

Cost Risk Appraisal: An Application of Project Risk Management Process in Libyan Construction Projects

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Abstract: Projects delay and cost overrun have become general facts in the construction industry. Project cost risk analysis considers the different costs associated with a project and focuses on the uncertainties and risks that may affect these costs. An implementation of PRM (project risk management) process on regional construction project has been carried out to maximize the likelihood of project meeting its objectives within its constraints. Qualitative and quantitative risk analyses have been carried out. The qualitative analysis is presented in a table that shows top ranked risks in Libyan construction projects based on probability-impact grid technique. In quantitative risk analyses, Mont Carlo simulation technique has been conducted to quantify and evaluate the overall level of risk exposure associated with the project completion cost. A project simulation uses a model that translates cost uncertainties into their potential impact on project objectives. A frequency curve model that represents simulation results of project completion costs has been constructed. The frequency curve model shows all possible outcomes of expected project cost at different probabilities. Project manager or decision maker can select the appropriate project budget. If a probability of 0.95 confident project budget is selected that means cost overrun risk can be minimized to a probability of 0.05. It is very helpful for project manager to take decisions based on information that shows project completion cost and its associated probability rather than using single information of estimated cost.

Key words: Project cost risk analysis, Monte Carlo simulation, delay factors.

1. Introduction

Change in project cost or cost growth occurs from many factors. Some of these factors are related to each other, and all are associated with some form of risk. Determining the existence and influence of cost overrun risk factor in construction projects can ultimately lead to better control on project cost estimate and assist in identifying possible solution for avoiding future estimate overrun. Construction projects are exposed to uncertain environments because of many factors such as planning, design, construction complexity, resources (e.g., materials, equipment and project funding), climate environment and the economic policies (e.g., custom delay, inflation rate and taxes) [1]. Williams [2] states that cost risk analysis is important at the start of the project and the use of this type of analysis for major projects, i.e.,

capital budgets, is said to be very successful. However, due to the inherent risks in the construction projects, the cost and time overruns become common facts in the construction industry [3].

It has been pointed out that there is a strong relationship between the application of project risk management and the success of any project. When the project management is implicated there will be a high chance of project success [4]. This paper is an attempt to implement project risk management process on Libyan construction projects to show its impact on project outcomes to meet their objectives and to minimize project cost risk by constructing project cost model. A building project of 25,000 housing units/Quarsha sector in Benghazi was chosen as a case study.

This paper is a continuation work of schedule risk assessment [5] and focuses on risks that face the construction projects which may lead to project delay and cost overrun. The paper objectives were to: (1)

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minimize project cost risk by delivering project cost plan that highlighting all possible outcomes; (2) draw project managers attention to contingency plan and project highest cost that may be occurred; (3) explore different risk factors that may affect project objectives.

2. Project Cost Risk

Causes for cost overruns in projects have been extensively researched worldwide and reported in scientific literature, public reports and in the media in general.

Cost risk assessment is an essential part of project risk analysis. Cost risk analysis considers the different costs associated with a project (labor, materials, equipment and administration, etc.) and focuses on the uncertainties and risks that may affect these costs. A project simulation uses a model that translates the uncertainties into their potential impact on project objectives. Uncertain activities with cost impact not always arise, but the authors need to know how to handle them when they arise. To assess the uncertainty in a project's cost, it will need to breakdown the total cost into parts, describe the uncertainty in each part and then put the parts back together to give a picture of the whole project cost. This is usually established from a WBS (work breakdown structure) which is a document that details, from the top down, the different WPs (work packages) of which the project consists (Fig. 1). Each WP may then be subdivided into an invoice of quantities and estimates of the labor required to complete them as illustrated in Fig. 1. Uncertainties

usually exist in a number of cost items in each WP [6, 7].

3. Delay Factors

Causes of delay and cost overrun in the construction industry lead to many negative effects such as loss of productivity and revenue, lawsuits between owners and contractors and contract termination. Assaf et al. [8] outlined the main causes of delay in large building projects in Saudi Arabia and their relative importance. A survey of randomly selected sample was undertaken. The survey included 56 causes of delay. The delay factors were grouped into nine major groups and the groups were measured and ranked by their importance index. It was shown that financing group of delay factors was ranked the highest and that environment was ranked the lowest. Lo et al. [9] summarized some of the studies that took place from 1971 to 2006 as shown in Table 1 [3].

