CHAPTER 1

INTRODUCTION

Financial Management has long been recognized as an important tool in construction management. However, the construction industry suffers the largest rate of insolvency of any sector of the economy. Many construction companies fail because of poor financial management, especially inadequate attention to cash flow forecasting .The major problem that construction managers encounter in making financial decisions involves both the uncertainty and ambiguity surrounding expected cash flows. Cash flows are essential to solvency. They can be presented as a record of something that has happened in the past, such as the sale of a particular product, or forecasted into the future, representing what a business or a person expects to take in and to spend. Cash flow is crucial to an entity's survival. Having ample cash on hand will ensure that creditors, employees and others can be paid on time. If a business or person does not have enough cash to support its operations, it is said to be insolvent, and a likely candidate for bankruptcy should the insolvency continue.

In the case of complex projects, the problem of uncertainty and ambiguity assumed even greater proportion because of the difficulty in predicting the impact of unexpected changes on construction progress and consequently, on cash flows. The uncertainty and ambiguity are caused not only by project-related problems but also by the economic and technological factors.

1.1Problem Statement:

The serious importance of the cash-flow prediction for construction contractors it has been indicated. A reliable cash flow prediction can help to accurately identify the expected project financial requirements. So that, decision can be made at a suitable time regarding the potential sources of this finance. Unfortunately, construction project cash-flow is mainly affected by many uncertain but predictable factors. Among these are accidents, thefts, inflation rate, weather inclement, changes interest rate, strikes …… etc.

Through the literature survey, it was noticed that the majority cash-flow prediction models have been based on standard deterministic cash flow S-Curves, developed using the traditional manual approach, mathematical and statistical models. Many of these models failed to consider and analyses the risk factors such as changes in the design or specifications, contract conditions pertaining to cash in flow, interim valuations and certificates and construction programming issues such as inclement weather responsible for the considerable variations in the modeled cash flow profiles. Hence, it is safe to say that a reliable cash-flow prediction should take into consideration the effect of these risk factors. Consequently it is expected that a probabilistic rather than a deterministic cash flow model can best typify the stochastic nature of the cash flow prediction.

1.2 Study objective and Scope

The objective of this study is twofold. First, is to identify the most important risk factors affecting the cash flow prediction of construction projects in Egypt. Second, is the development of a probabilistic cash flow prediction model that can take into consideration the serious effect of those risk factors. The scope of this study will be only confined to building construction projects.

1.3 Study Methodology:

The study conducted through the following sequence:

1. A literature review have been carried out to cover the most important studies in this research area.

2. Based on this literature review, a questionnaire survey was conducted to identify the most important risk factors affecting cash-flow prediction.

3. The development of a probabilistic cash flow model was also considered.

4. The validity of the proposed model have been tested based on a selected case study application.

1.4 Thesis Outline

This section outlines the various chapters of the thesis. After this introducing chapter, Chapter 2 presents literature review. Such review presents the different methods used to maintain the cash flow profiles. It also identifies the different risk factors that should be involved in the cash flow forecasting. Chapter 3 presents the questionnaire design and the data collection process. The main goal of this survey is to identify the main risk factors affecting the cash flow modeling. Chapter 4 discusses the development of the proposed probabilistic cash flow prediction model. Chapter 5 illustrates testing the validity of the proposed cash-flow model. Finally, Chapter 6 summarize the study and its major conclusions and recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter presents a brief description of the previously developed cash flow prediction methods, attention will be also given to the effect of the budget with different scenarios of project schedule & budget, identifying the risk factors involved in cash flow forecasting. So, two axis are available to work on , the first one is the identifying of the main risk factors that affect the modeling of the cash flow forecasting models, the second is the implementation of these risk factors into a net cash flow model to maintain a realistic cash flow profile that can adequately consider these risk factors.

A proactive approach to project cash flow management relies heavily on the use of a forecasting model that is, on the other hand, capable of generating reasonably accurate forecasts and, on the other hand, offers the flexibility which enables the financial manager to challenge the outcome of the forecast in the direction of corporate financial objectives of the organization.

The traditional approach to cash flow prediction usually involves the breakdown of the bill of quantities in line with the contract programmer to produce an estimated expenditure profile. This could be expected to be reasonably precise provided that the bill of quantities is accurate and the contract program is complied with (Lowe, 1987). However, is likely to be slow and costly to produce; as such, several attempts have been made to devise a 'short cut' method of estimation, which will be both quicker and cheaper to utilize. Attempts have been made at the mathematical formulae and statistical based modeling of construction cash flow in both the contractor and client's organizations. This was demonstrated by the development of a series of typical S-curves by many researchers (Kaka and Price, 1993). The models obtained by these researchers rest on the assumption that reasonably accurate prediction is possible by means of a single formula utilizing two or more parameters which may vary according to the type, nature, location, value and duration of the contract.

The main issue that all previous researches focused on maintaining a cash flow model or net cash flow model to help the contractor on the planning phase and a few of them on the construction phase. The problem that all these researches ignore the risks that affect the construction process and do not implement any risk factors in the estimation of the cash flow which cause a non-reliable cash flow forecasting and so a more cash problem to the contractor that makes him incapable to carry out his financial obligations.

The importance of carefully managing cash flow can hardly be overstated. It "cuts to the heart of the financial viability of a construction company" (Kenley, 2003) and leads to long-term profitability or bankruptcy from an inability to pay financing fees, debt reduction, and operations from inflows.

(Lowe, 1987) argued that the main factors responsible for variation in project cash flow could be grouped under five main headings of contractual, programming, pricing, valuation and economic factors. (Harris and Mccaffer, 1995) identified the factors that affect capital lock-up which ultimately affect project cash flow profile to include the margin (profit margin or contribution), retention, claims, tender unbalancing, delay in receiving payments from clients and delay in paying labours, plant hirers, materials suppliers and subcontractors. (Calvert, 1986) identified other factors to include seasonal effects on construction works, variability in preliminary expenses, contract extensions of time for inclement weather and valuation of variations. (Kaka, A.P. and Price, A.D.F, 1993) in developing a model for cash flow forecasting identified other risk factors affecting cash flow profiles to include estimating error, tendering strategies, cost and duration variances. The identified risk factors have been reported to affect cash flow profiles as well as significantly impacting on the modeling of cash flow. However the perception of the contractors to the likelihood of the risk factors occurring in different project types and of varying scope and duration is yet to be investigated.

2.2 Net Cash Flow Models

The most essential terms used are described as follows (Odeyinka, H A and Lowe, J G, 2001)

Cash flow is essentially the movement of money into and out of your business; it's the cycle of cash inflows and cash outflows that determine your business' solvency.

Cash flow = Receipts – Disbursements

Cash flow analysis is the study of the cycle of your business' cash inflows and outflows, with the purpose of maintaining an adequate cash flow for your business, and to provide the basis for cash flow management.

Net cash flow is the balance between the cash out flow and the cash in flow

Net Cash flow = Positive cash flow (receipts) - Negative cash flow (disbursements)

In an early work (Nazem, 1968) proposed a net cash flow model based on historic data, with the aim of discovering standard balance curves. He attempted to develop an 'ideal net cash flow reference curve' for use in predicting future capital requirements. Contractors do not undertake only one project at a time; therefore

Nazem emphasized the overall requirements of the firm, not the individual position for a project. He argued that an overlay of all projects would yield the capital requirements for a company over time. Nazem's proposal required that the ideal reference curve be derived as an average of a reasonable sample of projects. This method has not been successfully followed up, possibly due to problems in deriving such an average; however, there is evidence that some firms employ a similar technique as part of their management systems.

2.2.1 Ideal Curves and Previous Models

In the absence of an ideal net cash flow curve, previous researchers have used ideal value curves to produce net cash flow profiles. The method defines the cash-in curve as the value curve minus any retention held, with an allowance for time lag. Similarly, the cost curve is derived from the earnings curve using specified lags and percentages of earnings.

The possibility of building an ideal value curve based on historic data has been the subject of a considerable amount of research (Bromilow and Henderson, 1977); (Singh and Woon, 1984); (Drak, 1987); (Hudson, 1978). Although these approaches have gained general acceptance, they have not been without criticism. (Hardy, 1970) Found that there was no close correlation between the figures given for 25 projects considered, even when the projects were similar.

(Oliver, 1984) Analysed projects collected from three construction companies. He concluded that, although the number of projects analysed was statistically small, construction projects are individually unique and follow such diverse routes that value curves based on historical data are not capable of providing the accuracy required for individual contract control.

These and other curves were used in computer packages to forecast the net cash flow for construction projects. (Ashley and Teicholz, 1977)Developed a model based on the value curve to assist in the analysis of cash flow over the life of a project. The model also calculates the cost of borrowing and the present value of a given cash flow. (Mackay, 1971)Developed a computer program that estimated the shape of the value curve defined by a series of up to 20 break points connected by a series of straight lines. From this model, various cost categories with their associated time delays, contract value, profit, retentions, etc., were input to compute the resultant cash flow throughout the project. Through test simulations of the program, he determined that the shape made little difference in the cash flow pattern. This approach has been adopted in commercial software packages for use by quantity surveyors and contractors. However, a library of typical S-curves is installed to allow the user to select an S-curve that closely represents his project. In addition, the user may input his own estimated curve if a suitable one cannot be found in the library.

Other researchers thought that value curves were unique to single contracts, and therefore should be estimated for each project. (Peterman, 1972) Developed a net cash flow model using value curves based on bar charts of bill items. (Allsop, 1980) Linked a cash flow model to an estimating program which already existed at Loughborough University of Technology. The program used the estimated cost and estimated value with the contract schedules to calculate the cash flow of the project. The preparation of work schedules involves complex and expensive analyses at a time when resources are least available, and therefore the use of such models should be strongly justified. The justification lies in the importance of cash flow forecasts at the tendering stage and the level of inaccuracy of simplified S-curve models.

Studies on the accuracy of models based on ideal value curves are in conflict. The feasibility of building ideal value curves for different project types is questionable. There is evidence that single curves cannot be fitted accurately through even one type of project. Mackay's sensitivity analysis of net cash flow profiles to different value curves implies that either net cash flow curves conform to predictable patterns or they are sensitive to the selection of systematic delays.

(Kenley, 1986) Studied the variability of net cash flow profiles by collecting the cash-out and cash-in data from 26 commercial and industrial projects. The goodness of fit was reasonably accurate and 26 net cash flow profiles were produced. Comparisons between the results indicated that there was a wide degree of variation between the profiles of individual projects.

2.2.2 Weighted Mean Delays Method

From another point of view, some researches have concentrated on the method of 'weighted mean delays' in order to develop a method for modelling individual construction project net cash flows. This method involves applying systematic delays to a cash inflow profile, in order to reckon the outflow profile. The balance between the two is the net cash flow.

(Peterman, 1972) Proposed an early model utilizing standard delays, and this was followed by (Ashley and Teicholz, 1977) and (Mccaffer, 1979). McCaffer refined the approach using forecast income schedules based on network analysis. These models did not use standard sigmoid (S) curves as their base, although both (Ashley and Teicholz, 1977)and (Mccaffer, 1979)suggested that standard curves may adequately replace the more complex and expensive derivation of project income schedules.

(Hardy, 1970) Utilized a system with gross cash flow curves derived from the application of built-up rates to a network schedule (PERT analysis). He used this, together with an outgoings curve (inferred through applied systematic delays), to derive the net cash flow forecast for a project.

Hardy's model would be difficult to test because of the shortage of available cash payment data. This shortage made it difficult to test the model against historical data; thus the delay system was initiated. Hardy was able to perform some testing on hypothetical projects, obtaining an indication of the model's ability to be consistent and accommodate change, but not of its accuracy. The model is therefore largely intuitive, based on the results of estimated (and assumed constant) delays which could not be tested using empirical data.

(Mackay, 1971) Used standard curves for the originating curves rather than curves derived from forecast work schedules. Subsequently McCaffer produced a comprehensive computer program which forecast construction project net cash flows using standard curves. Use was made of standard curves because the preparation of work schedules (which were only as accurate as the schedule) involved complex and expensive analyses at a time when resources would be least available.

The systematic delay method used by (Mccaffer, 1979) and reported by (Tucker and Rahilly, 1982), relied on the hypothesis that the value curve can be modelled by the use of standard curves, and that the cash-in curve and cash-out curve can be modelled by the application of delay factors to the value curve. The value curve represents the certified value of the work, so the delay of payment from the client (due to contractual or other causes) gives the cash-in curve. The outflow or cost curve is equivalent to the value curve for outgoings, and represents the value of work done (as compared to that certified) and is calculated from the value curve through applied factors. The cash-out curve is then found from the cost curve, as the outlay will usually occur after a period of delay which varies according to the outlay and project conditions. McCaffer used a method of weighted mean delays to derive the component curves from the standard value set at the commencement of this procedure.

McCaffer's procedure is similar to that used by Ashley and Teicholz who defined the cash-in curve as the earnings minus held retention, with allowance for lag. Similarly, the cost curve was derived from the earnings curve using specified lags and percentages of earnings.

The results of the weighted mean delay method have not been directly compared with the actual historical data for a project forecast. This is unfortunate because one observation by (Mackay, 1971)was that the selection of an appropriate originating (standard) curve did not greatly affect the net cash flow model yielded. This suggests that the accuracy of systematic delay models is dependent solely upon the selection of appropriate delays, and not upon the selection of the originating curve. It may seem inherently more likely that net cash flow would be more affected by the period between expenditure and income rather than the rate of progress of the project, this approach ignores the possibility that the components may have differing rates of progress (curve slopes) - and thus the weighted mean delay method would be insufficient to derive one component curve from the other. A comparison with real data may have indicated that differing component curve slopes yield widely different net cash flow curves in practice, as was found within the present project.

Both the ideal reference curve and weighted mean delay models have limitations, one being that they use methods which yield consistent results regardless of the selection of originating curves. There is a large degree of variability between individual project net cash flows; therefore it is necessary to develop a model capable of adjusting to a wide range of variable profiles. Such a model is unlikely to use polynomial regression of net cash flow data, as 'the regression analysis has failed to produce a convincing explanation of cash flow differences' ((O'Keefe, 1971), cited in Kerr, 1973). Hence further research must return to the work of (Jepson, 1969) who suggested that 'generating' or 'component' curves (the inflow and outflow profiles) be used to derive individual project net cash flows.

(Peterman, 1972) Illustrated the large variation possible between the net cash flows for various projects, and the derivation of the residual or working capital profile from component income and cost ogives. Similarly (Nazem, 1968), (Mccaffer, 1979)and (Neo, 1978) illustrated the interaction between the component ogives and the residual.

2.2.3 Idiographic Method vs. Nomothetic Method

Several approaches to the analysis have been used and they may all be characterized as nomothetic. They attempted to discover general laws and principles across categorized or non-categorized groups of construction projects, with the purpose of *a-priori* prediction of cash flows. In contrast an idiographic methodology; the search for specific laws pertaining to individual projects.

