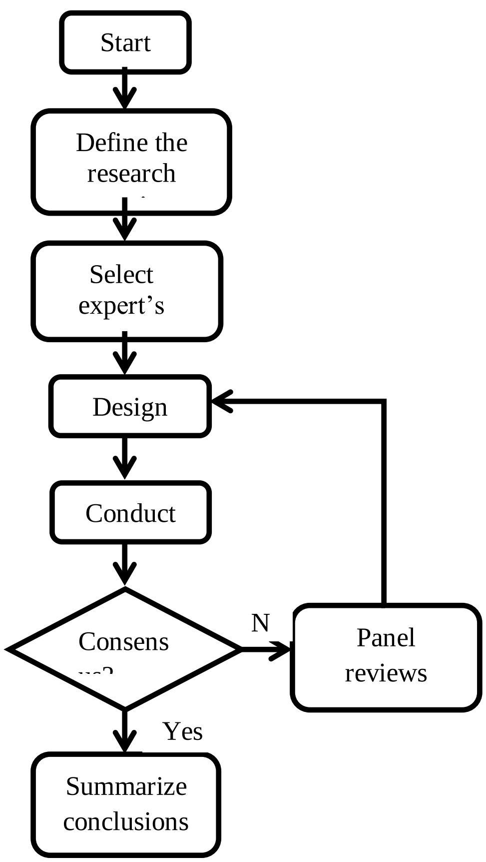

Figure 1: Process of Delphi Method [14]

This technique is useful when the opinions and judgments of experts and practitioners are necessary. It is especially appropriate when it is not possible to convene experts in one meeting. [15] identified the Delphi technique as a method for gaining judgments on complex matters where precise information is unavailable. Today, Delphi method is commonly used by many researchers in various fields such as for environmental, marketing and sales forecasting.

The Delphi method is beneficial when other methods are not adequate or appropriate for data collection [16]. One of the advantages of using the Delphi method is this method is well suited to situations where no or very limited historical data is available. The method is used to assess long-term issues. As the procedure is aimed at identifying statements that are relevant for the future, it reduces the tacit and complex knowledge to a single statement and makes it possible to pass judgment [17].

The Delphi Method makes use of a panel of experts who are selected based on the required areas of expertise. It is believed that the group will converge toward the "best" response through this consensus process. In each succeeding round of questionnaires, the range of responses by the panelists will presumably decrease and it will move toward what is deemed to be the "correct" answer [18].

[19]has agreed that Delphi is a technique frequently used for eliciting consensus from within a group of experts that has application in reliability and has many advantages over other methods that use panel decision making. [19], [10], [20] found that one of the major advantages of using Delphi as a group response is that consensus will emerge with one representative opinion from the experts.

Table 2 compares and contrasts the strengths and weaknesses of a Delphi study versus the traditional survey approach as a research strategy. In light of this comparison, Delphi method was selected for the following reasons:

i. This study is an assessment of risk level of time and cost factors throughout CPLC. This complex issue requires knowledge and experience from experts who understand the issues of time and cost overrun in construction projects in different phases. Thus, the expert panels involved in this survey have the capability to answer the research questions.

ii. An expert panel is the most appropriate to answer the research questions, rather than any individual responses because the expert panels have a large background knowledge derived from their ten years experiences in construction projects.

iii. Although it is difficult to keep the whole experts responding to each round, the Delphi's sample requirements are modest, and it would be practical to solicit from 15-20 experts.

iv. The Delphi study is flexible in its design, and amenable to follow-up interviews. This permits the collection of richer data leading to a deeper understanding of the fundamental research questions.