For Libyan projects cost and time overrun is one of the biggest problems that construction firms face in Libya. This is because most companies in Libya do not have any risk analysis and management plans. Some of the problems that face the construction projects in Libya are in common with other problems that face the construction industry all over the world which will lead to the cost and time overrun. Table 2 shows causes of time and cost overrun and their associated problems in Libyan construction projects.

4. PRM (Project Risk Management) Process

Project risk analysis is an essential part of PRM (project risk management) process. Raz et al. [10]

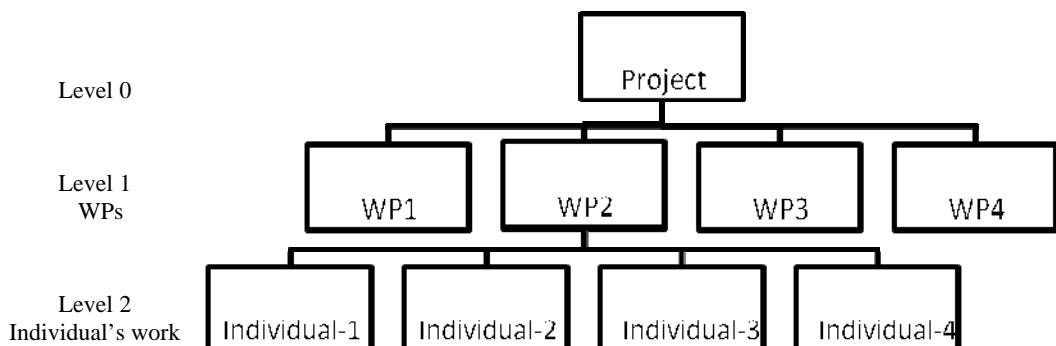


Fig. 1 Work breakdown structure.

Table 1 Summary of previous studies of the causes of delay in construction projects.

