Project cost risk assessment: 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 project risk management (PRM) 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.
Keywords: 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, project funding), climate environment and the economic policies (e.g. custom delay, inflation rate, taxes) (Greedy, 2005). Williams (1995) 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 (Menesi, 2007).

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 (Elkington and Smallman, 2002). 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 25000 housing units / Quarsha sector in Benghazi was chosen as a case study.

This paper is a continuation work of schedule risk assessment (Hossen and Alubaidy, 2010) and focuses on risks that face the construction projects which may lead to project delay and cost overrun. The paper objectives were to: i) minimize project cost risk by delivering project cost plan that highlighting all possible outcomes, ii) draw project managers attention to contingency plan and project highest cost that may be occurred, and iii) 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, 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 we 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 Work Breakdown Structure (WBS) which is a document that details, from the top down, the different work packages (WPs) of which the project consists, see Figure 1. Each WP may then be subdivided into an invoice of quantities and estimates of the labor required to complete them as illustrated in Figure.1. Uncertainties usually exist in a number of cost items in each WP (PMBOK, 2004; Hossen, 2006).

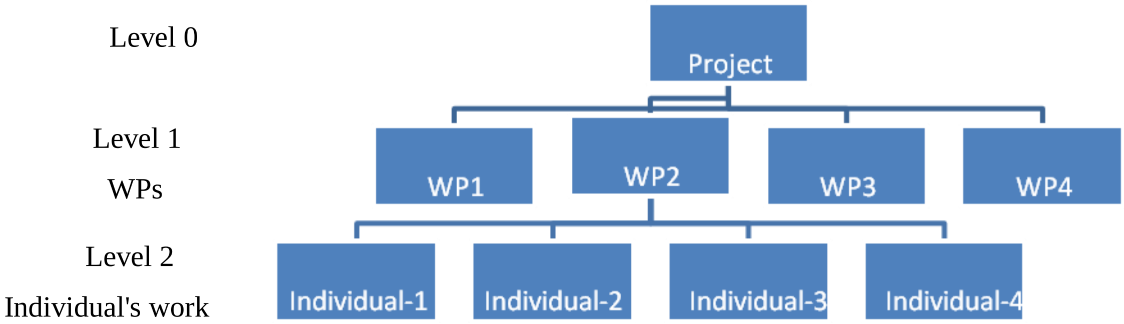

Figure. 1 Work Breakdown Structure

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. (1995) outlined the main causes of delay in large building projects in Saudia 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. (1995) summarized some of the studies that took place from1971 to 2006 as shown in Table 1 (Menesi, 2007).

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	- inclement weather - shortages of labour supply - subcontracting system
Arditi et al. (1985)	Turkey	- shortages of resources - financial difficulties faced by public agencies and contractors - organizational deficiencies - delays in design work - frequent changes in orders/design - considerable additional work
Semple et al. (1994)	Canada	- increases in the scope of the work - inclement weather - restricted access
Assaf et al. (1995)	Saudi Arabia	- slow preparation and approval of shop drawings - delays in payments to contractors - changes in design/design error - shortages of labour supply - poor workmanship
Al-Khal and Al-Ghafly (1999)	Saudi Arabia	- cash flow problems/financial difficulties - difficulties in obtaining permits -"lowest bid wins" system
Assaf and Al-Hejji (2006)	Saudi Arabia	- 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
Faridi and El-Sayegh (2006)	UAE	- 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

Al-Momani (2000)	Jordan	- poor design - changes in orders/design - inclement weather - unforeseen site conditions - late deliveries
Okpala and Aniekwu (1988)	Nigeria	- shortages of materials - failure to pay for completed work - poor contract management
Dlakwa and Culpin (1990	Nigeria	- delays in payment by agencies to contractors - fluctuations in materials, labour and plant costs
Mansfield et al. (1994)	Nigeria	- improper financial and payment arrangements - poor contract management - shortages of materials - inaccurate cost estimates - fluctuations in cost
Ogunlana et al. (1996)	Thailand	- shortages of materials - changes of design - liaison problems among the contracting parties
Chan and Kumaraswamy (1996)	Hong Kong	- unforeseen ground conditions - poor site management and supervision - slow decision making by project teams - client-initiated variations
Lo et al. (2006)	Hong Kong	- inadequate resources - unforeseen ground conditions - exceptionally low bids - inexperienced contractor - work in conflict with existing utilities - poor site management and supervision -unrealistic contract duration

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 don't 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.