Table 2: Comparison between traditional surveys and Delphi surveys

Evaluation criteria	Traditional survey	Delphi study
Representativeness of sample	Using statistical sampling techniques, the researchers randomly select a sample that is representative of the population of interest.	A Delphi study is a virtual panel of experts gathered to arrive at an answer to a difficult question. Thus, a Delphi study could be considered as a type of virtual meeting or as a group decision technique, though it appears to be a complicated survey.
Sample size for statistical power and significant findings	Because the goal is to generalize results to a larger population, the researchers need to select a sample size that is large enough to detect statistically significant effects in the population.	The Delphi group size does not depend on statistical power, but rather on group dynamics for arriving at consensus among experts. Thus, the literature recommends 10–18 experts for a Delphi panel.
Anonymity	Respondents are always anonymous to each other, and often anonymous to the researcher.	Respondents are always anonymous to each other, but never anonymous to the researcher. This gives the researchers more opportunity to follow up for clarifications and further qualitative data.
Non-response issues	Researchers need to investigate the possibility of non-response bias to ensure that the sample remains representative of the population.	Non-response is typically very low in Delphi surveys, since most researchers have obtained assurance of participation
Attrition effects	For single surveys, attrition (participant drop-out) is a non-issue. For multi-step repeated survey studies, researcher should investigate attrition to assure that it is random and non-systematic.	Similar to non-response, attrition tends to be low in Delphi studies, and the researchers usually can easily ascertain the cause by talking to the dropouts.
Richness of data	The richness of data depends on the form and depth of the questions, and on the possibility of follow-up, such as interviews.	Delphi studies inherently provide richer data because of their multiple iterations and their response revision due to feedback

3.2.1 Reliability of Delphi method

The principal difficulties in a Delphi method are in maintaining the high level of response and in reaching and implementing a consensus. It is very important to keep the whole panel of experts responding to each round of Delphi. The majority of Delphi studies have used 15-20 respondents. Moreover, good results can be obtained even with a panel as small as 10-15 individuals. Therefore, the opinions solicited from the 12 experts in the second round of the Delphi survey were considered adequate to provide reliable results. Besides that, results of the study are considered to achieve the consensus when it reaches an agreement of at least 70 percent of respondents [13]. These criteria are very important to ensure that a quality data can be gathered.
According to [21], two rounds of Delphi questionnaire survey were conducted in the construction market of China to identify the key competences of Design and Build (DB) clients. The experts that involved in this survey consisted of 17 experts in first round and 16 experts in second round.

3.3. Analysis Method

The analysis methods adopted in the study were (a) descriptive analysis to determine the average value for each probability of occurrence and their severity level, (b) risk matrix to categorize the factors into three groups consisting of low, moderate and high.

3.3.1 Reliability Test

Reliability test refers to the degree to which a test is consistent and stable in measuring what it is intended to measure. It is one of the most important elements of test quality. In measuring the reliability of data, Cronbach α method was applied for this study and was calculated by using the following formula:

$$\alpha = \frac{N - \bar{r}}{1 + (N-1) - \bar{r}} \quad (3.1)$$

Where,
N = Number of items
$\bar{r}$ = average inter correlation items

3.3.2 Descriptive Analysis

In descriptive analysis, the probability of occurrence and level of severity for each factor were calculated using Average Index (AI) as shown in table 3 that was adopted by [22].

$$\text{Average Index} = \frac{\sum (1X_1 + 2X_2 + 3X_3 + 4X_4 + 5X_5)}{N}$$

Table 3: Parameter for degree of agreement

Parameter	Degree of Agreement
1	Strongly Disagree
2	Disagree
3	Moderately Agree
4	Agree
5	Strongly Agree

Where,
N= Number of respondents,
X_1, X_2, X_3, X_4, X_5 = Number of respondents for each parameters

For this study, the item "degree of agreement" was adapted to represent the probability of occurrence and level of severity as shown in Table 4.

Table 4: Parameters for assessing level of occurrence and severity

Parameter	Probability of Occurrence	Level of Severity
1	Do not occur	No Significant
2	Slightly occur	Slightly Significant
3	Moderately occur	Moderately Significant
4	Often occur	Very Significant

5	Very often occur	Extremely Significant

3.3.3 Risk Matrix

Risk matrix is a graphical representation of the risk level for different values of probability and severity. The colour coding indicates the risk level, red is *High* risk, yellow is *Medium* risk, and green is *Low* risk. In general, a risk matrix has two axis:

i. The probability, which measure the frequency of a risk.
ii. The severities, which measure the impact of a risk on a specific scale, such as time and cost.