The idiographic-nomothetic debate flourished within the social sciences, from the 1950s through to the early 1960s (Runyan, 1983). The contention arose, according to (De Groot, 1969), from the inability to classify the social sciences as either cultural or natural sciences. The social sciences, to which construction management must belong, have components of both cultural sciences (for example history) and natural sciences (for example physics), and have aspects which are 'individual and unique; they are own - (character) - describing: idiographic' (De Groot, 1969). De Groot claimed that 'if one seeks to conduct a scientific investigation into an individual, unique phenomenon. The regular methodology of (natural) science provides no help'. As construction projects are unique it would seem logical that their cash flows should be considered as individual and unique.

The nomothetic approach assumes there are consistent similarities between projects hen produce what are viewed as non-transient industry averages for groups of projects. This rationale ignores idiosyncratic differences between projects, discounting their significance by treating such variation as random (hence implying unimportant) error. While Idiographic method recognizes that variation between projects is a product of their individuality rather than a random error about an established ideal.

Individual variation between projects is caused by a multiplicity of factors, the great majority of which can neither be isolated in sample data, nor predicted in future projects. Some existing cash flow models hold that generally two factors, date and project type, are sufficient to derive an ideal construction project cash flow curve. Such convenient divisions ignore the complex interaction between such influences as economic and political climate, managerial structure and actions, union relations and personality conflicts. Many of these factors have been perceived to be important in related studies such as cost, time and quality performance of building projects (Ireland, 1983), and therefore models which ignore all these factors in cash flow research must be questioned.

The majority of previous studies use historical data. Standard curve models, based on historic data, have been extensively used in cash flow research[or example: (Balkau, 1975); (Bromilow, 1978); (Bromilow, and Henderson, 1977); (Drak, 1987); (Hudson, 1978); (Hudson and Maunick, 1974); (Kerr, 1973); (Mccaffer, 1979); (Singh and Woon, 1984); (Tucker and Rahilly, 1982)] Although these approaches have gained general acceptance, they have not been without criticism. (Hardy, 1970) Found that there was no close similarity between the ogives for 25 projects considered, even when the projects were within one category. This implicit support for an idiographic methodology was subsequently ignored, despite the problems which some researchers found in supporting their models. Hudson observed that 'difficulties are to be expected when trying to apply a simple mathematical equation to a real life situation, particularly one as complex as the erection of a building' [(Hudson and Maunick, 1974); (Hudson, 1978)]. It is interesting to contrast the size of Hardy's sample of 25 projects, with the relatively small samples used by many of the researchers finding nomothetic, ideal curves. For example (Bromilow and Henderson, 1977) used four projects, while (Hardy, 1970) used three projects and (Peer, 1982) used four projects.

There has been an implied trend over time towards an idiographic construction project cash flow model. The early models, which may be termed 'industry' models, searched for generally applicable patterns across the entire industry. When it was recognized that this was unlikely to be achieved, greater flexibility was introduced by searching for patterns within groups or categories of project (the division usually being made according to project type and/or dollar value - e.g. (Hudson, and Maunick, 1974). This still wholly nomothetic approach was modified by (Berny and Howes, 1982) who adapted the (Hudson and Maunick, 1974) category model to a form which could reflect the specific form of individual projects. Even within categories, it had been found that there were occasional projects which did not fit the forecast expenditure well (Hudson and Maunick, 1974); (Hudson, 1978).

(Berny and Howes, 1982) Designed methods for calculating the specific curve for a given project, based on their general equation. In doing so they pointed the way for future research in this field. Their model made a very important cognitive step. By proposing an equation for the general case of an individual project curve, as distinct from the curve of the general (standard) function, it moved from a nomothetic to an idiographic approach.

(Kenley and Wilson, 1986) take Consideration of the idiographic-nomothetic debate led to that the natural science methodology was inappropriate for unique phenomena such as construction projects due to a multiplicity of factors and influences effect project cash flows, many of which are unquantifiable and have differential impact.

It is therefore contended that an idiographic methodology is more appropriate to the study of construction project cash flows, than is a nomothetic methodology, and a nomothetic methodology can only be supported if a significant similarity can be shown to exist within groups. The experimental hypothesis is that there is substantial variation between projects.

In Their models it was noticed that the projects examined have yielded individual profiles, which support Hardy's (1970) contention that no close similarities exist between projects. It is their belief that group models are both functionally as well as conceptually in error.

2.2.4 Probabilistic Cost and Duration Estimating

As with all variability in activity cost and duration due to expected and unexpected changes upon the project various phases, Probabilistic estimation is needed. Recently, commercial computer programs have been developed with the specific purpose of probabilistic estimating [e.g. Monte Carlo simulation (Monte Carloe Version 2.0.) and @RISK for Project (2012)]. These simulation applications are capable of developing integrated probabilistic cost and duration estimating performance CPM calculations in order to find the early and late event times for each activity. If, in each iteration, values of cost are found for each time increment, a possible S-curve can be generated. The final graph will have a representation similar to that shown in Fig 2.1, where the envelope of completion cost and duration values includes the end point of each simulated S-curve (Bent and Humphreys, 1996). From the simulation results, Probability Density Functions (PDF) for final cost and project duration can be obtained, as well as their Cumulative Distribution Functions (CDF), thus providing the required information to develop an integrated risk analysis. From the CDF, cost and duration values can be obtained for different levels of certainty. Fig 2.1 shows probability distributions for final cost and project duration. From these distributions, values of cost and duration, with an acceptable probability of cost and schedule underrun, are independently chosen as the planned cost and time budgets, respectively. For instance, cost and duration estimates corresponding to 80% of certainty for cost underrun and finishing on time, are shown in Fig 2.1.

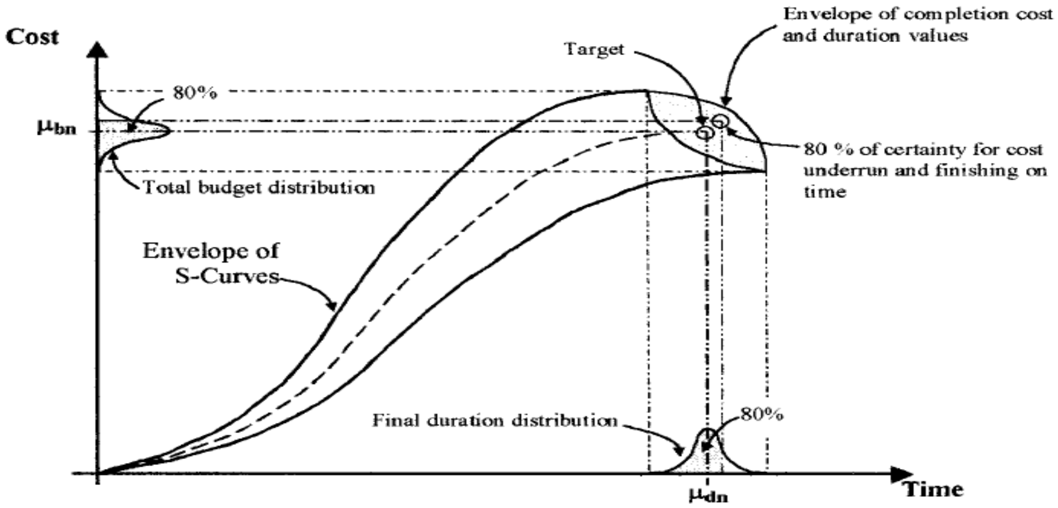

Figure 2.1: Cost and Schedule Probabilistic Estimating (Barraza, Back and Mata, 2000)

2.2.4.1 Probabilistic Forecasting Of Project Performance Using Stochastic S-Curves

Progress-based S curves are defined as plots of cumulative budget and planned duration against project progress (Barraza, 2000)Performance monitoring using PB-S curves is equivalent to the use of the EVS, however it has the advantage of representing the three units required to follow integrated performance: cost, time, and work (progress). Different criteria can be followed to evaluate the percentage of work performed (project progress) required for obtaining the PB-S curves. If the contribution of an activity to the progress of the entire project is evaluated as the percentage that the activity planned cost contributes to the total project budget, the plot of time versus progress resembles the shape of an inverted S and the plot of cost versus progress corresponds to a straight line. The use of PB-S curves is a technique that allows the graphical representation of an integrated probabilistic performance forecast. Using a simulation approach and the PB-S curves representation, different possible total cost and project durations may be evaluated. Thus, for each simulation iteration, a possible PB-S curve can be plotted. (Barraza, 2000) Defined the resulting set of PB-S curves as stochastic S curves (SS curves). By analyzing all possible values of cost and duration, probability distributions can be obtained for cost and duration at any specific percentage of work completed (progress). Fig2.2 Shows SS Curves and Distributions of Budgeted Cost and Project Duration at Each 10% Increment of Project Progress.

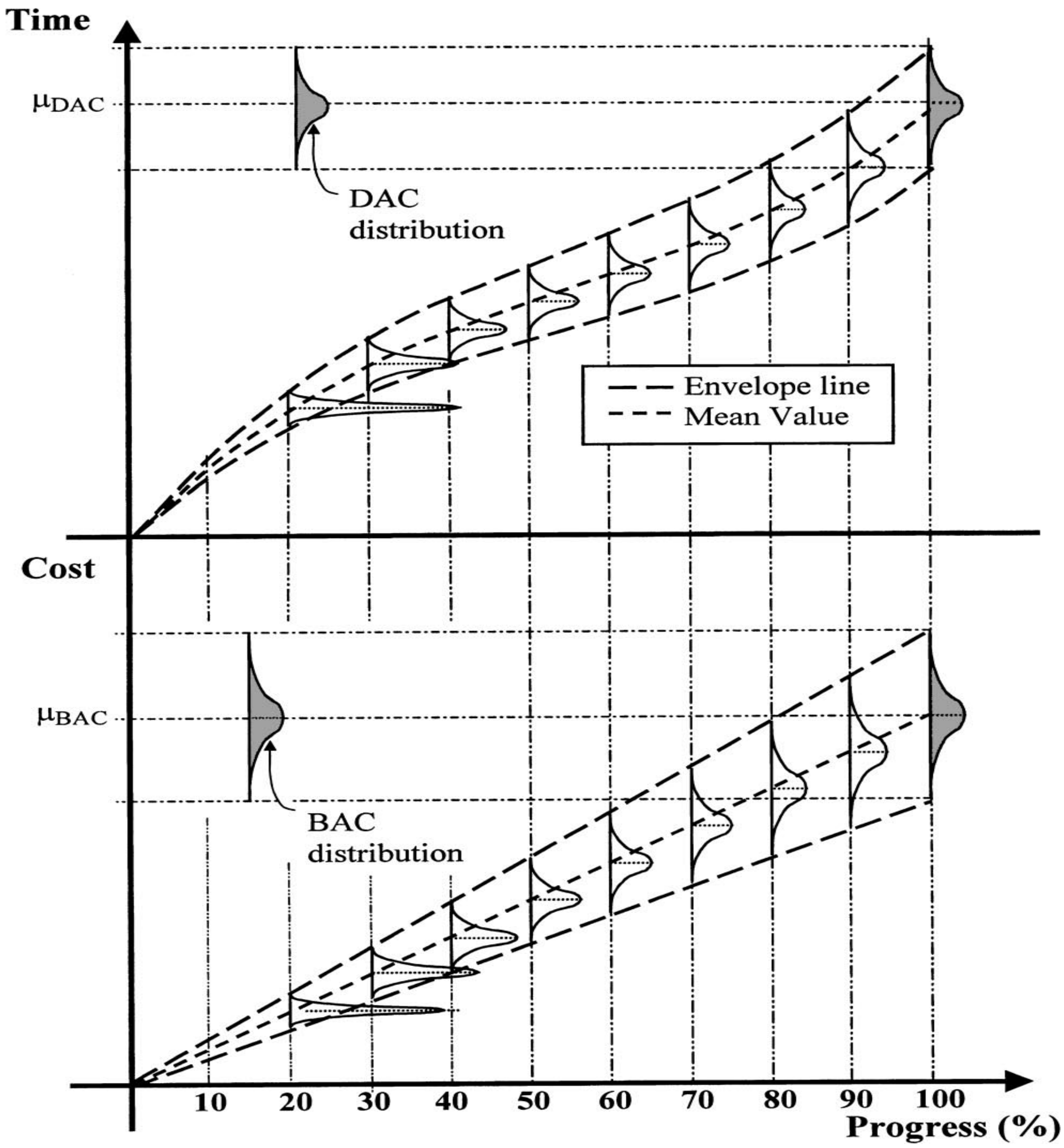

Figure 2.2: Stochastic S Curves Applying Progress-Based S Curves Representation (Barraza, Back and Mata, 2004)

2.3 Risk Factors Involved in Modeling Cash Flow Forecast

Many models have been developed to assist contractors and clients in their cash flow forecasting. The majority of these have been based on standard cash flow S-curves, developed using the traditional manual approach, mathematical and statistical models.

Many of these models failed to consider and analyses the factors responsible for the considerable variations in the modeled cash flow profiles. More than 60 systematic and rational approaches have been proposed as logical substitutes for the traditional, intuitive, unsystematic approach used by most contractors for assessing and pricing risk (Laryea and Hughes, 2008).

These factors can be grouped in some categories, these included size of construction firms, project types, procurement options, client types, project duration and project value. In the next section the main risk factors concerning project cash flow will be deeply discussed.

Consultant's instructions

Any changes in design or specification the consultant do or suggest will have corresponding changes in the expected quantity or nature of the different bill of quantity items.

Provision for interim certificate

The submission of the work at the required specification and after the consultant agreeing according to the specification in the bill of quantity.

Receiving interim certificates

Receiving interim certificates is to receiving periodically cash in and increasing the inflow cash and it's the next step after Provision for interim certificates.

Agreeing interim valuations on site

Agreeing the temporary evaluation by the consultant organization to complete job, move on the next activity or apply their notes on the work.

Retention

Retention, sometimes called retainage, refers to the amount of payment withheld from a contractor's contract. The contractor should show the amount completed, and then request payment for only 90-95% of that amount. The money held back is the retention, typically 5-10% of the total contract price. There are often two levels of retention on a project. The owner, you, will withhold retention from the general contractor. The general contractor, in turn, withholds retention from each of his subcontractors.

In other words, retention is a tool that allows a project owner to withhold some payment to contractors until the entire project is complete and a certificate of completion or certificate of occupancy has been granted. Once this completion has been granted, the owner typically has to release retention.

Delay in agreeing variation

Delays in agreeing any changes in specification, quantity and materials were done by coordinating with the consultant party. This affecting on the project duration and increase useless time (Stopping time) & overheads and so on. By avoiding this type of delay will save a lot of time and cash as well.

Delay in settling claims

A construction Claim tend to have negative connotations on the Construction Industry, and claims scenarios on projects usually result in strained relations between the Contracting parties.

Construction claims are usually submitted by contractors or sub-Contractors for recovering sums of money or for expanding the original duration of the contracts (to get relief from liquidated damages and extension of time claims)owing to delay or disruption to their works caused by the acts of other contracting party. Claims from the developers and consultant are also quite common.