Researcher	Country	Major causes of delay
Baldwin et al. (1971)	United States	<ul style="list-style-type: none"> -Inclement weather -Shortages of labor supply -Subcontracting system -Shortages of resources -Financial difficulties faced by public agencies and contractors
Arditi et al. (1985)	Turkey	<ul style="list-style-type: none"> -Organizational deficiencies -Delays in design work -Frequent changes in orders/design -Considerable additional work -Increases in the scope of the work
Semple et al. (1994)	Canada	<ul style="list-style-type: none"> -Inclement weather -Restricted access -Slow preparation and approval of shop drawings
Assaf et al. (1995)	Saudi Arabia	<ul style="list-style-type: none"> -Delays in payments to contractors -Changes in design/design error -Shortages of labor supply -Poor workmanship -Cash flow problems/financial difficulties
Al-Khal and Al-Ghafly (1999)	Saudi Arabia	<ul style="list-style-type: none"> -Difficulties in obtaining permits -“Lowest bid wins” system -Change in orders by the owner during construction -Delay in progress payment -Ineffective planning and scheduling -Shortage of labor -Difficulties in financing on the part of the contractor -Slow preparation and approval of drawings -Inadequate early planning of the project -Slowness of owner’s decision making -Shortage of manpower -Poor site management and supervision -Low productivity of manpower -Poor design -Changes in orders/design
Assaf and Al-Hejji (2006)	Saudi Arabia	<ul style="list-style-type: none"> -Inadequate early planning of the project -Slowness of owner’s decision making -Shortage of manpower -Poor site management and supervision -Low productivity of manpower -Poor design -Changes in orders/design -Inclement weather -Unforeseen site conditions -Late deliveries -Shortages of materials -Failure to pay for completed work -Poor contract management
Faridi and El-Sayegh (2006)	UAE	<ul style="list-style-type: none"> -Delays in payment by agencies to contractors -Fluctuations in materials, labor and plant costs -Improper financial and payment arrangements -Poor contract management -Shortages of materials -Inaccurate cost estimates -Fluctuations in cost -Shortages of materials -Changes of design -Liaison problems among the contracting parties -Unforeseen ground conditions -Poor site management and supervision -Slow decision making by project teams -Client-initiated variations -Inadequate resources -Unforeseen ground conditions -Exceptionally low bids -Inexperienced contractor -Work in conflict with existing utilities -Poor site management and supervision -Unrealistic contract duration
Al-Momani (2000)	Jordan	<ul style="list-style-type: none"> -Unforeseen site conditions -Late deliveries -Shortages of materials -Failure to pay for completed work -Poor contract management
Okpala and Aniekwu (1988)	Nigeria	<ul style="list-style-type: none"> -Delays in payment by agencies to contractors -Fluctuations in materials, labor and plant costs -Improper financial and payment arrangements -Poor contract management -Shortages of materials -Inaccurate cost estimates -Fluctuations in cost -Shortages of materials -Changes of design -Liaison problems among the contracting parties -Unforeseen ground conditions -Poor site management and supervision -Slow decision making by project teams -Client-initiated variations -Inadequate resources -Unforeseen ground conditions -Exceptionally low bids -Inexperienced contractor -Work in conflict with existing utilities -Poor site management and supervision -Unrealistic contract duration
Dlakwa and Culpin (1990)	Nigeria	<ul style="list-style-type: none"> -Unforeseen site conditions -Late deliveries -Shortages of materials -Failure to pay for completed work -Poor contract management
Mansfield et al. (1994)	Nigeria	<ul style="list-style-type: none"> -Delays in payment by agencies to contractors -Fluctuations in materials, labor and plant costs -Improper financial and payment arrangements -Poor contract management -Shortages of materials -Inaccurate cost estimates -Fluctuations in cost -Shortages of materials -Changes of design -Liaison problems among the contracting parties -Unforeseen ground conditions -Poor site management and supervision -Slow decision making by project teams -Client-initiated variations -Inadequate resources -Unforeseen ground conditions -Exceptionally low bids -Inexperienced contractor -Work in conflict with existing utilities -Poor site management and supervision -Unrealistic contract duration
Ogunlana et al. (1996)	Thailand	<ul style="list-style-type: none"> -Unforeseen site conditions -Late deliveries -Shortages of materials -Failure to pay for completed work -Poor contract management
Chan and Kumaraswamy (1996)	Hong Kong	<ul style="list-style-type: none"> -Delays in payment by agencies to contractors -Fluctuations in materials, labor and plant costs -Improper financial and payment arrangements -Poor contract management -Shortages of materials -Inaccurate cost estimates -Fluctuations in cost -Shortages of materials -Changes of design -Liaison problems among the contracting parties -Unforeseen ground conditions -Poor site management and supervision -Slow decision making by project teams -Client-initiated variations -Inadequate resources -Unforeseen ground conditions -Exceptionally low bids -Inexperienced contractor -Work in conflict with existing utilities -Poor site management and supervision -Unrealistic contract duration
Lo et al. (2006)	Hong Kong	<ul style="list-style-type: none"> -Unforeseen site conditions -Late deliveries -Shortages of materials -Failure to pay for completed work -Poor contract management

Table 2 Some of major causes of time and cost overrun in Libyan construction projects.

No.	Name of risk	No.	Name of risk
1	Lack of experience and financial abilities of the contracting companies	19	Changes in tax rate
2	Delays in payment to the contractors	20	Delay due to testing procedures used in the project
3	Delay because of bureaucracy for late approval by the consultant	21	Permission or agency actions delayed longer than expected
4	Errors in designs and specifications	22	Inflation rising above the estimated allowances
5	The time required to change or adjust the designs and their financial approval	23	Failure of equipments
6	Insufficient budget for the project	24	Design changes due to changes in requests
7	Unexpected inclement (weather)	25	Prolonging the completion time of the project beyond the expected
8	Unforeseen adverse ground condition and geological problems at the site	26	Lack of safety provision
9	Shortages in skilled labor	27	Lack of coordination between the different project's activities
10	Delay in tender approval after design changes	28	Lack in the experience of the contractors
11	Failure in lab. tests to reach the desired quality	29	Cash flow problems of the client
12	Lack of crucial materials	30	Tendering mistakes
13	Raw materials not meeting the desired specifications	31	Improper feasibility study
14	Damage to the materials from bad storage conditions	32	Injuries and accidents during construction
15	Excessive use of resources	33	Changes in the regulations, rules and policies
16	Increase in materials prices	34	Conflicts between the contractor and the consultant
17	Increase in labors prices	35	Insufficient coordination/communication between the various parties of the project
18	Custom delay	36	Subcontractor is one of the various parties of the project