According to [23], risk matrix is a methodology that is typically used to identify, prioritize and manage key risks. In this study, risk matrix was used to define the levels of risk based on probability of occurrence and severity level. The advantages of applying this method are:

i. This is a simple mechanism to increase visibility of risks and assist management decision making.
ii. Does not require extensive knowledge of quantitative risk analysis to use.
iii. Has clear guidance to applicability.
iv. Has consistent likelihood range that covers the full spectrum of potential scenarios.
v. Has clearly defined tolerable and intolerable risk level.
vi. Provides clear guidance on what action is necessary to mitigate scenarios with intolerable risk levels.

Table 5 and figure 2 show the standard risk matrix which is used to determine the risk zone for each factors [24].

Table 5: Scale used to identify factor's severity and probability of occurrence

Scale	Probability	Severity
1	Very low (VL)	Very low (VL)
2	Low (L)	Low (L)
3	Moderate (M)	Moderate (M)
4	High (H)	High (H)
5	Very High (VH)	Very High (VH)

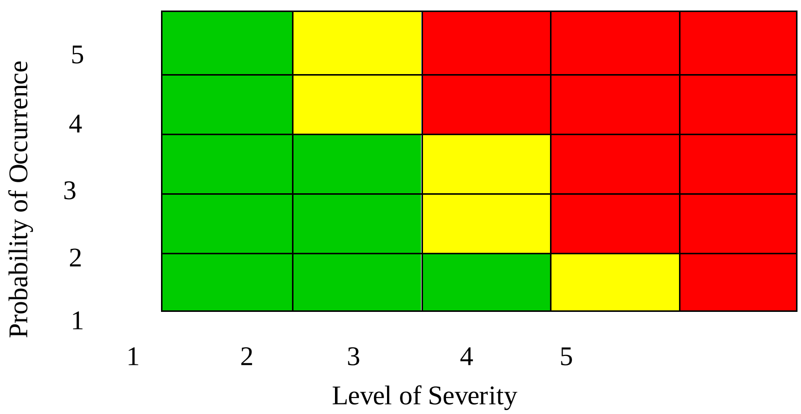

Figure 2: Risk matrix [24]

Figure 2shows that this risk matrix is classified into various zones as explained below.

i. Green zone: Risks in this zone are low level and can be ignored.
ii. Yellow zone: Risks in this zone are of moderate importance; if these things happen, one can cope with them and move on. However, if their probability of occurrence is moderate it should be reduced and if their impact is moderate, it should be controlled and reduced and a contingency plans should be in place just in case they do occur.
iii. Red zone: Risks in this zone are of critical importance. These are top priorities and a close attention should be paid to them.

Risk matrix was selected for this study because it helps to rank the risk in the order of importance in developing risk response plans.

4. Pilot Study Analysis

A pilot study is also called a feasibility study. It involves a number of experts from the field of construction industry. This pilot study was carried out by interviewing practitioners who have more than ten years' experience in the construction sector. The selected respondents were asked to assess the level of risk for each factor according to the phases of the project life cycle based on assessment made according to scale.

4.1. Demography of Respondent

Demography involves the characteristics of the respondent i.e. qualification, years of experience in construction, category of organizations and working position. In this study a total of five respondents which included three from client's representative, one from contractor and one from consultant representative were interviewed. The characteristics of respondents who participated in the pilot study are presented in Table 6.

Table 6: Demography of Respondents

Respondent	Qualification	Experience (years)	Category of Organization	Position
Contractor	Degree	21-30	Private	Engineer
Consultant	Degree	21-30	Private	Engineer
Client	Degree	11-20	Government	Engineer
Client	Master	21-30	Government	Deputy director
Client	Degree	31 above	Government	Deputy director

Table 6 shows that all the respondents have more than 10 years working experience in handling projects. In terms of educational qualification, majority of respondents hold engineering degree. Three of the respondents were from government organization and the rest were from private organization. This confirmed that the respondents selected in this study were competent enough for data collection.

4.2. Reliability Test of Factors

Reliability test is conducted to check the stability and consistency of data. In this study, Cronbach's Alpha (α) was calculated using statistical software SPSS. The results of reliability test are presented in Table 7.