Claims on construction projects generally relate to the following

1- Claim for extension of time to the contract duration
2- Claim for additional monies for delay and/or disruption to the project works.
3- Claim for acceleration of the project works.

Delays in settling these claims cause more time delays and money loss.
Settling these claims as soon as possible help to continue the work and avoid stuck in stopping stage.

Inclement weather

Unexpected action in weather that have a significant effect on the industry and cause project delays or any project reworks due to rains, hurricanes etc.

Problems with the foundations

From the early start of the project at the excavation we can found problems that can make a significant effect on the project duration and cost like unexpected sewer pipeline or electricity line or gas etc., that wasn't on the infrastructure drawings. That require conversion or removal of this line and that will require an extra cost and time.

Extent of float in contract schedule

The float is allowance in the extension in time for each activity duration. The availability to activity to delay without any delay in the project duration.

Tender unbalancing

There are two types of unbalanced Bids—mathematical and material:
A mathematically unbalanced Bid is one that contains lump sum or unit bid items that does not appear to reflect reasonable actual costs. Those reasonable actual costs would include a reasonable proportionate share of the Bidder's anticipated profit, Overhead costs, and other indirect costs that the Bidder anticipates for the Performance of the items in question. While mathematically unbalanced bids are not prohibited per se, evidence of a mathematically unbalanced bid is the first step in Proving a bid to be materially unbalanced.
A materially unbalanced Bid is one that produces a reasonable doubt that award to the low bidder, who submitted the mathematically unbalanced bid, would result in the lowest ultimate cost to the agency. There are numerous reasons why a bidder may want to unbalance a bid. One reason is to get more money at the beginning of the project by overpricing the work done early in the project. This is called "front loading" the contract. Another reason is to maximize profits. This is done by overpricing bid items the bidder believes will be used in greater quantities than estimated and underpricing items that will be used in significantly lesser quantities. (Oregon department of transportation construction manual-chapter 7).

Estimating error

Estimating is the process of looking into the future and trying to predict project costs and resource requirements, It is one of the major process in the construction, all other stages depend on its accuracy.SO any estimating error will affect all the successive stages where the cash flow analysis stage is one of these stages. Any estimating error at any step of the estimating process will has its consequences on the cash-out of the contractor and the cash-in as well the net cash flow.

Provisions for phased handover

It's the final delivery of the project or one or more phase of it

Level of inflation

Inflation is defined as a sustained increase in the general level of prices for goods and services. It is measured as an annual percentage increase. As inflation rises, every Currency you own buys a smaller percentage of a good or service.

The value of any currency does not stay constant when there is inflation. The value of Currency is observed in terms of purchasing power, which is the real, tangible goods that money can buy. When inflation goes up, there is a decline in the purchasing power of money.

There are several variations on inflation:

- Deflation is when the general level of prices is falling. This is the opposite of inflation.
- Hyperinflation is unusually rapid inflation. In extreme cases, this can lead to the breakdown of a nation's monetary system. One of the most notable examples of hyperinflation occurred in Germany in 1923, when prices rose 2,500% in one month!
- Stagflation is the combination of high unemployment and economic stagnation with inflation. This happened in industrialized countries during the 1970s, when a bad economy was combined with OPEC raising oil prices.

Changes in the level of inflation will change the value of money and goods that means that all prices and costs comes from the estimating process are changeable so when it is not taken in in consideration it will counter great losses and over costs.

Archaeological remains

Ancient man-made objects, structures, or ancient burials that have been preserved on the earth’s surface, underground, or underwater and serve as the objects of archaeological study. Archaeological remains are the material historical sources that make it possible to reconstruct the past history of human society, including mankind’s prehistory. Basic archaeological remains include work tools, weapons, domestic utensils, clothing, and ornaments; settlements including campsites, fortified and unfortified settlements, and separate dwellings; ancient fortifications; the remains of ancient hydraulic structures; ancient agricultural fields; roads; mining pits and workshops; ancient burial grounds and various burial and religious structures (stelae, stone figurines, stone fish monoliths (vishaps), menhirs, cromlechs, dolmens, sanctuaries); drawings and inscriptions carved into individual stones and cliffs; and architectural monuments. Archaeological remains also include ancient ships and their cargoes that sank in rivers and seas and settlements that came to be underwater as a result of shifts in the earth’s crust.

All what we care about in these types of remains is the structures, ancient structure can be categorized under two main types:

1- Useless and abandoned structure remains of a regular building and the only problems that we have with this type is destruction and the removal of the remains which takes time and cash.
2- Archaeological building and the issue of this type in its historical value that prevent from removal and destruction and could cause of project site modification and in some cases the change of the whole project place.

Changes in interest rates

Interest rate is the amount charged, expressed as a percentage of principal, by a lender to a borrower for the use of assets. Interest rates are typically noted on an annual basis, known as the annual percentage rate (APR). The assets borrowed could include, cash, consumer goods, large assets, such as a vehicle or building. Interest is essentially a rental, or leasing charge to the borrower, for the asset's use. In the case of a large asset, like a vehicle or building, the interest rate is sometimes known as the “lease rate”.

When the borrower is a low risk party, they will usually be charged a low interest rate; if the borrower is considered high risk, the interest rate that they are charged will be higher.

The changes in the interest rate affect the construction industry, when it increases the attraction to investment decreases so the government try to hold it still.

The increase in the interest rate could affect the contractor by many ways

- If he depends on an external financing resource that mean that the interest on the loan will be higher than expected and calculated then the increase in interest will cut off from the profit margin.
- Could affect the sub-contractor and cause a bankruptcy which causes the stopping of work then increasing time and cost.
- Increasing the trade credit finance which increase cost so cash out flow, cash inflow and net cash flow

Provision for fluctuation payments

The agreement of any sudden payment that was demanded in time was not agreed according to contract.

Delays in payments from client

Delays in payments from client are a major issue. It causes a shifting the cash inflow profile and as consequences It will change the net cash profile which will differ from expected profile and surprise the manger with a new one that he cannot handle or over the contractor capabilities.

Listed buildings

A listed building is a building that has been placed on the Statutory List of Buildings of Special Architectural or Historic Interest. It is a widely used status, applied to around half a million buildings. A listed building may not be demolished, extended or altered without special permission from the local planning authority (which typically consults the relevant central government agency, particularly for significant alterations to the more notable listed buildings). Exemption from secular listed building control is provided for some buildings in current use for worship but only in cases where the relevant religious organization operates its own equivalent permissions procedure. Owners of listed buildings are, in some circumstances, compelled to repair and maintain them and can face criminal prosecution if they fail to do so or if they perform unauthorized alterations.

Penalty due to the violation of authority regulation and rules

Any fine or cash have been forced due to the violation of regulation rules and environmental regulation

Strikes

Any activity depends on human resources stop working due to strikes to ask for demands or more rights and advantages like salary increase, more secure etc.

Material Delay

The delay of the construction material that affect the project and cause delay in the project duration and sometimes it can cause a fine which will affect the cash flow.

Rework due to error in execution

Sometime a misunderstanding in drawings or specification can cause a false job or unqualified item so a rework will take place with their extra cost and time.

Equipment breakdown

The breakdown of the equipment that affect the project and cause delay in the project duration and sometimes it can cause a fine which will affect the cash flow.

Bankruptcy of subcontractor

The subcontractor is an important party in construction industry. When the subcontractor has a bankruptcy that means he is no longer working on his job .the problem that the general contractors lost the cash paid to the subcontractor and have to assign the job to another one which cause a loss in cash and time.

Provision for fluctuation payments

The fluctuation of the cash deposits from the client is a major issue. When the cash in payment time changes from the original plan of the contractor cash flow. It can cause gab in the cash flow profile that have a consequences on the net cash flow profile and the max negative cash flow. In some cases the contractor cannot handle this max causing a suspend on the project activities and sometime a bankruptcy.

Changes in currency exchange rates

The changes on the exchange rate of the foreign currency and the instability of their exchange rates that causes the instability, mainly price increase on some of materials, for an example Reinforcement steel.

2.4 Summary and Conclusions

This chapter presents the reviews of cash flow models with their corresponding risk factors. The traditional cash flow prediction method of using ideal curves was presented with their examples and disadvantage. The idiographic-nomothetic debate was presented also. It was found that the nomothetic methods have major disadvantage that the construction project is a unique so even in the same category each project has its unique cash flow profile. The idiographic method was much better and less errors because it take in consideration variability between the projects. The probabilistic approach was also presented as it’s the new trend and more rational as the cost and duration of activities have a variable behavior.

The cash flow risk factors were represented as well. Risk factors were collected from previous researches, it was found to be twenty seven different factors. The assessment of these risk factors with consideration to frequency and impact will be conducted in the next chapter.

CHAPTER 3

FIELD SURVEY FOR CASH FLOW RISK FACTORS

3.1 Introduction

This chapter illustrates the procedures of the survey that aims to identify the most important risk factors that are expected to affect the construction project cash flow in Egypt. A questionnaire survey was conducted among three main parties in construction industry; Client, Consultant and Contractor to identify the probable risk factors that have the greatest impact on the construction project cash flow. Such questionnaire survey is based on the risk factors that were previously identified in the previous literature review.

3.2 Cash Flow Risk Factors

As discussed in the literature review, it was found that twenty seven risk factors are expected to affect the cash flow prediction. Those factors may vary greatly in their frequency and impact on the cash flow. Some factors may be highly frequent but may have a low impact; for an example "Retention", while others are expected to rarely happen but they can have a great impact; among those is "Estimating Error". So, in order to identify the most important factors that have the highest effect in the project cash flow, it was essential to investigate the opinions of the main participants involved in construction projects.

3.2.1 Questionnaire Design.

The questionnaire was designed to test the characteristic of the risk factor frequency and impact. The two characteristics were tested on 5 point scale. For frequency the digit 1 means rarely happened and 5 means commonly happened. Moreover, for impact the digit 1 means very low impact and 5 means high impact. Each respondent has to assess all factors on both characteristic. He can also add any risk factors that he may see not included in the survey.

The questionnaire consists of twenty seven risk factors that were previously identified. These factors were gathered through literature review. A part of these factors can affect the cash out profile as problem with foundation, accidents, strikes etc. on the other side, factors can affect the cash in profile as agreeing interim valuation on site, delay in agreeing variation and delay in settling claims.

The survey covers the three main parties of construction projects, contractor, client and consultant. The survey was focusing on the contractor category because it is the most affected with the consequences of those risk factors on the cash flow profile. A sample of this questionnaire is shown in appendix A.

3.2.2 Sample Size Selection.

The size of the sample required from the population was determined based on statistical principles for this type of exploratory investigation to reflect a confidence level of 99%. The sample size was determined using the following equation (Dutta 2006 cited in (El Abbasy, 2008)):

$$N = \frac{(Z_{1-\alpha})^2 \times \sigma^2}{e^2} \qquad \text{……………………………………………………………..….. (3.1)}$$

Where: N is the sample size, $Z_{1-\alpha}$ is the desired level of confidence (1-α), which determines the critical Z value, σ is the standard deviation, and e is the acceptable sampling error.

For this research, the 99% degree confidence level corresponds to α= 0.01. Each of the shaded tails shown in the standard normal distribution curve (Fig. 3.1) has an area of α/2 = 0.005. The region is 0.5 – 0.005 = 0.495. Then, from the table of the standard normal distribution (*z*), an area of 0.495 corresponds to a *z* value of 2.58. The critical value is therefore $Z_{1-\alpha}$ = 2.58, the margin of error was assumed as *e* = 0.20, and from a 20 random samples, the standard deviation was calculated; σ = 0.57. Accordingly, the sample size is calculated as follows:

$$N = \frac{2.58^2 \times 0.57^2}{0.2^2} = 54$$

Substituting the values in equation (3.1) above, the sample size is calculated to be 54. This means that the minimum sample required is 54 from the population to reach 99% confidence level.

In order to assess the perception of the risk factors involved in the cash flow forecast, a structured questionnaire was designed. The questionnaire was administered through a postal survey, E-mail and direct interview with a total of 200 participant of building projects companies. A total of 60 respondents returned their questionnaires duly completed. This represents about 30% response rate which is compatible with prevailing, about 20-30%, response rate in most postal questionnaire survey of the construction industry (Akintoye, A. And Fitzgerald, E, 2000)

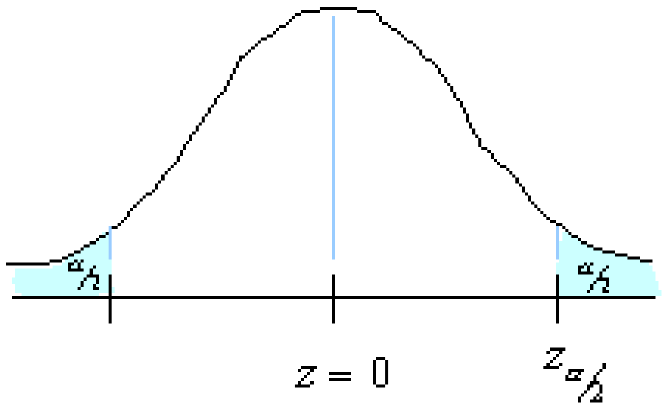

Figure 3.1: Standard Normal Distribution Curve

3.3 Respondents Classifications

Figure 3.2 shows the classification of the sixty respondents according to their party. It was found to have 30 contractors, 20 consultants and 10 owners. It is obvious that owners representative are the least participant to respond to the survey that's because they did not understand the survey due to the non-construction knowledge or they may not concerned in the survey and seeing that the whole issue without any advantage and useless. Another reason that they all don't know the most of our risk factors in the survey and not familiar with. on the other side contractors were the most helpful and the most participant in the survey and that's why they know the problem, familiar with it and with all the risk factors in the survey and they are the most affected party.

Figures (3.3), (3.4), (3.5) illustrate the distribution of respondents with the respect to sector property, Average annual work load and previous experience in construction industry respectively.

Figure: 3.3 illustrate represents the classification of the respondents with respect to sector property. It shows that high difference between the public sector and private sector participation. That is due to difference between the number of public and private organizations. Other reason that the ease of access and response of the employers in the private sector than others in the public sector.

Figure 3.4 illustrates the average annual work load of respondents' organization.

Figure 3-5 illustrates the previous experience in construction that respondents have. It's obvious that almost half of the participants in the category of 1-5 years' experience.

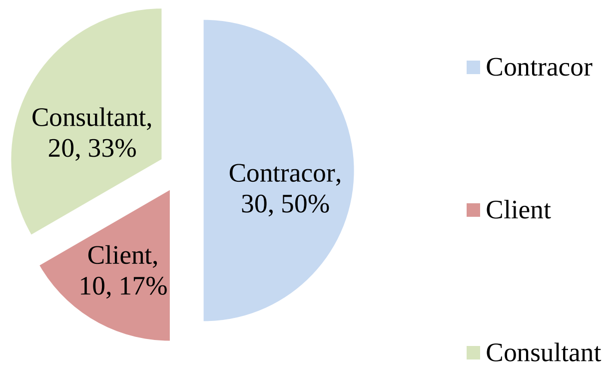

Figure 3.2: Classification of Respondents According to Their Party Type.