have defined PRM as “a process that accompanies the project from its definition through its planning, execution and control phase up to its completion and closure”. The PMI (project management institute) [7] presented six phases of PRM process: risk management planning, risk identification, qualitative risk analysis, quantitative risk analysis, risk response planning and risk monitoring and control. Elkington et al. [4], Boehm [11] and Chapman [12] all suggested that PRM process should consist of two main phases: (1) risk analysis which includes the identification, prioritization estimation and evaluation of risk; (2) risk management which includes planning appropriate responses, monitoring and managing those responses. Although there is a general agreement about what should be included in the PRM process with some differences in the level of details, however, the very common phases of PRM process are: risk identification, qualitative risk analysis, quantitative risk analysis, risk response/mitigation and risk monitoring and control. Hossen et al. [5] explored different elements of PRM

process such as risk identification, qualitative/quantitative risk analysis, risk mitigation, and risk monitoring and control.

5. Case Study

The 25,000 housing units’ project which was selected as a case study consists of several sites. One of these sites, called Quarsha sector in Benghazi, composed of 100 buildings (each building is a block of 8 flats), consists of four floors and roof floor. Each floor is divided into two residential units (flats), in total there were 800 housing units in this site. The total duration to complete this project should be 540 days with approved budget for each building is L.D. 410680 according to project’s contract.

5.1 Risk Identification

The PRM process should start with risk identification phase. This phase is to find out and identify all possible risk factors that can threaten the project objectives. A large number of tools and

techniques exist for risk identification such as check lists, interviews with individuals or groups, questionnaires, brainstorming, or using Delphi technique [12].

Interviews and questionnaire were used to identify risks factors. The questionnaire was developed consisting of six sections: The first section contains general questions about the respondent; The second section is to find out the experience of the respondent to ensure the accuracy of the information obtained from him/her; The third section determines the knowledge of the respondent regarding project risk management as a part of the project management process; The fourth section focuses on the knowledge of the respondent to the project's objectives and the risks surrounding them. The fifth section is to identify the risks regarding the time schedule from the respondent. The last section is to determine the risk factors, the probability of occurrence and risk impact.

The questionnaire was sent to 45 respondents (project managers, responsible engineers and consultant engineers). From that 45, only 23 questionnaires had been completed and returned. The results from using this technique was a list of 36 identified risks which will be used for further analysis. These risk factors are shown in Table 2.

5.2 Qualitative Risk Analysis

Qualitative risk analysis assesses the importance of the identified risks to determine their likelihood and potential impact on project objectives and allowing risks to be prioritized for further analysis by developing prioritized list. The primary technique for this is the probability-impact matrix as shown in Table 3. Probability and impacts of individual risks are assessed and sorted into H (high), M (medium) and L

(low), with additional adverbs including very. Numerical scales may also be used to score each risk in term of impact and probability of occurrence. The product of these assessments will give an overall measure of severity of risk. However, the higher risk rating will indicate the more important risk [13]. Qualitative risk analysis does not require model and usually rapid and less cost than quantitative risks analysis. Qualitative risk analysis establishes priorities for risk response planning and lays the foundation for the quantitative risks analysis.

In the questionnaire the numerical scores from 1 to 10 had been used to represent the probability and the impact of each risk, the probability-impact scores are assessed as: From 1 to 3—L (low), 4 to 6—M (medium) and 7-10—H (high). The rating is based on the calculated priority score to indicate the class of the risk which considered being the highest, intermediate and lowest importance, respectively, however, this rating score does not represent the actual magnitude of risk.

The results from this analysis were prioritized risk's level in a table to determine the most important risks and to apply appropriate resources for the highest ranked risks. An example is illustrated in Table 4. Priority rating may also be showed using colors such as low (green), medium (yellow), high (red).

5.3 Quantitative Risk Analysis (Cost Risk Assessment)

Quantitative risk analysis generally follows the qualitative risk analysis phase. Quantitative risk analysis seeks to quantify the combined effect of risk on project objectives, using tools such as Mont Carlo simulation analysis, sensitivity analysis and decision trees. These involve building a model of the whole project or key elements and analyzing the combine effect on project outcome using statistical simulations.