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

4. PROJECT RISK MANAGEMENT (PRM) PROCESS

Project risk analysis is an essential part of Project Risk Management (PRM) process. Raz and Michael (2001) 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 Project Management Institute (PMI) (PMBOK, 2004) 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. Boehm (1991), Chapman (2001), and Elkington and Smallman (2002) suggested PRM process should consisted of two main phases :(1) risk analysis which includes the identification, prioritization estimation and evaluation of risk, and (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 and Alubaidy (2010) 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 25000 housing unit project/ Benghazi which is composed of 800 housing unit, was selected as a case study. This project composed of 100 building (block of flats), each building consists of four floors and roof floor. Each floor is divided into two residential units (flats). The total duration to complete this project should be (540) days with approved budget for the project is (410680) L.D for each block of flats 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 threat 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 (Chapman, 2001).

Interviews and questionnaire were used to identify risks factors. The questionnaire was developed consisting of six sections. The first section contained general questions about the respondent. The second section was 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 High (H), Medium (M), or Low (L)); 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 (Ward, 1999). 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.

Table 3: Qualitative Scoring using Probability – Impact grid (Ward, 1999)

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

In the questionnaire the numerical scores from (1-10) had been used to represent the probability and the impact of each risk, the probability-impact scores are assessed as: From (1 - 3) Low (L), (4 – 6) Medium (M), and (7 -10) High (H). 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 doesn't represent the actual magnitude of risk.

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	
2	Delays in payment to the contractors	25	Medium	
8	Unforeseen adverse ground condition and geological problems at the site	1	Low	

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. 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 (Palisade Corp., 1997) and Primavera (Primavera Systems, 1995). 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 Work Breakdown Structure (WBS), which is made up of Work Packages (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 (Vose, 1996). 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.

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' cost are entered as probability distribution functions. Costs for project activities are randomly selected from probability distributions see Figure 2.

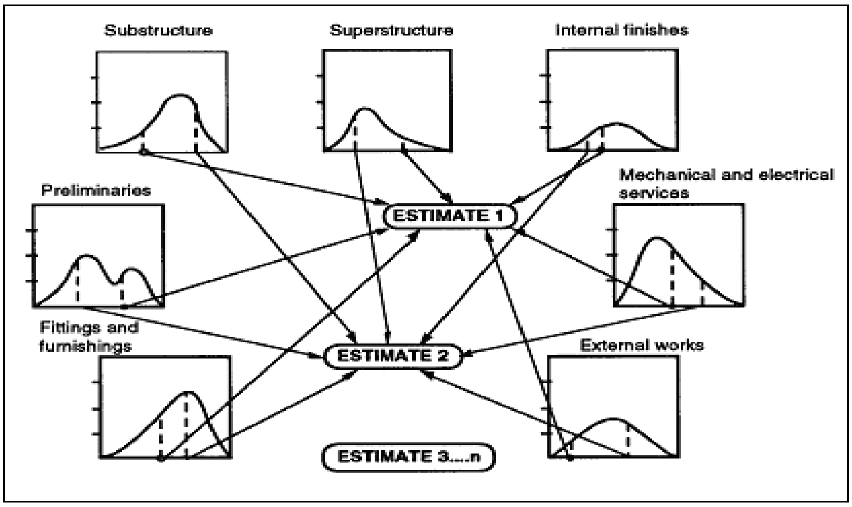

Figure 2 Random Variable Sampling (Flanagan and Norman, 1993)

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 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. 1000 replication can give smooth curve (Flanagan and Norman, 1993). Figure 3 shows an example of the simulation model for quantifying project cost/schedule risk.