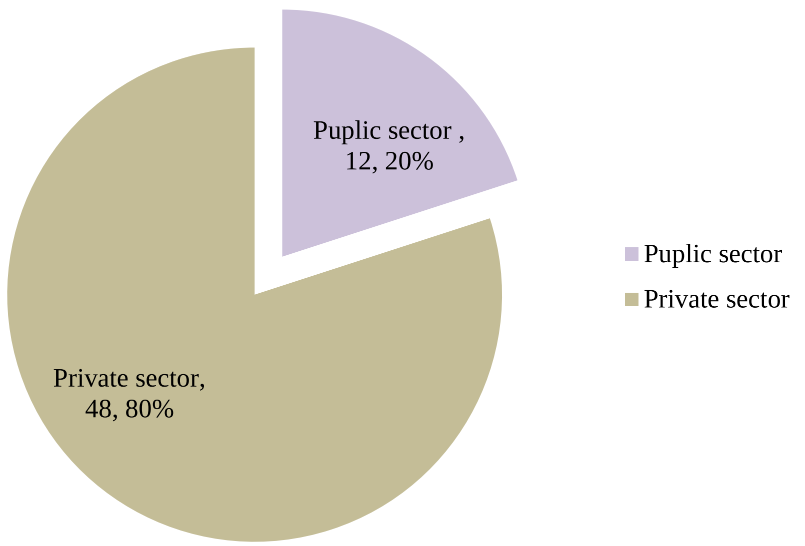

Figure 3.3: Classification of Respondents According to Sector Property.

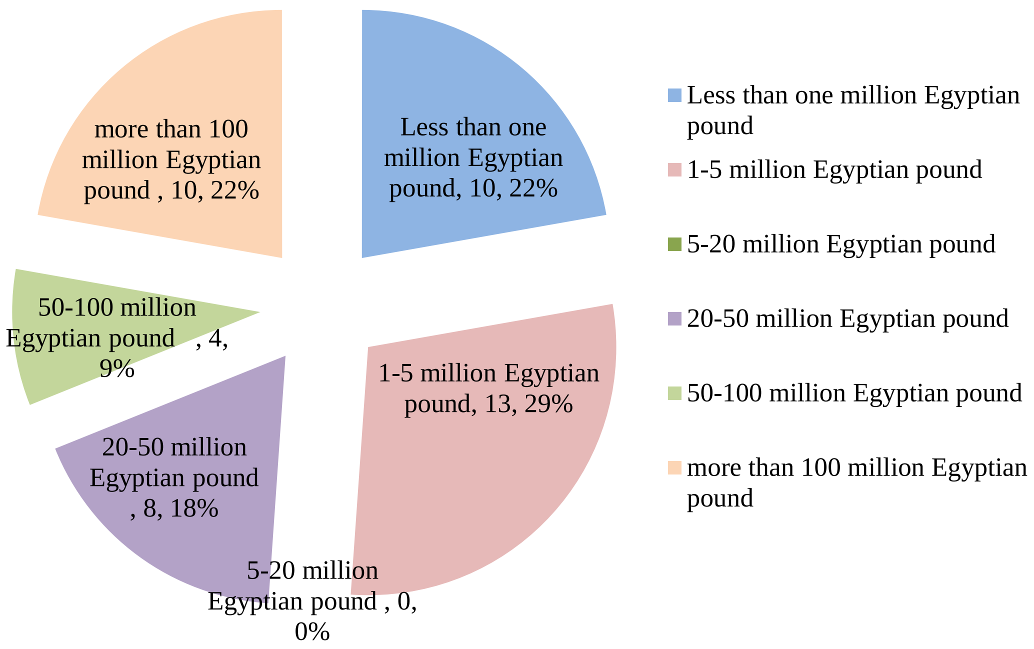

Figure 3.4: Classification of Respondents According to Annual Work Volume of Their Organization.

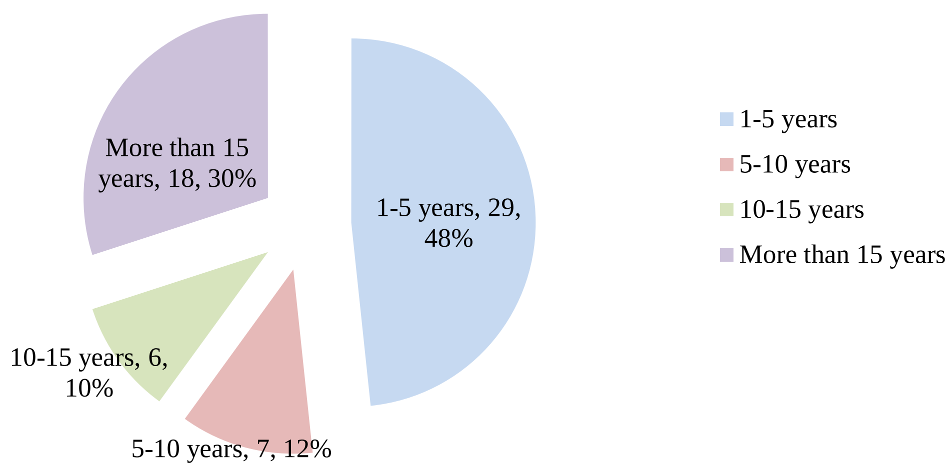

Figure 3.5: Classification of Respondents According Their Experience in Construction.

3.3.1 Calculation and Ranking Risk Factors

After receiving questionnaires from respondents the next step is to calculate the relative importance of each of the twenty seven risk factors. First the score of each factor will be calculated by multiplying the frequency with the impact weight. The impact weight will be 1 for 5 point, 0.8 for 4 points, 0.6 for 3 points, 0.4 for 2 points and 0.2 for 1 point so the score of each risk factor will be calculated from the following equation:

SCf=Ff xI Wf ……………………….……………………………………. (3.2)

Total SCf=∑ Ff x IWf ……………………..………………………………. .(3.3)

Where

SCf is the factor score

Ff is the frequency score for the corresponding factor

IWf is the impact weight for the corresponding factor

Total SCf is the total factor score

By assigning this equation all factors scoring have been calculated

Table 3.1: Results of Risk Factors Affecting Net Cash Flow

Factor	Total Score
Problems with the foundations	95.2
Listed buildings	93
Archaeological remains	78.2
Inclement weather	89.6
Accidents & theft	119
Extent of float in contract schedule	132.2
Receiving interim certificates	158.6
Retention	123
Delays in payments from client	153
Provision for fluctuation payments	137.2

Table 3.1: Results of Risk Factors Affecting the Net Cash Flow (Continued)

Factor	Total Score
Changes in currency exchange rates	113.4
Strikes	109
Level of inflation	116.4
Changes in interest rates	67.2
Estimating error	117.6
Penalty due to the violation of Authority regulation and rules	94.2
Provision for interim certificate	129.4
Material delay	125.2
Error in execution & rework	95.2
Equipment breakdown	99.2
Bankruptcy of subcontractor	83.8
Tender unbalancing	94.6
Consultant’s Instructions	149.8
Agreeing interim valuations on site	171
Delay in agreeing variation	140.4
Delay in settling claims	133.8
Provisions for phased handover	147.4

The max score is calculated as illustrated above by applying equation 3.4. The total score for the factors were calculated (Table 3.1). Factors are arranged in descending order (as shown in Table 3.2) according to their Importance index. Such index is calculated by dividing the total score of each factor by the available max score. This max score can be calculated as:

The max score = max frequency x max impact weight x No of respondents …. (3.4)

The max score = 5 x 1 x 60 = 300 points.

Table 3.2: Ranked Risk Factors Affecting Net Cash Flow (Overall Ranking)

Factor	Total Score	Importance Index
Agreeing interim valuations on site	171	57.0%
Receiving interim certificates	158.6	52.9%
Delays in payments from client	153	51.0%
Consultant's Instructions	149.8	49.9%
Provisions for phased handover	147.4	49.1%
Delay in agreeing variation	140.4	46.8%
Provision for fluctuation payments	137.2	45.7%
Delay in settling claims	133.8	44.6%
Extent of float in contract schedule	132.2	44.1%
Provision for interim certificate	129.4	43.1%
Material delay	125.2	41.7%
Retention	123	41.0%
Accidents & theft	119	39.7%
Estimating errors	117.6	39.2%
Level of inflation	116.4	38.8%
Changes in currency exchange rates	113.4	37.8%
Strikes	109	36.3%
Equipment breakdown	99.2	33.1%
Problems with the foundations	95.2	31.7%

Table 3.2: Ranked Risk Factors Affecting the Net Cash Flow (Overall Ranking) (Continued)

Factor	Total Score	Importance Index
Error in execution & rework	95.2	31.7%
Tender unbalancing	94.6	31.5%
Penalty due to the violation of Authority regulation and rules	94.2	31.4%
Listed buildings	93	31.0%
Inclement weather	89.6	29.9%
Bankruptcy of subcontractor	83.8	27.9%
Archaeological remains	78.2	26.1%
Changes in interest rates	67.2	22.4%

From Table 3.3 it was seen that the ranking of the risk factors with the respect to work respondent's categorization. For an example the factor "level of inflation" has an approximately agreement from the three parties for example, it ranked 14th overall while it ranked 13th, 15th and 15th for contractor, consultant and Owner respectively. "Changes in interest rates**"** has a totally agreement to elaborate more, it ranked 27th overall while it ranked 27th, 27th and 27th for contractor, consultant and owner respectively. On the other side, other factors as "material delay" ranked 7th overall while it ranked 14th, 8th and 10th for contractor, consultant and owner respectively. It's obvious that the judging differs from party to party depends on factor and how this party familiar with and how it affect from their point of view.

Four risk factors were found to have near importance index, delay in agreeing variation, accidents & theft, inclement weather and changes in interest rates. Those risk factors have nearly the same importance index among contractor, consultant and owner which indicates that they have the same influence from their point of view.

Thereafter, it was supposed to decide which of the twenty seven factors to be taken into consideration in the prediction of the cash flow. The percentages obtained for each factor shown in Table 3.2 were summed and divided by the number of factors to determine the average percentage (A_p) of the factors. Then, the percentage of each factor was compared with the average percentage. Factors with percentages more than or equal to the average percentage were considered as an important factor, while the others were not considered. The average percentage is determined as follows:

A_p=(57+53+51+50+49+47+46+45+44+43+42+41+40+39+39+38+36+33+32+32+ 32+31+31+30+28+26+22) / 27 = 39.2 %

Therefore, factors with percentage more than or equal 39.2% were important. Table 3.4 shows the most important factors that will be taken into consideration.

Table 3.4 presents the most important factor with their total score and importance index. These 14 factors that were found to be the most importance factors that affect the cash flow analysis according to their importance index. It was found that the highest importance index factor is related to the relation between consultant and contractor.

Table 3.3: Ranking of Risk Factors Affecting Net Cash Flow (Respondents Categories)

Risk Factor	Overall%	Overall Rank	Contractor%	Contractor rank	Consultant%	Consultant rank	Owner %	owner Rank
Problems with the foundations	31.7%	19	27.9%	24	36.8%	17	33.2%	20
Listed buildings	31.0%	23	27.1%	25	40.2%	12	24.4%	26
Archaeological remains	26.1%	26	27.1%	26	22.6%	26	30.0%	24
Inclement weather	29.9%	24	31.5%	19	27.8%	23	29.2%	25
Accidents & theft	39.7%	13	39.6%	11	38.8%	13	41.6%	11
Extent of float in contract schedule	44.1%	9	41.2%	9	41.6%	11	57.6%	3
Receiving interim certificates	52.9%	2	59.7%	1	45.8%	7	46.4%	9
Retention	41.0%	12	39.3%	12	36.8%	16	54.4%	4
Delays in payments from client	51.0%	3	47.3%	6	53.0%	4	58.0%	2
Provision for fluctuation payments	45.7%	7	36.9%	15	57.4%	2	48.8%	8
Changes in currency exchange rates	37.8%	16	40.9%	10	34.6%	19	34.8%	19
Strikes	36.3%	17	29.6%	20	38.6%	14	52.0%	6
Level of inflation	38.8%	15	38.9%	13	38.2%	15	39.6%	15

Table 3.3: Ranking of Risk Factors Affecting Net Cash Flow Respondents Categories (Continued)

Changes in interest rates	22.4%	27	23.2%	27	22.0%	27	20.8%	27
Estimating error	39.2%	14	35.1%	17	35.2%	18	59.6%	1
Penalty due to the violation of Authority regulation and rules	31.4%	22	29.1%	22	30.2%	21	40.8%	12
Provision for interim certificate	43.1%	10	47.6%	5	42.4%	10	31.2%	23
Material delay	41.7%	11	38.3%	14	44.6%	8	46.4%	10
Error in execution & rework	31.7%	20	34.1%	18	26.2%	24	35.6%	17
Equipment breakdown	33.1%	18	35.9%	16	28.8%	22	33.2%	21
Bankruptcy of subcontractor	27.9%	25	29.6%	21	22.8%	25	33.2%	22
Tender unbalancing	31.5%	21	29.1%	23	30.6%	20	40.8%	13
Consultant’s Instructions	49.9%	4	49.9%	4	57.4%	3	35.2%	18
Agreeing interim valuations on site	57.0%	1	54.27%	2	62.80%	1	53.60%	5
Delay in agreeing variation	46.8%	6	46.93%	7	44.40%	9	51.20%	7
Delay in settling claims	44.6%	8	42.00%	8	50.60%	5	40.40%	14
Provisions for phased handover	49.1%	5	51.73%	3	50.20%	6	39.20%	16

Table 3.4: The Most Important Factors Affecting Net Cash Flow

Factor	Total Score	%
Agreeing interim valuations on	171	57.0%
Receiving interim certificates	158.6	52.9%
Delays in payments from client	153	51.0%
Consultant's Instructions	149.8	49.9%
Provisions for phased handover	147.4	49.1%
Delay in agreeing variation	140.4	46.8%
Provision for fluctuation payments	137.2	45.7%
Delay in settling claims	133.8	44.6%
Extent of float in contract	132.2	44.1%
Provision for interim certificate	129.4	43.1%
Material delay	125.2	41.7%
Retention	123	41.0%
Accidents & theft	119	39.7%
Estimating error	117.6	39.2%

3.4 Summary and Conclusion

In this chapter fourteen risk factors from twenty seven risk factors were identified to be the most important factors affecting the project-level cash flow. This step was chosen based on the opinions of sixty respondents throughout a questionnaire survey. These factors were agreeing interim valuations on site, receiving interim certificates, delays in payments from client, consultant's Instructions, provisions for phased handover, delay in agreeing variation, provision for fluctuation payments, delay in settling claims, and extent of float in contract schedule, provision for interim certificate, material delay, retention, Accidents & theft and Estimating error.