Table 3 Qualitative scoring using probability—impact grid [13].

		Probability		
		Low score 1	Medium score 5	High score 10
Impact	Low score 1	1	5	10
	Medium score 5	5	25	50
	High score 10	10	50	100

Table 4 An example of prioritizing of project risk.

No.	Name of risk	Rank score	Rank type	Color
1	Lack of experience and financial abilities of the contracting companies	100	High	Red
2	Delays in payment to the contractors	25	Medium	Yellow
8	Unforeseen adverse ground condition and geological problems at the site	1	Low	Green

The result is probability distribution of the project's completion cost or date based on the risks in the project. Quantitative risk analysis involves statistical techniques that can be used with specialized software, such as @Risk [14] and Primavera [15]. The aim is to determine the overall level of risk exposure associated with a project and assisting in development of appropriate responses.

The analysis of project cost risk is based on the WBS, which is made up of WPs. Each WP in the WBS requires three-point estimate for the cost of the planned work. The three estimates are the minimum, most likely and maximum values for each WP cost. The cost of project components (WPs) is replaced by a probability distribution to reflect the uncertainty of those estimates. Beta and triangle distributions are commonly used to represent uncertainty in project cost [16]. Risk analysis using Monte Carlo simulation allows analyzing a project cost using probability

distributions to describe uncertainty in activity costs. In this study, the triangle distribution was used to model the cost of each task. The minimum, maximum and most likely estimated cost were estimated by project team and expert opinion. These uncertain variables are entered as probability distribution functions.

5.4 Monte Carlo Simulation

Monte Carlo simulation is a technique that allows computer to calculate project completion cost or time many times. Each calculation is iteration. Uncertain activities' costs are entered as probability distribution functions. Costs for project activities are randomly selected from probability distributions (Fig. 2).

The process starts from generating random numbers between 0 and 1, and then generates random deviates or variants from a density function of a specific probability distribution such as triangular or beta

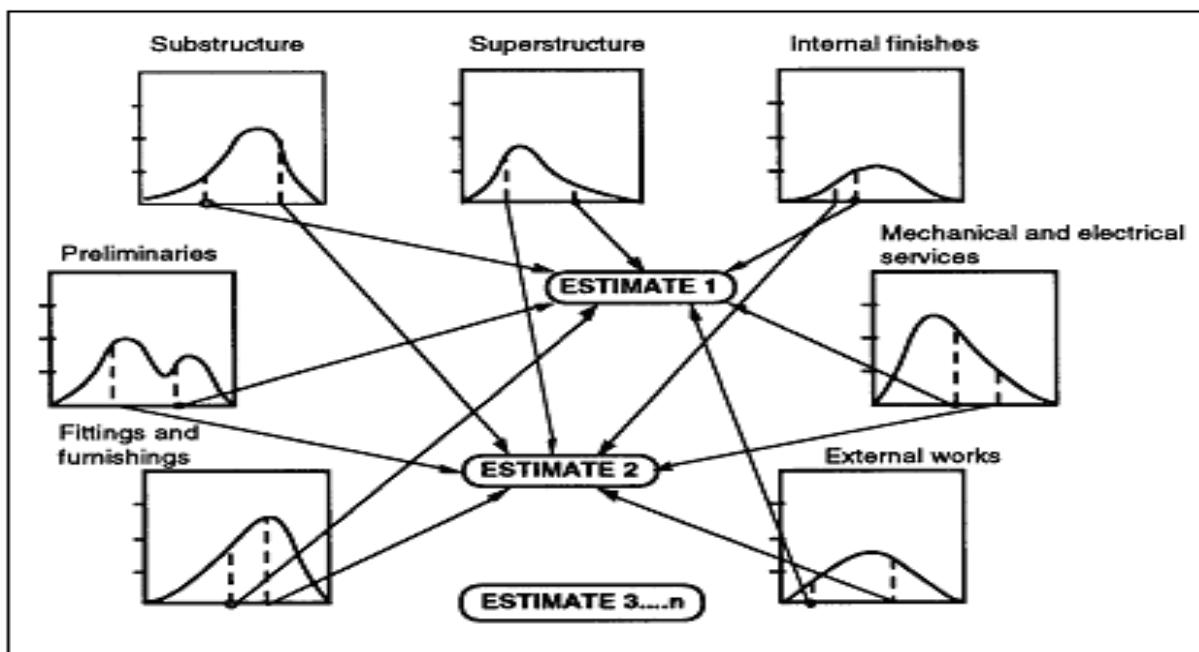


Fig. 2 Random variable sampling [17].