Table 7: Reliability test results

Phase	Cronbach Alpha, α			Number of Item
	Probability of Occurrence	Level of Severity		
		Time Overrun	Cost Overrun	
Planning	0.993	0.989	0.993	35
Design	0.991	0.978	0.993	35
Construction	0.976	0.982	0.982	35
Finishing	0.991	0.993	0.994	35
Overall	0.995	0.993	0.995	140

Table 8 shows the value of alpha that was calculated for each phase as well as overall data. The values of alpha were in the range of 0.976 to 0.995. This range is considered high as previous studies showed that if Cronbach α is more than 0.7, it indicates that inner consistency of data is in high level and it can be highly acceptable [25]. Since alpha value for each phase as well as overall data estimated for this study were found to be higher than 0.7, this indicated that the questionnaire data were valid and reliable.

4.3. Risk Level of Factors

Data gathered from the pilot study was analyzed using Average Index (AI) calculation. From that calculation, AI value for probability of occurrence and severity level for the factors that caused time and cost overrun was calculated in each phase of the project life cycle.

Based on these values, risk level for each factor was determined and each factor was classified using the risk matrix. Based on the risk matrix results, the factors were classified as low, moderate and high risk factors. The findings of pilot study analysis are presented in Table 9 where factors with low risks are highlighted with green colour, while factors with yellow colour as medium risk factors and red colour as high risk factors. Besides that, these factors were also classified into 7 categories namely, *Contractor's Site Management Related Factor (CSM), Design and Documentation Related Factor (DDF), Financial Management Related Factors (FIN), Information and Communication Technology Related Factors (ICT), Labour Management Related Factors (LAB), Material and Machinery Related Factors (MMF)* and *Project Management and Contract Administration Related Factors (PMCA).*

Table 8: Analysis of Factors

No	Factors	Planning		Design		Construction		Finishing		Category
		RT	RC	RT	RC	RT	RC	RT	RC	
1	Poor site management and supervision	3.2	3.2	3.2	3.6	10.9	9.6	7.8	8.4	CSM
2	Incompetent subcontractors	3.6	3.6	4.8	4.8	9.6	7.8	6.8	6.2	
3	Schedule delay	3.2	3.2	4.7	3.2	12.2	10.2	9.6	9.0	
4	Inadequate planning and scheduling	5.3	4.8	6.2	5.3	10.2	8.3	8.4	8.4	
5	Lack of experience	5.2	4.8	6.7	5.8	7.8	7.8	7.3	7.3	
6	Inaccurate time and cost estimates	3.2	3.2	3.6	4.0	6.7	7.2	7.2	6.7	
7	Mistakes during construction	2.9	2.9	2.9	2.9	9.0	9.0	9.0	8.4	
8	Inadequate monitoring and control	3.2	3.2	3.2	3.6	7.8	6.7	5.8	5.8	
9	Frequent design changes	4.8	4.0	4.4	4.4	7.3	6.2	4.8	4.8	DDF
10	Mistakes and errors in design	3.2	3.2	4.0	4.0	6.8	7.3	6.2	6.2	
11	Incomplete design at the time of tender	3.6	3.2	4.4	4.0	6.2	7.0	3.8	3.5	
12	Poor design and delays in Design	4.0	3.2	4.4	4.8	7.3	6.8	5.3	5.3	
13	Delay Preparation and approval of drawings	2.9	3.6	2.9	3.6	4.8	4.0	4.8	4.8	
14	Cash flow and financial difficulties faced by contractors	2.9	2.9	3.6	3.6	9.0	6.6	6.2	5.3	FIN
15	Poor financial control on site	4.0	3.6	3.2	3.2	5.3	5.3	5.3	5.3	
16	Financial difficulties of owner	4.4	3.6	3.2	3.6	7.3	6.2	6.2	6.2	
17	Delay in progress payment by owner	3.2	3.6	3.2	3.2	7.8	6.7	4.8	4.8	
18	Delay payment to supplier /subcontractor	2.9	3.2	3.2	3.6	9.6	7.7	5.8	5.3	
19	Contractual claims, such as, extension of time with cost claims	3.2	3.6	3.2	3.6	7.8	7.3	4.0	4.8	