Later on the next chapters it is planned to incorporate the effect of these factors in the project cash flow through a probabilistic cash flow model.

CHAPTER 4

PROBABILISTIC CASH FLOW RISK MODEL

4.1 Introduction

This chapter explains the incorporation of the previously identified risk factors into construction project cash flow. In this chapter the effect of these factors on the different cash flow elements will be investigated. Among these elements are cash out, cash in, net cash flow and cost of finance. This will be through the development of a probabilistic model for cash flow prediction.

4.2 Structure of the Model

In this chapter two commercial software will be utilized, which are commonly used in the construction industry; "primavera p6 professional p6.1" and "primavera risk analysis". The first one is used as a planning and scheduling tool while the second is used as a risk management tool. The first software provides the planner with simple data entry of the activities; dependencies, relationships, duration…etc. This software performs CPM calculations on the project as well as representing the project schedule in the form of a bar chart and network diagrams. The second software allows modeling more complex calculation using VBA (Visual Basic in Application) by implementing the risk factors on the cash out only so we will not be able to implement the risk factors upon the cash in profile. Consequently, a separate model will be developed to incorporate the effect of these risk factors in the cash in profile. Microsoft Excel was used to complete our modeling system outputs by generating cash in, net cash flow and overdraft profiles.

4.3 Implementation Details

The implementation mechanism consists of three stages (Fig 4.1). The first stage is the planning and scheduling which is performed by one of the planning programs as primavera p6, Microsoft project 2010 and etc. (in this research primavera p6 is used for its wide commercial use). The second stage is the implementation of risk factors to the cash out. This stage is performed by using any risk analysis simulation program as primavera risk analysis, @risk, etc. to get probabilistic cash out. In this research primavera risk analysis was used as it is the highly skilled and powerful software and finally it's more compatible with the primavera p6. The third stage is to develop cash in model through an excel-macro sheet to get probabilistic cash in, net cash flow and the overdraft calculation.

The first stage inputs are the project activities with their dependencies, relationships, duration, resources and costs to get the project total duration and cost as cash out S curve. At this stage the project is broken down into activities with their dependencies, after that cost estimate should be done to determine different type of resources identified by cost and quantity with the project assignment to the activities. Resource assignment should be assigned with respect to time cost and performance. Figure 4.2 and Fig 4.3 illustrate the whole stage.

The second stage is the implementation of the previously identified risk factors on the cash flow curve results from the previous stage to get a probabilistic cash out. In this stage, the primavera risk analysis is used. The first step in this stage is to import the project files from primavera P6 with all its data. Then to build risk register of the classified risk factors that have been mentioned previously with their impact and probability. These impact and probability were calculated based on the results of the previous questionnaire survey (Table 4.1).

Table 4.1: Average Probability and Impact for Selected Risk Factors

No	Factor	Frequency	Impact
1	Accidents & theft	Medium	Medium
2	Extent of float in contract schedule	Medium	High
3	Receiving interim certificates	Medium	High
4	Retention	Medium	Medium
5	Delays in payments from client	High	High
6	Provision for fluctuation payments	Medium	High
7	Estimating error	Medium	High
8	Provision for interim certificate	Medium	Medium
9	Material delay	Medium	High
10	Consultant’s Instructions	Medium	High
11	Agreeing interim valuations on site	High	High
12	Delay in agreeing variation	Medium	High
13	Delay in settling claims	Medium	High
14	Provisions for phased handover	High	High

According to Fig 4.1, the third stage using the cash in model developed using the Microsoft excel macro sheet to calculate the cash in, net cash flow and overdraft calculations and simulate their curves.

In the designed macro sheet the inputs are the probabilistic cash out data and the desirable percentage of markup, overheads, down payment and the monthly interest rate then these inputs goes throw the mathematical model equations in the macro sheet. The equations are illustrated below:

$Pt = Ct *(1+M)*(1-R)$ ………………………………………………………….. (4.1)

Where,

Pt Cash in at time “t”

Ct Cash out at time “t”

M Markup percentage

R Retention Percentage

NSTCHt(1) = $\sum_{i=1}^{t} Ci - \sum_{i=1}^{t-1} Pi + \sum_{i=1}^{t-1} FCt$ ……………………………………………………… (4.2)

NSTCHt(2) = NSTCHt(1) - Pt ……………………………………………….…………… (4.3)

FCt = NSTCHt(1) * i

Where,

NSTCHt(1) Net cash flow at time "t", just before last payment

NSTCHt(2) Net cash flow at time "t", just after last payment

FCt Cost of finance at time "t"

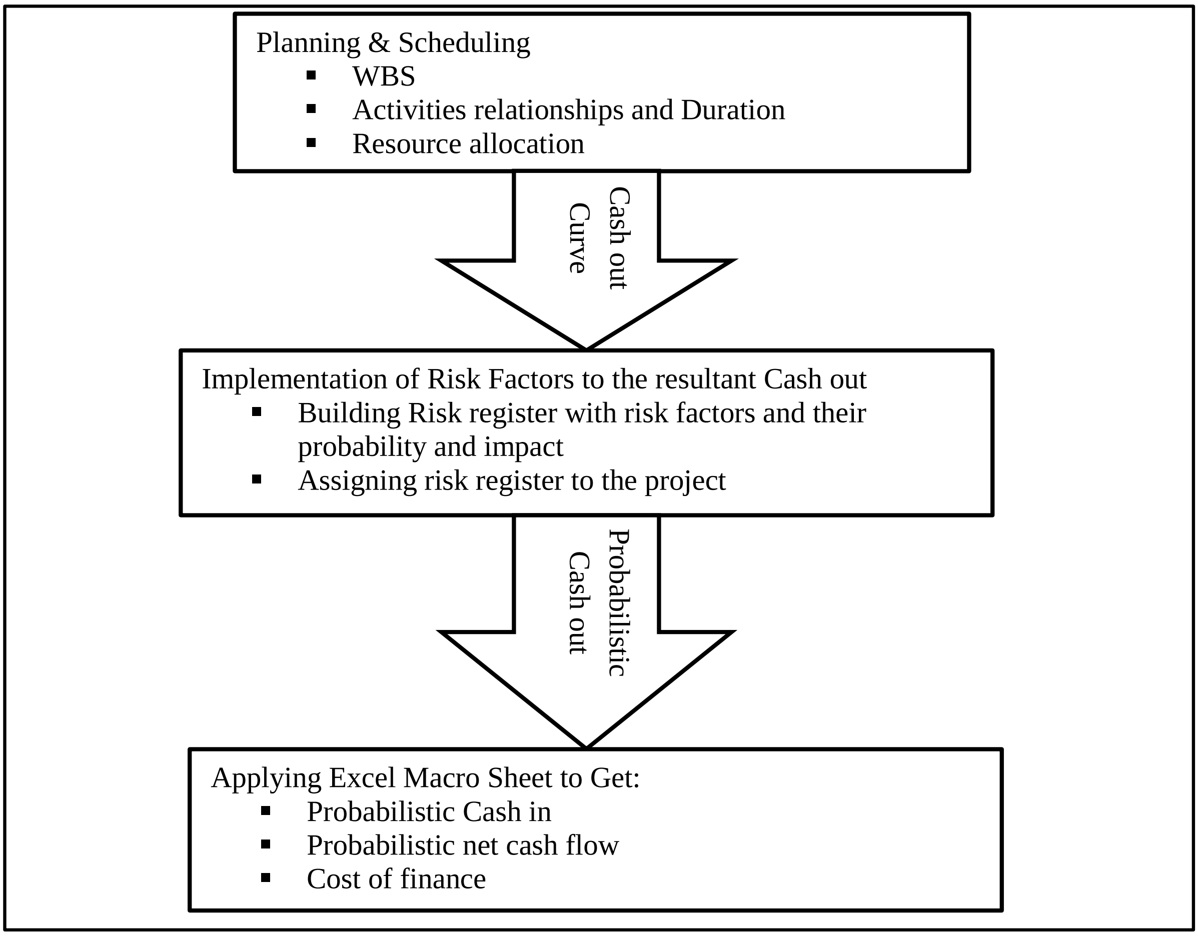

Figure 4.1: Risk Model Stages

After running the macro sheet designed with the previous mathematical model, the output data probabilistic cash in, probabilistic net cash flow and cost of finance are generated with a schedule graphical representation.

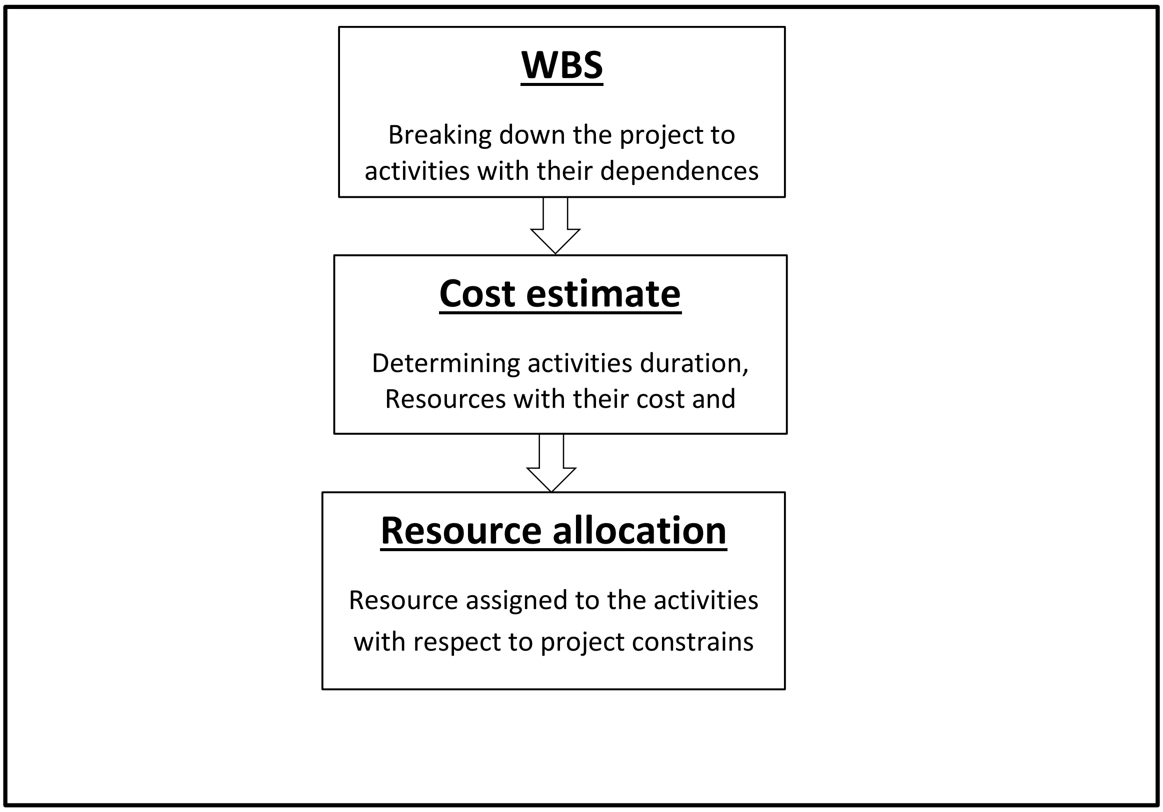

Figure 4.2: Planning and Scheduling Stage

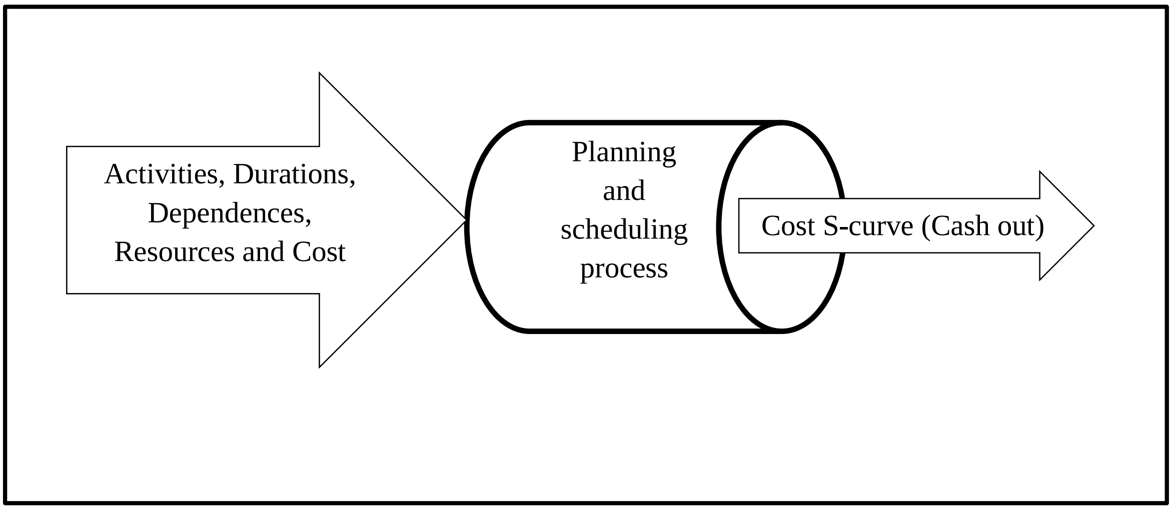

Figure 4.3: Inputs and Outputs in Planning and Scheduling Stage

4.4 Example for Model Testing and Verification

In order to examine the proposed system and test its capabilities to model probabilistic cash flow, an example project a building extension consisting of eleven activities was used. .Table 4.2 illustrates the project data.

Table 4.2: Activities Relationship, Cost and Duration

Activity ID	Activity Name	Predecessor	Cost	Duration
A1000	Site excavation	None	114800	10
A1010	PC-Foundation	A1000	200850	2
A1020	First Stage Isolation	A1010	214720	8
A1030	Second Stage Isolation	A1020 &A1060	80427	14
A1040	RC-Foundation	A1020	639955	22
A1050	RC-RW & Col Level 1	A1010	394460	18
A1060	RC-Slab - Level 1	A1050	395395	18
A1070	RC-RW & Col Level 2	A1030	394460	18
A1080	RC-Slab - Level 2	A1070	395395	18
A1090	Backfilling	A1080	19710	7
A1100	poly Sheets with 5cm PC	A1090	71070	5

The project has been worked out with primavera p6 at the first stage and was found to have an estimated cost of 2,921,242 EGP and a duration of 180 days or 6 months.

The second stage started with exporting project data to primavera risk analysis and start with building risk register for the project. Risk register uses the previously identified risk factors with their corresponding probability and impact that has been previously determined based on the questionnaire survey.

Then such risk factors were assigned to the corresponding activity. This process was done by experience of the top management head or by a brain storming sessions with the management team. After that risk analysis was used with the desired number of iterations. The output data from this software is probabilistic date with respect time and cost. Figure 4.4 to 4.6 illustrate the program outcome in the form of probability distribution. The graphs illustrate the number of iteration hits for each probability.