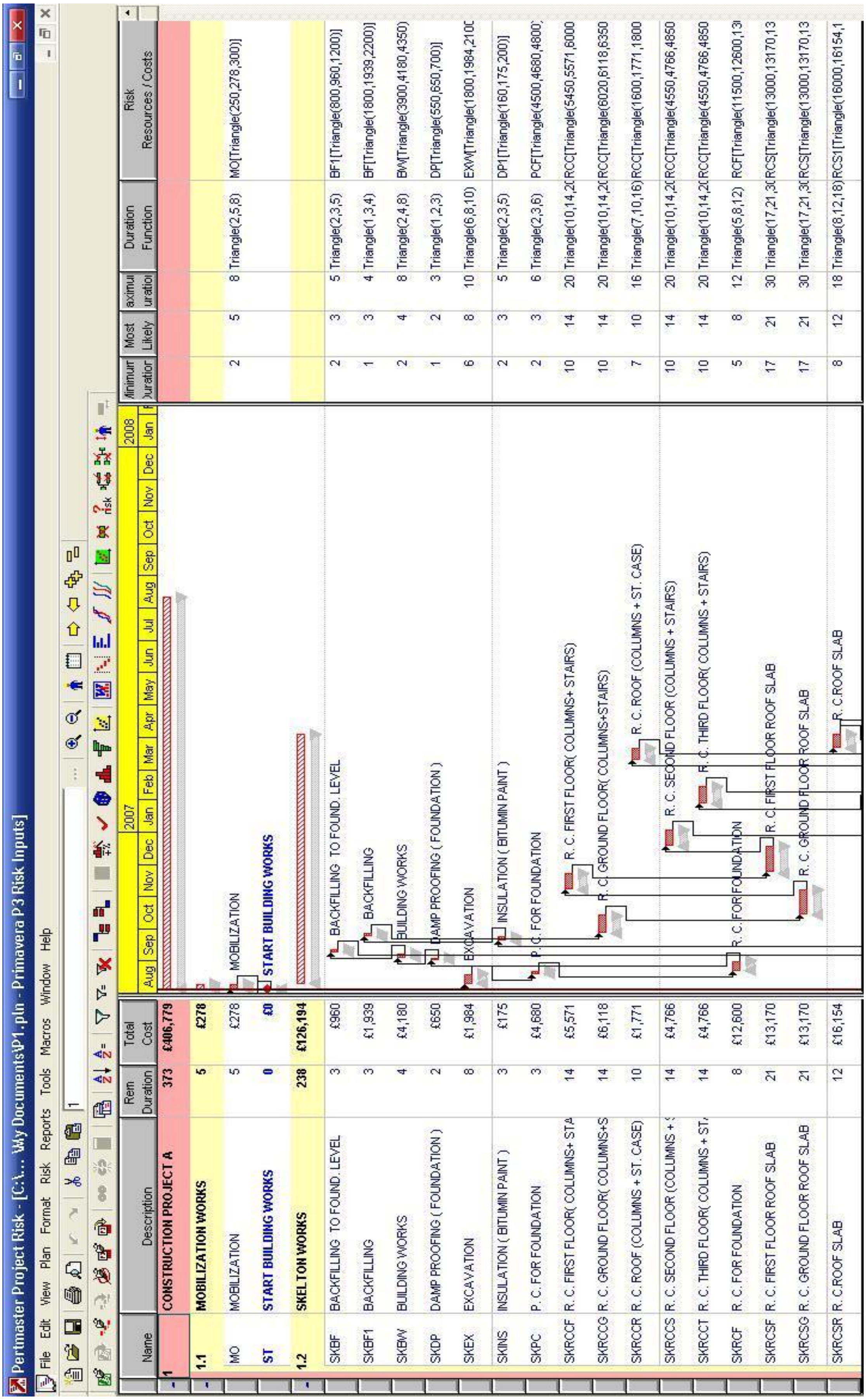

Figure.3 Cost /Schedule Simulation Model

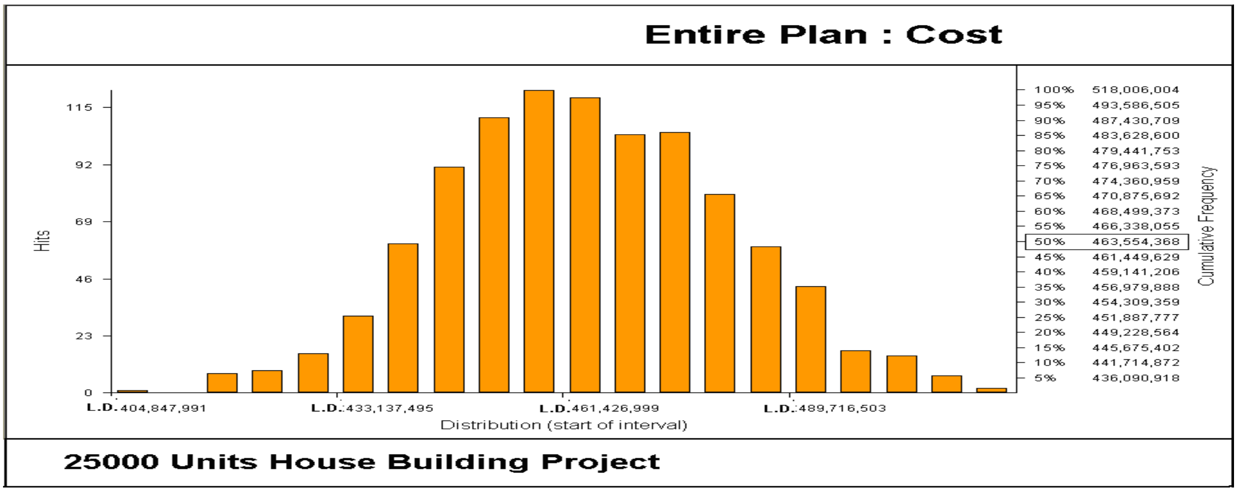

Figure 4 Histogram of