distribution. Each simulation (iteration or replication), the simulator takes a random sample from the specified probability distribution, which is used to model that uncertain factor. The process is repeated a large

number of times to generate a distribution of project cost. 1,000 replication can give smooth curve [17]. Fig. 3 shows an example of the simulation model for quantifying project cost/schedule risk.

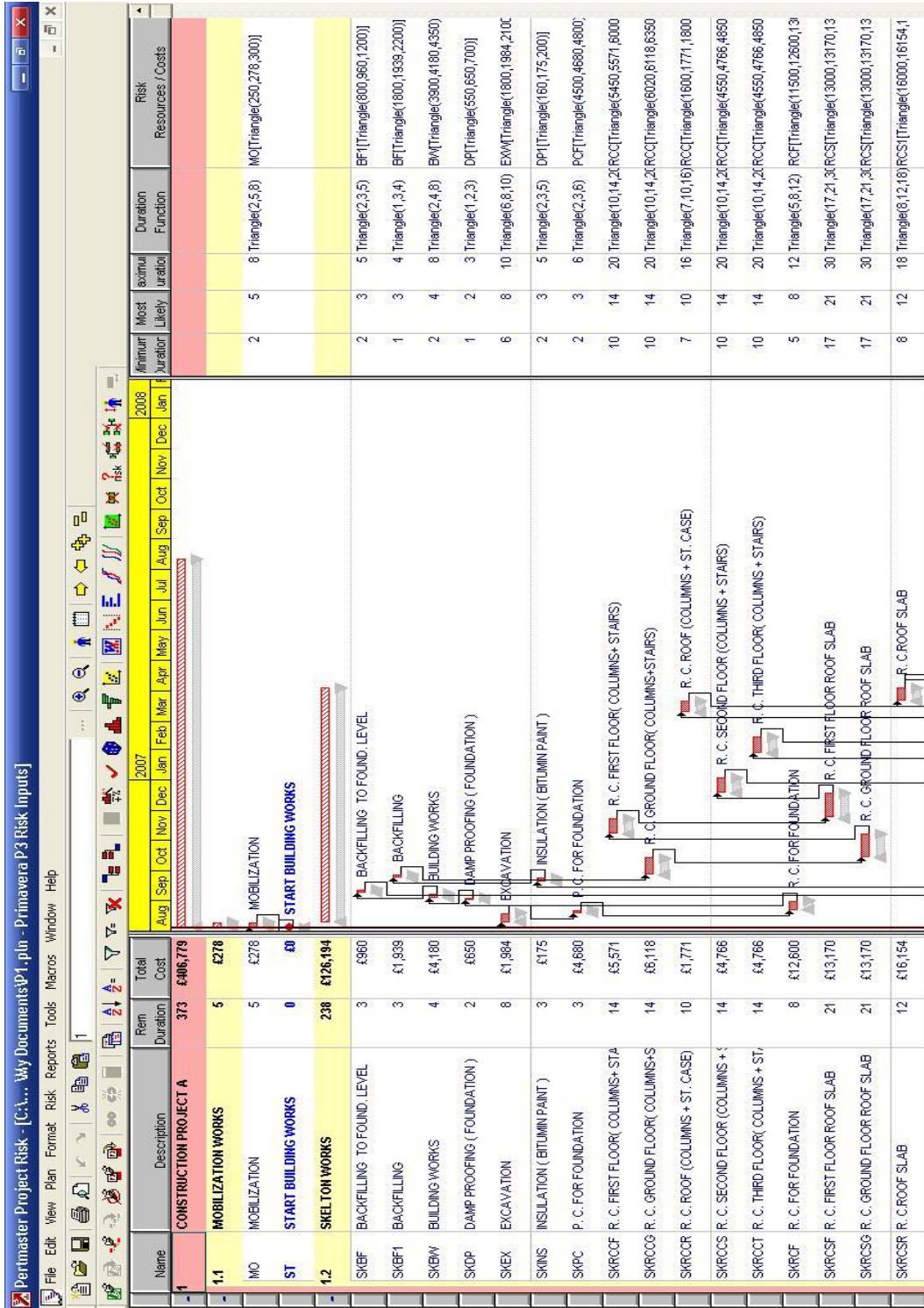


Fig. 3 Cost/schedule simulation model.