Figure 4.4 shows the project duration was found to be 180, 287 and 355 days at corresponding probabilities of 0%, 50 %, and 100% respectively while Figure 4.5 Cost shows the project cost for a probability of 0%, 50 %, and 100% to be 2,921,242EP, 4,720,617EP and 6, 926,010EP respectively.

Figure 4.7 represents the probabilistic cash out for the project with probability 0%, 50 %, 100% (For Both cost and time) as 2,921,242EP, 4,720,617EP and 6,926,010EP respectively and 180,287 and 355 days respectively. From this figure, it's obvious that the mean value of this probabilistic cash out is in the same line with the deterministic value but with an increase in cost and time which really happen in the real life project. This project has been executed and finished before this study, so the final cost and time data are available. The project has been completed in 350 days and with actual cost of 3,005,440 EGP. The corresponding probability for this duration and cost is 97% and 2% respectively.

The bars in Figures 4.4 to 4.6 illustrate the number of iteration that give this probability. As in Figure 4.4 the corresponding number of iteration for probability 50% is 130 iteration.

It's logic for duration to be with this value as the most of construction projects are completed after their scheduled time, but contractor is very interested in the cost control so the cost overrun may not be more than 5% .

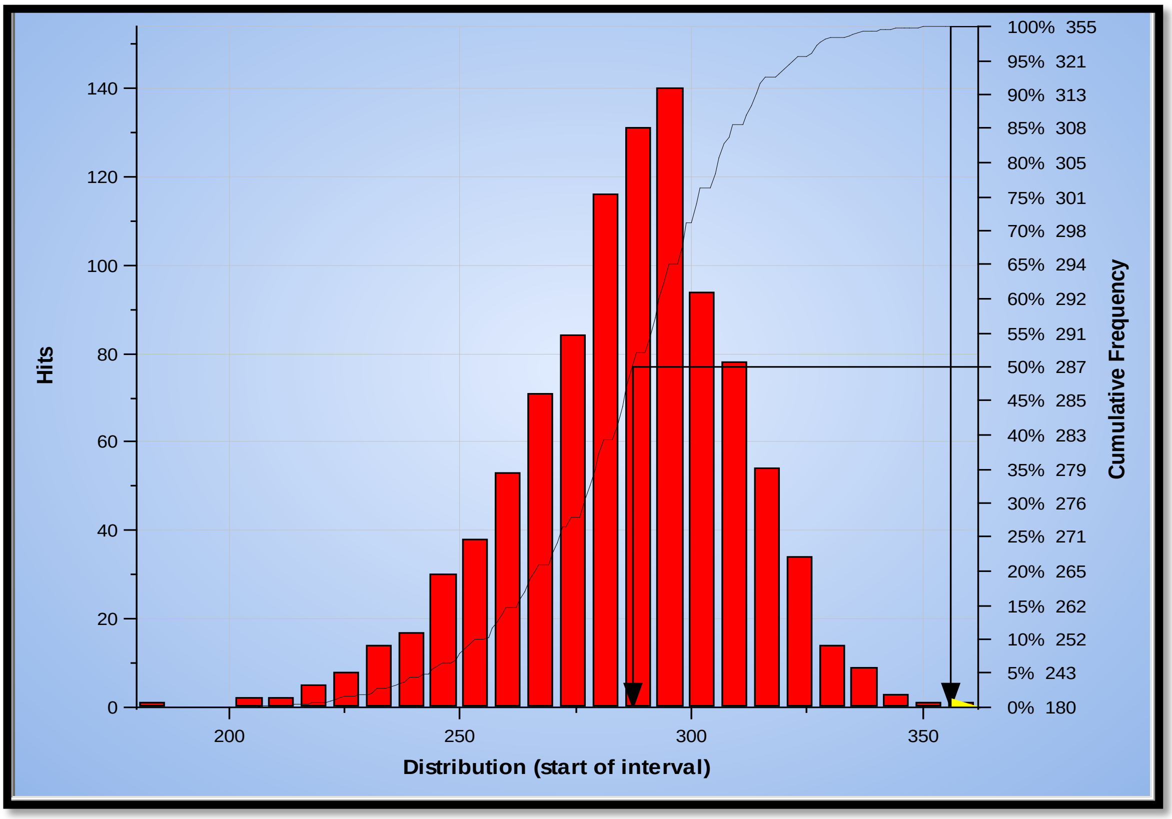

Figure 4.4: Duration Probability Distribution

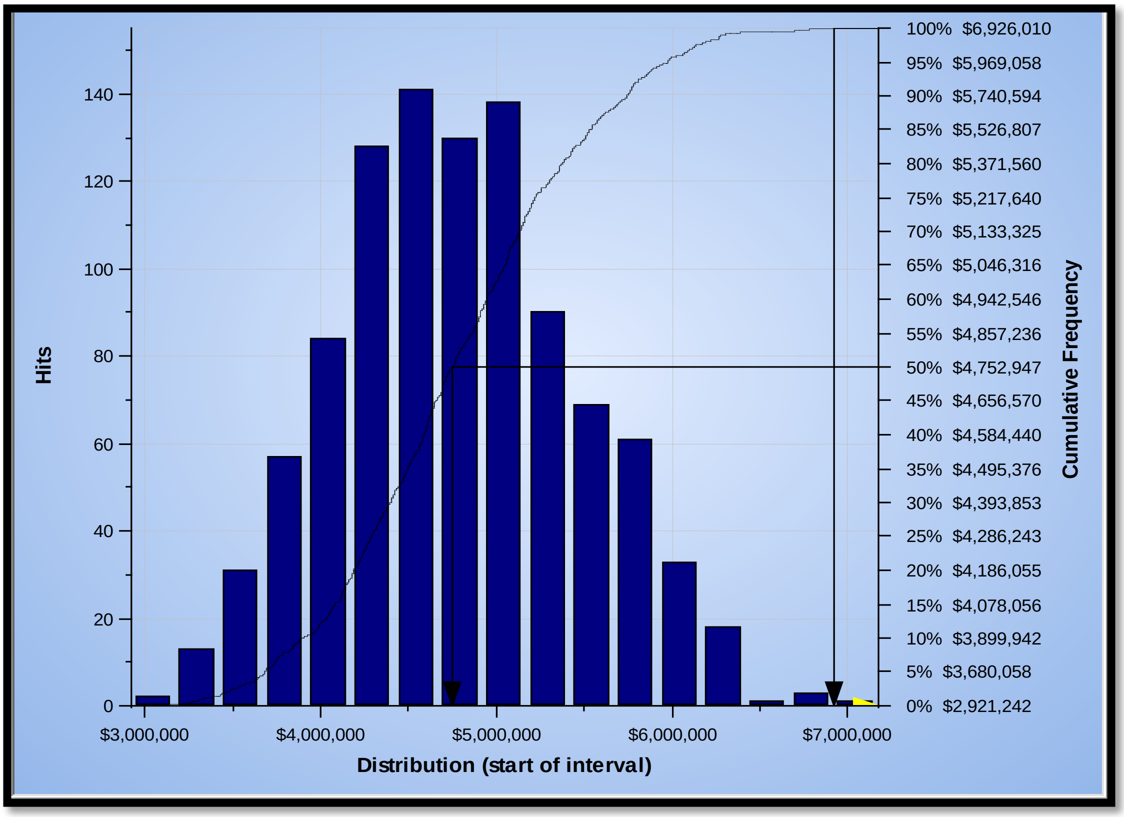

Figure 4.5: Cost Probability Distribution

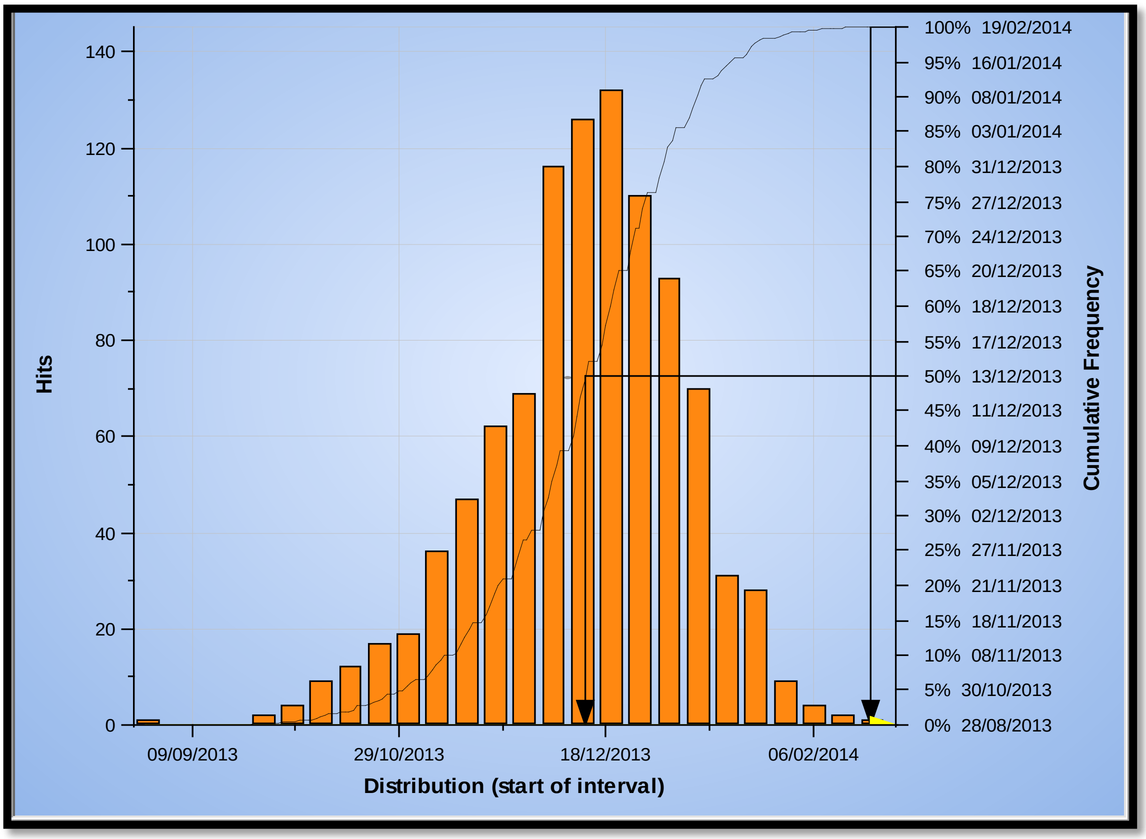

Figure 4.6: Finish Date Probability Distribution

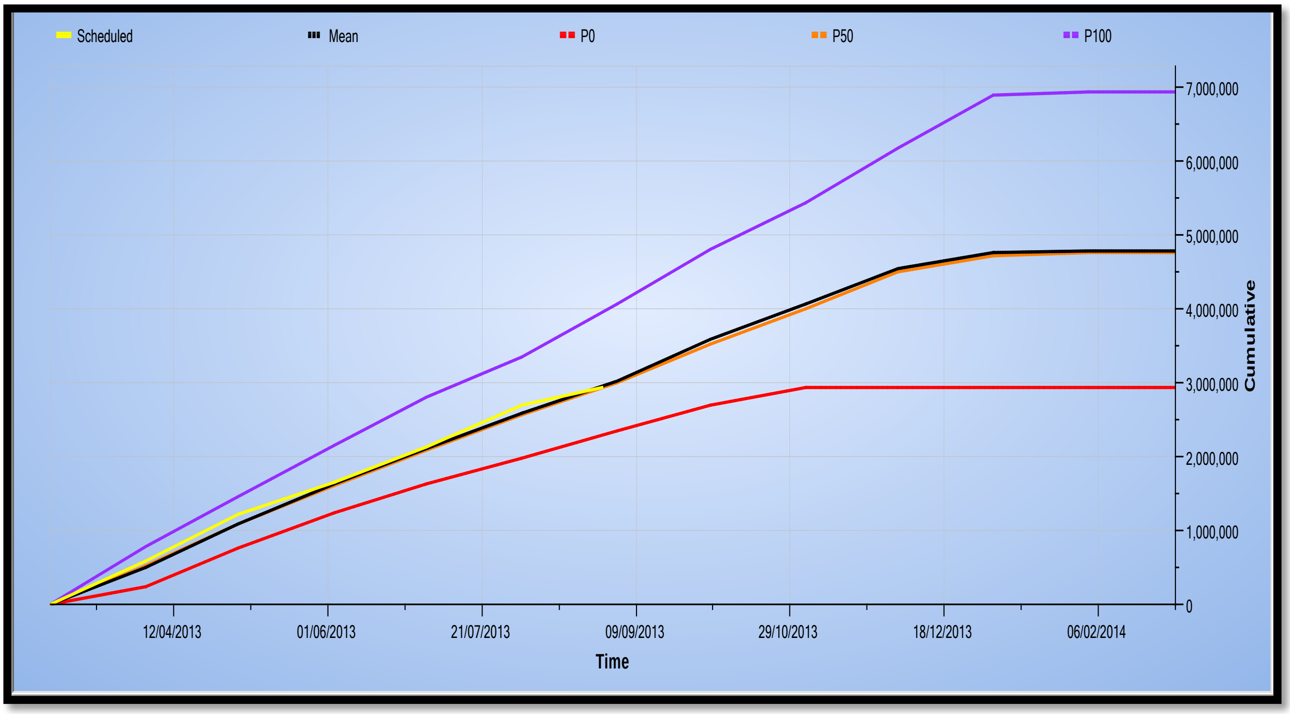

Figure 4.7: Probabilistic Cash Out

The third and last stage of this system is the cash in model that have been developed through the excel macro sheet which will calculate the cash in, net cash flow and the overdraft calculations. Microsoft excel was used as a tool of getting such calculations outputs and for graphical representation.

The input of this stage is the output from the previous stage, probabilistic cash out (Table 4.3)and some other variables as markup, monthly interest value, percentage of down payment (if any) and retention. From the probabilistic cash out we get monthly cost then it goes through the designed mathematical model.

Table 4.3: Monthly Cost Probability Distribution

Month	P0	P50	P100
0	0	0	0
1	243006	511841	773315
2	511259	575104	670904
3	481055	529764	705342
4	395955	460034	658583
5	354807	480382	528858
6	360197	439109	726799
7	352732	530286	741898
8	222231	477078	624255
9	0	498992	745385
10	0	218027	702201
11	0	0	48470

This mathematical model used to calculate the monthly cash in and the net cash flow. The model can also used to calculate the overdraft values as well as the corresponding finance cost if there is any external source of finance.

To calculate the cash in of this example application some assumption should be made. Such variables mainly include

Markup = 20%, Retention = 10%, Down payment=10%, Monthly interest rate = 1%

The calculated monthly cash in is shown in Table 4.4.

Table 4.4: Cash in Probability Distribution

Month	P0	P50	P100
0	350,549	566,474	831,121
1	0	0	0
2	233,286	491,367	742,382
3	490,809	552,100	644,068
4	461,813	508,573	677,128
5	380,117	441,633	632,240
6	340,615	461,167	507,704
7	345,789	421,545	697,727
8	338,623	509,075	712,222
9	563,891	457,995	599,285
10		479,032	715,570
11		775,780	674,113
12			877,652

Then the next step is to calculate the overdraft requirement for various probability values with a monthly interest assumption of 1% in (Tables 4.5 to 4.7).