20	Lack of coordination between parties	4.4	4.4	6.2	5.2	8.4	7.2	6.2	5.8	ICT
21	Slow information flow between parties	5.3	4.8	4.4	4.4	4.8	5.3	5.3	4.8	
22	Lack of communication between parties	6.2	6.2	5.3	5.3	6.2	6.2	5.3	5.3	
23	Labour productivity	3.2	3.2	4.8	4.0	5.3	5.8	4.8	5.3	LAB
24	Shortage of site workers	2.9	3.2	3.2	3.6	5.3	5.3	4.8	4.8	
25	Shortage of technical personnel (skilled labour)	2.9	3.6	4.0	3.6	7.8	7.2	4.3	4.3	
26	High cost of labour	3.6	4.0	3.6	3.6	4.4	3.6	3.6	3.2	
27	Labour absenteeism	3.2	3.2	3.2	3.2	4.8	3.6	3.6	2.9	
28	Fluctuation of prices of materials	3.2	3.2	2.9	3.6	2.9	2.9	4.0	3.6	MMF
29	Shortages of materials	3.2	3.2	2.9	3.6	5.8	5.8	4.8	4.0	
30	Late delivery of materials and equipment	3.6	3.2	2.9	3.2	7.8	5.7	4.4	4.4	
31	Equipment availability and failure	3.2	3.2	2.9	2.9	5.3	5.3	4.0	4.0	
32	Poor project management	3.6	3.6	2.6	2.9	9.0	7.8	6.2	6.2	PMCA
33	Change in the scope of the project	7.8	6.7	6.8	4.7	7.8	6.8	5.3	5.3	
34	Delays in decisions making	5.8	4.8	5.8	5.3	7.8	6.2	5.7	5.3	
35	Inaccurate quantity take-off	3.2	3.2	2.9	3.6	6.7	6.7	4.4	5.2	

Note: RT = Risk on Time, RC = Risk on Cost

Table 8 shows that the factors have low and medium risk on time and cost overrun during planning and design phase. While, in construction phase, the majority of factors have medium risks and 5 factors have high risk on time overrun, while 6 factors have high risk on cost overrun. The factors that have high risk on time overrun are poor site management and supervision, incompetent subcontractors, schedule delay, inadequate planning and scheduling, and delay payment to supplier /subcontractor. The factors with high risk on cost overrun in this phase are poor site management and supervision, incompetent subcontractors, schedule delay, inadequate planning and scheduling, incomplete design at the time of tender, and delay payment to supplier /subcontractor. In finishing phase most of the factors have moderate risk and only 1 factor i.e. schedule delay has high risk on project time. The results of risk classification are summarized in Table 9.

Table 9: Risk classification of factors on time and cost

Phase	Time Overrun			Cost Overrun		
	Low	**Moderate**	**High**	**Low**	**Moderate**	**High**
Planning	26	9	0	29	6	0
Design	27	8	0	30	5	0
Construction	1	29	5	4	25	6
Finishing	6	28	1	6	29	0

From Table 9, factors in the green zone are considered as low risk level and can be ignored as described in Risk matrix. Only risk factors in yellow and red zones are considered as important factors. Thus, this result is a little different compared to the result that was based on previous studies. It can be concluded that in Malaysian construction projects. The numbers of risk factors in planning, design and construction phase are quite similar with others countries. However, in finishing phase the number of risk factors in Malaysian construction projects is higher than other countries. This is possibly due to the environment and geological differences in every country that can affect the factors in each phase.

5. Conclusion

Literature review was conducted to identify significant factors of time and cost overrun within the construction project life cycles. Then, mapping of the identified factors was to eliminate redundancy of the factors. Pilot study was conducted with 5 construction experts and data was collected using Delphi techniques. It involved 15 respondents in two round approach. It was found that the construction phase has the highest number of high risk factors either for time and also cost overruns. These findings will benefit the construction practitioners in avoiding the possibilities of encountering overrun while handling the construction activities.

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