After running the cost simulation model all combinations of possible project cost are developed in a histogram. The histogram of all possible outcomes of project cost is produced by the software as it shown in

Fig. 4. The result of the simulation is then represented using a cumulative frequency curve or ECDF (empirical cumulative distribution function) as shown in Figs. 5 and 6. This curve demonstrates the project

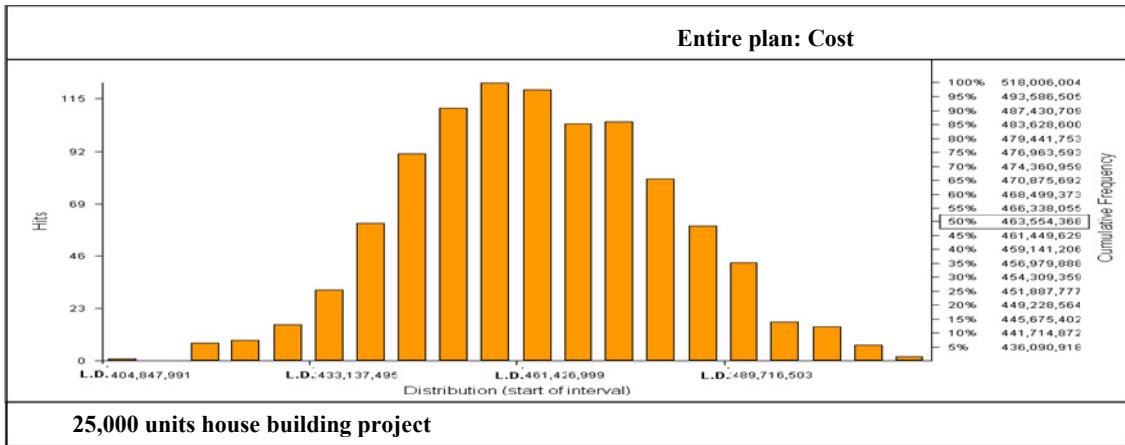


Fig. 4 Histogram of project cost (simulation results).

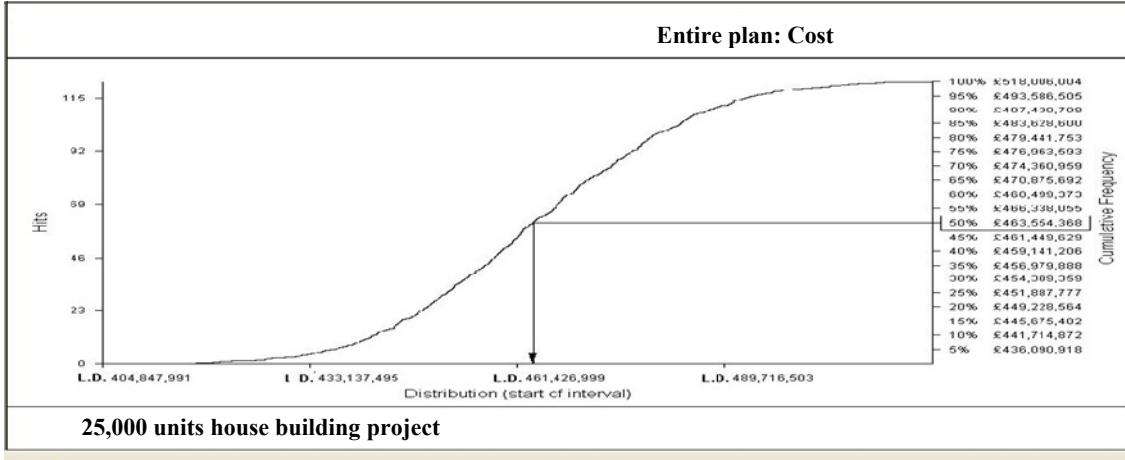


Fig. 5 Frequency curve (ECDF) of project cost (cost risk assessment).