Table 4.5: Overdraft Calculation for Probability 0%

P 0%					
Month	**Expenses**	**Payment**	**Overdraft**	**interest**	**total**
0	0	350,549	0	0	0
1	243,006	0	-107,543	0	-107,543
2	511,259	233,286	403,716	4,037	407,753
3	481,055	490,809	655,522	6,555	662,078
4	395,955	461,813	567,224	5,672	572,896
5	354,807	380,117	465,890	4,659	470,549
6	360,197	340,615	450,629	4,506	455,136
7	352,732	345,789	467,253	4,673	471,926
8	222,231	338,623	348,367	3,484	351,851
9	0	563,891	13,228	132	13,361
10	0	0	-550,530	0	-550,530
11	0	0		0	0
12	0	0		0	0
				33,718	

Table 4.6: Overdraft Calculation for Probability 50%

P 50%					
Month	**Expenses**	**Payment**	**Overdraft**	**interest**	**total**
0	0	566,474	0	0	0
1	511,841	0	-54,633	0	-54,633
2	575,104	491,367	520,471	5,205	525,676
3	529,764	552,100	564,072	5,641	569,713
4	460,034	508,573	477,647	4,776	482,424
5	480,382	441,633	454,232	4,542	458,775
6	439,109	461,167	456,251	4,563	460,813
7	530,286	421,545	529,933	5,299	535,232
8	477,078	509,075	590,765	5,908	596,673
9	498,992	457,995	586,590	5,866	592,456
10	218,027	479,032	352,489	3,525	356,013
11	0	775,780	-123,019	0	-123,019
12	0	0	-898,799	0	-898,799
				45,325	

Table 4.7: Overdraft Calculation for Probability 100%

P 100%					
Month	**Expenses**	**Payment**	**Overdraft**	**interest**	**total**
0	0	831,121	0	0	0
1	773,315	0	-57,806	0	-57,806
2	670,904	742,382	613,098	6,131	619,229
3	705,342	644,068	582,188	5,822	588,010
4	658,583	677,128	602,525	6,025	608,551
5	528,858	632,240	460,280	4,603	464,883
6	726,799	507,704	559,442	5,594	565,037
7	741,898	697,727	799,231	7,992	807,224
8	624,255	712,222	733,751	7,338	741,089
9	745,385	599,285	774,252	7,743	781,994
10	702,201	715,570	884,911	8,849	893,760
11	48,470	674,113	226,660	2,267	228,927
12		877,652	-445,186	0	-445,186
13			-1,322,839	0	-1,322,839
				62,363	

The finance cost for the 0 %, 50%and 100% was 33,718, 45,325 and 62,363 respectively. The last output of the cash in model is the graphical representation shown in (Figures 4.8 to 4.10). The graphs illustrate the cash in, cash out and net cash flow individually.

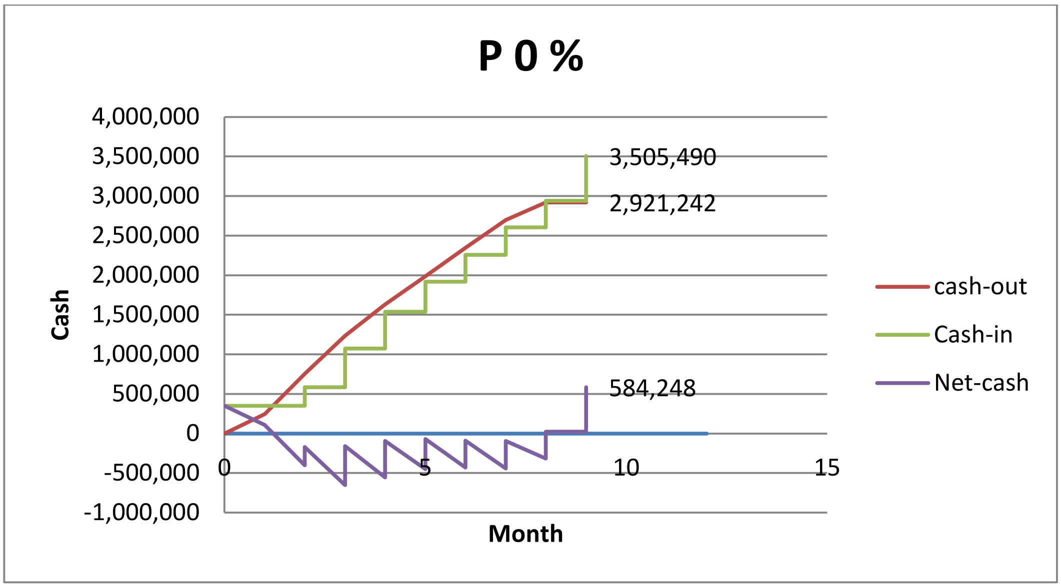

Figure 4.8: Cash Flow for Probability 0%

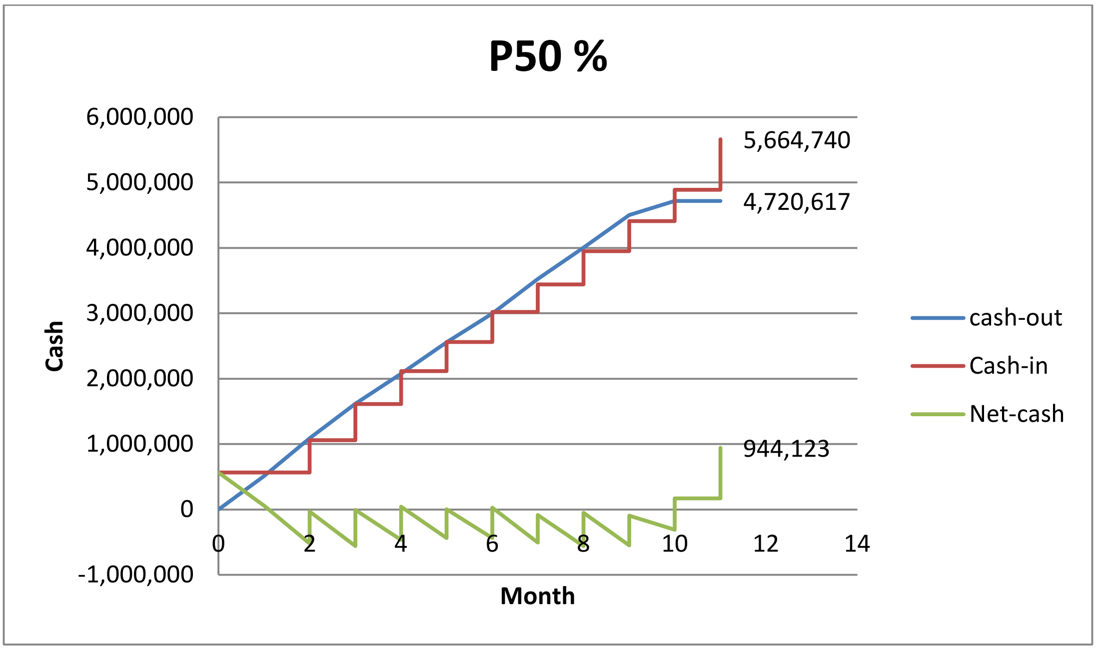

Figure 4.9: Cash flow for Probability 50%

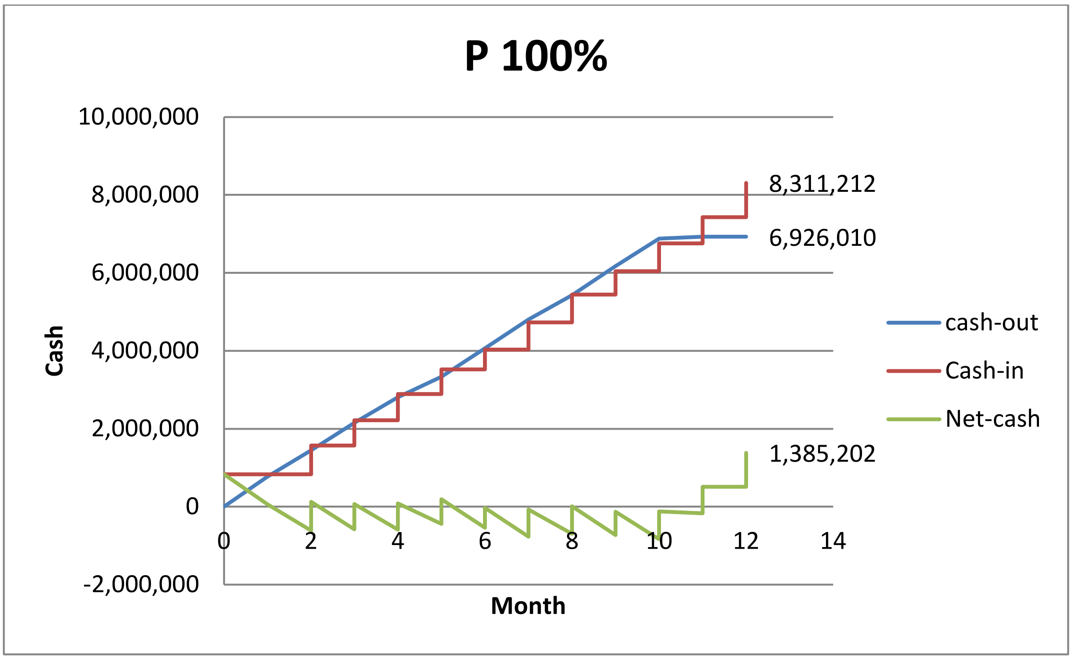

Figure 4.10: Cash Flow for Probability 100%

Figures 4.11 illustrates the probabilistic cash in for the boundary probability, Figure 4.12 illustrates the probabilistic cash out and Figure 4.13 illustrates the net cash flow and the residue between the two previous figures, cash in and cash out. These figures illustrate the final product the probabilistic data for the three main cash flow elements which illustrate the envelop for the resultant probabilistic data.