Project Cost (Simulation Results)

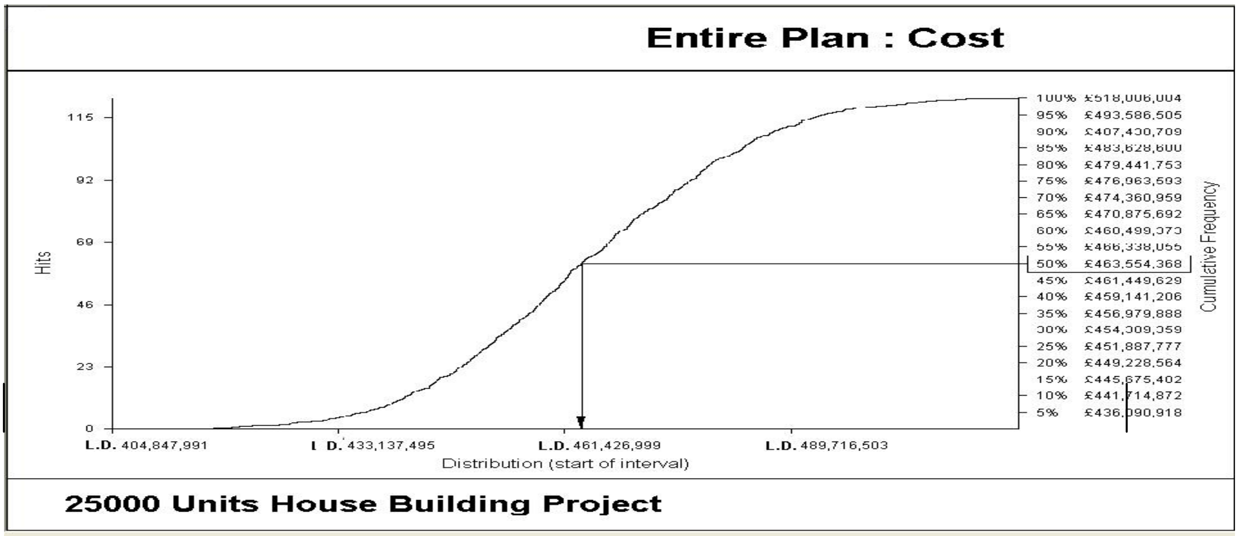

Figure 5 Frequency Curve (ECDF) of Project Cost (Cost Risk Assessment)