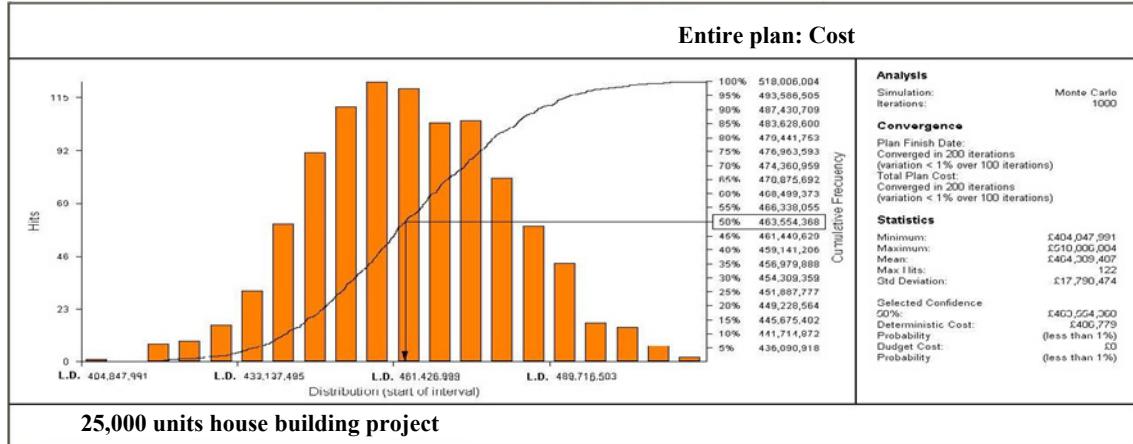


Fig. 6 Distribution of project cost (cost risk assessment).

Table 5 Comparing project costs.

Most likely cost	Contract's cost	50% confident cost
406,779	410,680	463,554.368

total cost at different probabilities. These generated costs are more likely to represent the range of total project cost to be expected [18].

The most likely estimated project cost, the project contract's cost, and the 50% confident project cost will be compared (Table 5). It can be observed, that the most likely cost for the project is L.D.406779 and the approved budget for the project is L.D. 410680 according to project's contract. The cost risk analysis indicates that the probability of completing the project with contract's budget is less than 0.01 (equivalent to 1%) (Figs. 5 and 6). This means that there is a probability of 0.99 risk (equivalent to 99%) of not completing the project within this budget as represented by the cumulative frequency curve. This cumulative frequency curve shows the probability that reflects the risk of overrunning the sum of the most likely estimated cost as illustrated in Figs. 5 and 6.

Figs. 5 and 6 show the project total cost at different probabilities. Project manager can select project total cost with desired confidence level. If the company wants a 50% confident (probability of 0.50) likelihood of success, then a budget of (L.D. 463554.368) is required. The cost contingency to the 50% is (L.D. 56775.368), or about 14% versus (L.D. 406779) the sum of the most likely estimate. In addition, from Figs. 5 and 6, a 95% confident budget (probability of 0.95) can be extracted and that means cost risk can be minimized to a probability of 0.05. The cumulative probability distribution curve enables the decision maker to assess the probability of completing a project within a specific budget. It is very helpful for project manager to take decisions based on information that shows completion cost and its associated probability rather than using information of estimated cost.

6. Conclusions

For project manager, it is very helpful to take

decisions based on information that shows completion cost and its associated probability rather than using information of estimated cost.

Through the use of quantitative risk analysis of these risks to weigh up their effect on the project, the risks affecting the cost of the project were quantitatively analyzed by the use of Mont Carlo simulation. Mont Carlo simulation has been used to model uncertain factors by generating a number of simulations that give an indication of the range of all possible outcomes. A frequency curve or ECDF—empirical cumulative distribution function that represents simulation results for project cost risk has been constructed with probability of 0.50 confidence. The model also shows project total cost with different probabilities. Using this model, the project manager or decision maker can decide project total budget with a suitable confident probability.

The 36 risks that considered the most common risks all over the world, which were listed in the questionnaire, were confirmed by the responders.

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Cost Risk Appraisal: An Application of Project Risk Management Process in Libyan Construction Projects

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