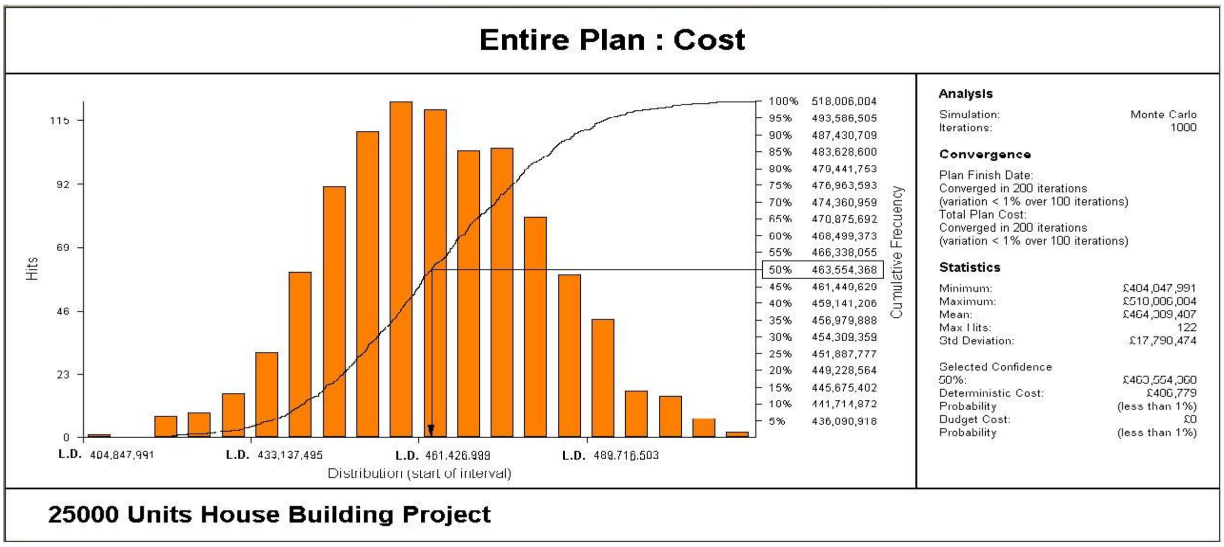

Figure 6 Distribution of Project Cost (Cost Risk Assessment)

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 Figure 4. The result of the simulation is then represented using a Cumulative Frequency Curve (or Empirical Cumulative Distribution Function, ECDF) as shown in Figure 5 and 6. This curve demonstrates the project total cost at different probabilities. These generated costs are more likely to represent the range of total project cost to be expected (Nicholas, 2001).

The most likely estimated project cost, the project contract's cost, and the 50% confident project cost will be compared, see Table 5. It can be observed, that the most likely cost for the project is (406779) L.D and the approved budget for the project is (410680) L.D 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%), see Figure 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 Figure 5 and 6.

Table 5 Comparing Project Costs

Most likely Cost	Contract's Cost	50% Confident Cost
406779	410680	463554.368

Figure 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 (463554.368 L.D) is required. The cost contingency to the 50% is (56775.368 L.D), or about 14% versus (406779 L. D) the sum of the most likely estimate. In addition from Figure 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 one information of estimated cost.

6. CONCLUSION

For project manager, it is very helpful to take decisions based on information that shows completion cost and its associated probability rather than using one 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 Empirical Cumulative Distribution Function, ECDF) 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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