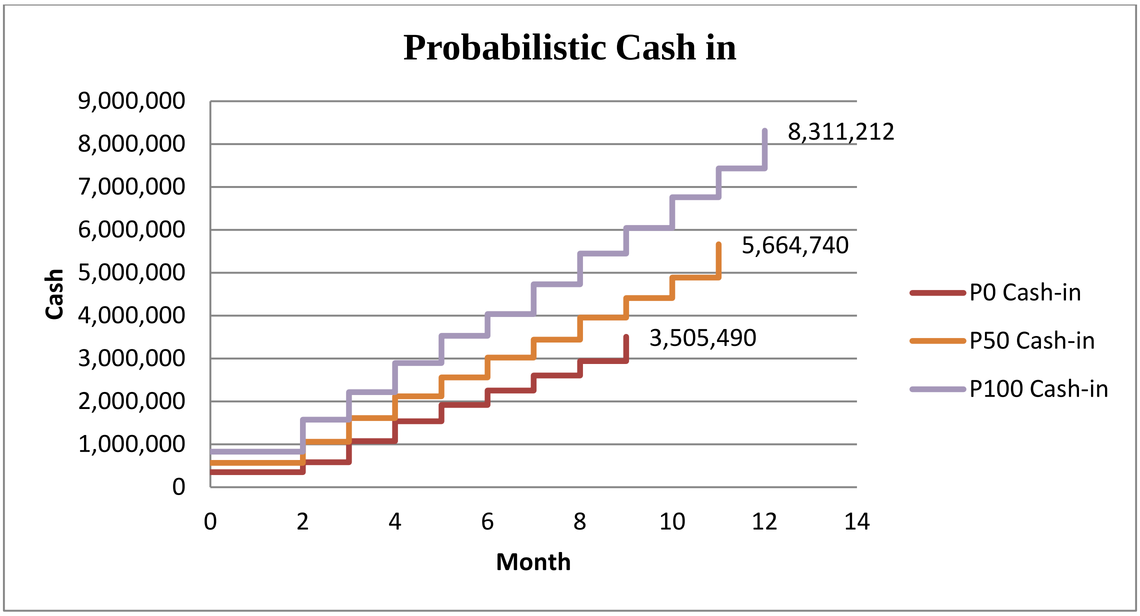

Figure 4.11: Probabilistic Cash In

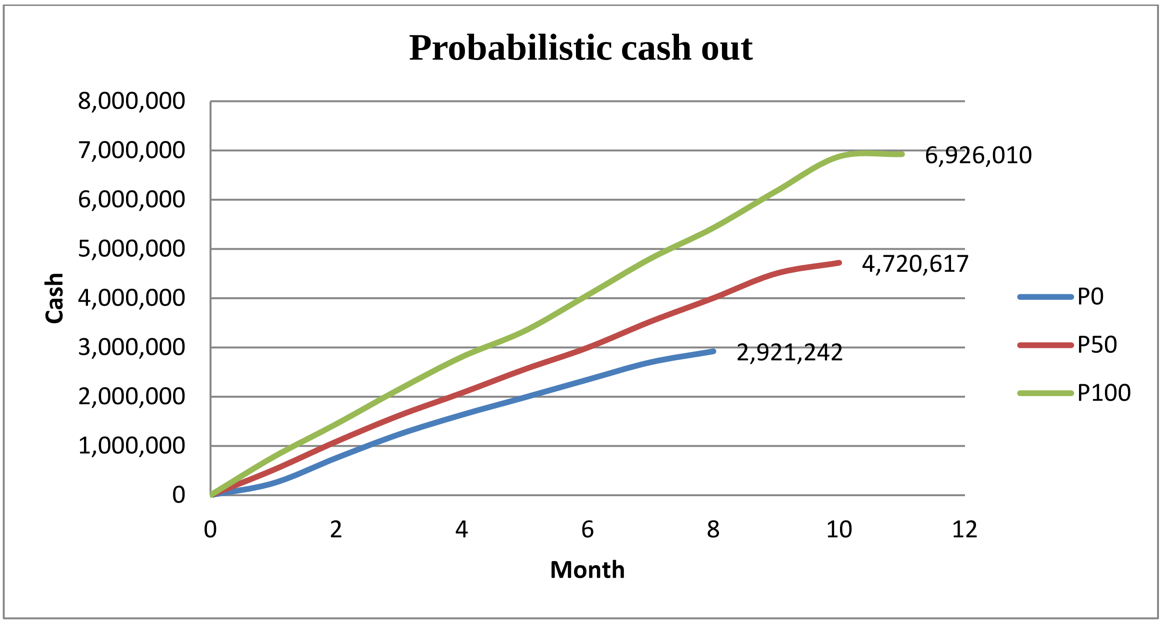

Figure 4.12: Probabilistic Cash Out

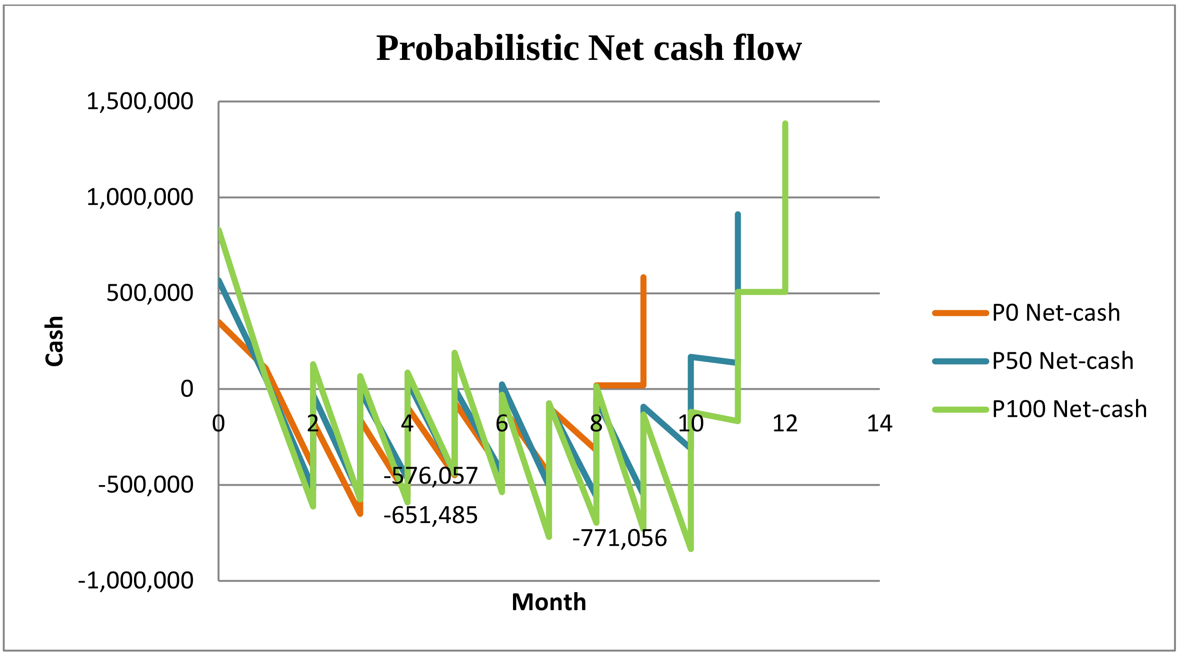

Figure 4.13: Probabilistic Net Cash Flow

4.5 Summary and Conclusions

In this chapter two of the most widely used computer software were used to provide a probabilistic cash flow by apply the effect of risk factors. Primavera p 6 was used as a planning and scheduling tool. The implementation of the risk factors done by primavera risk analysis. In addition a cash in model was developed using a Microsoft macro excel sheet to be used as an tool to provide the necessary calculations of the monthly cash in, net cash flow and overdraft. It can also provide the user with a suitable graphical representation for these values. The system was tested and was found to carry out a correct calculation. The system data was quietly accepted as it was compared with the actual date from previously executed project.

CHAPTER 5

CASE STUDY APPLICATION

5.1 Introduction

In the previous chapter the designed model was tested through a small example project with a full data to confirm that the model can correctly carry out the different cash flow calculations. A case study of real life project will be presented in this chapter as an application of the proposed cash flow model. The objective of this case study is to investigate the ability of the proposed model to provide a reliable forecasting of the different cash flow elements on a large scale project.

5.2 Case Study

5.2.1 Project Description

This project is one building of the German University project in Cairo located in the 5^{th} settlement, built on an area of 1200 m^2. This project is an educational building consists of 5 typical floors, each contains 4 classrooms and an auditorium. It is constructed as a steel structure to get some benefits as: salvage value, long spans, and quick installation, easy for further replacement in contrary of concrete structures. The project consists of 147 activities with a total estimated duration of 451 days and an estimated cost of 30,479277 EGP.

5.2.2 Planning and Scheduling

The project has been broken down to activities with their dependencies and relations as illustrated in appendix B. After that those date entered on primavera p6 with the sot date and resources and it found that the project consists of 147 activities with a total estimated duration of 451 days and an estimated cost of 30,479,277 EGP.

5.2.3 Risk Implementation

The second stage is the risk implementation process that was started now after finishing the planning and scheduling stage with their output and the corresponding risk data mentioned before.

The risk register of the primavera risk analysis was assigned to each activity. The risk register itself does not change from project to anther it is only the assignment of the risks to the activities. Then the risk plan was carried out.

The results of this risk analysis are shown in the form of probability distribution for both cost and time. Figure 5.1 shows the expected duration probability of 0%, 50 %, and 100% was 451, 538 and 631 days respectively. Moreover, Figure 5.2 presents the expected cost of 30,488,460 EGP, 31,952,106 EGP and 33,894,665 EGP at corresponding probability of 0%, 50 %, and 100% respectively. Figure 5.3 represent the probabilistic finish date.

The next step is the application of cash in model developed with Microsoft macro excel. For this step the input data will be the probabilistic data from the previous step. These data are the corresponding cost and duration for probability 0%, 50% and 100 % to build the cash in and net cash curves. For the validation example at the studied probability points of the corresponding cost and duration have been met. It differs in this example where for the max cost (33,894,665EGP) the corresponding duration was 540 days which stand for the probability of 50%. On the other side the 50% probability cost (31,952,106EGP) has a total duration of 630 days which correspond for 100 % of duration probability. The min cost probability at 0 % (30,488,460EGP) where the corresponding duration is 600 days with probability 85 %.

So to cover all the expected different scenarios for both cost and time, several combination of alternatives for the expected cost and time were investigated. The results of these cases were shown in Figures 5.2, 5.3 and 5.4. So five different alternatives were studied with different probability for cost and time. As an example the first alternative named P (0, 85) were 0 % is corresponding probability for cost and 85 % is corresponding for time.

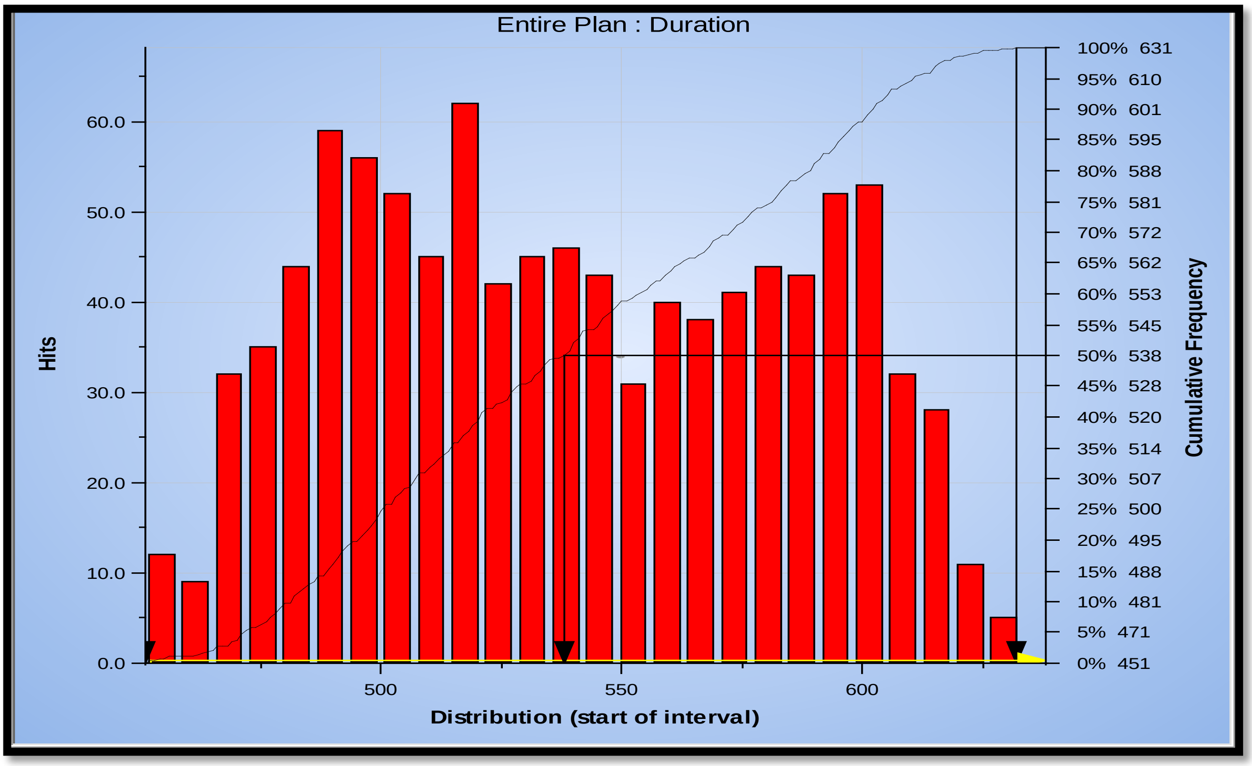

Figure 5.1: Duration Probability Distribution

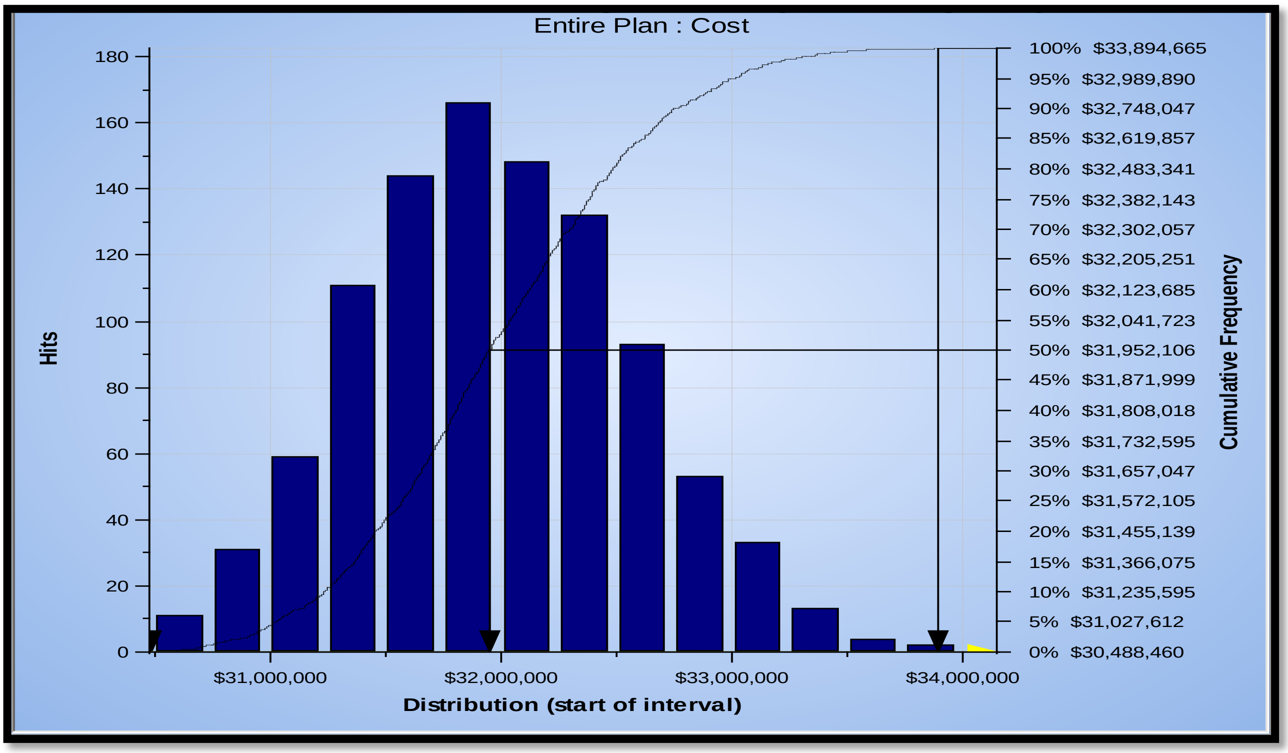

Figure 5.2: Cost Probability Distribution

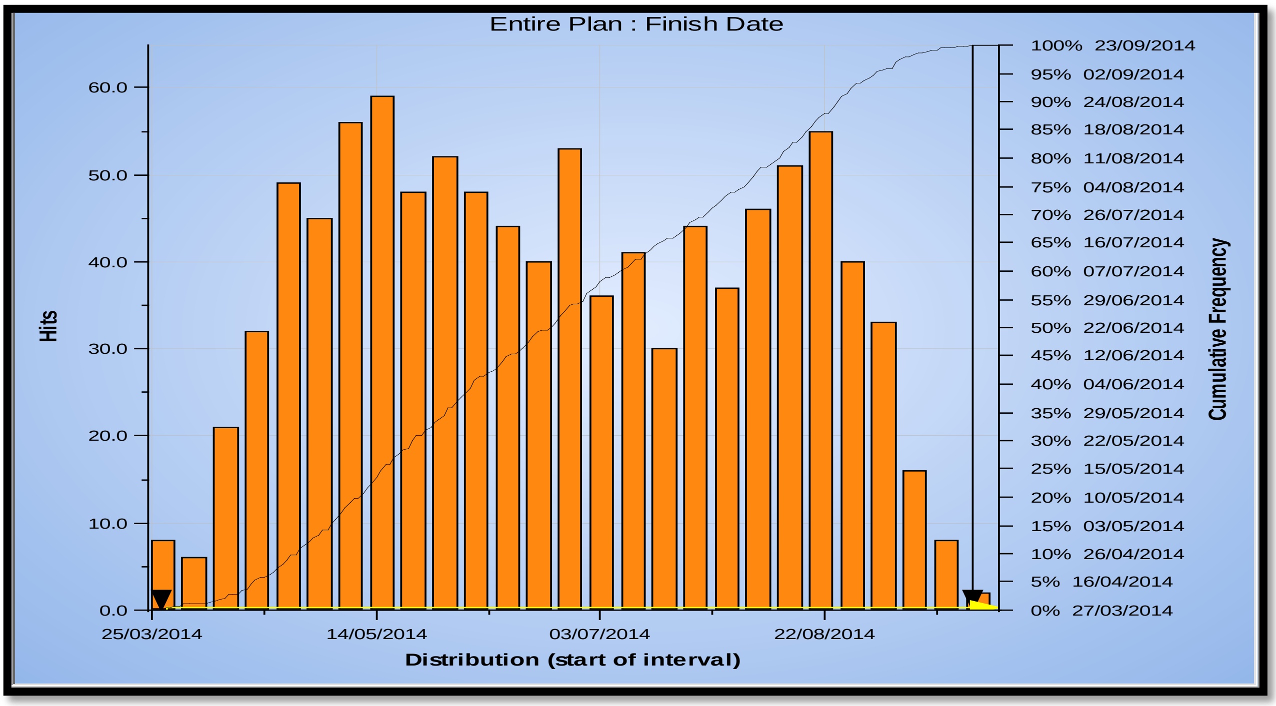

Figure 5.3: Finish Date Probability Distribution

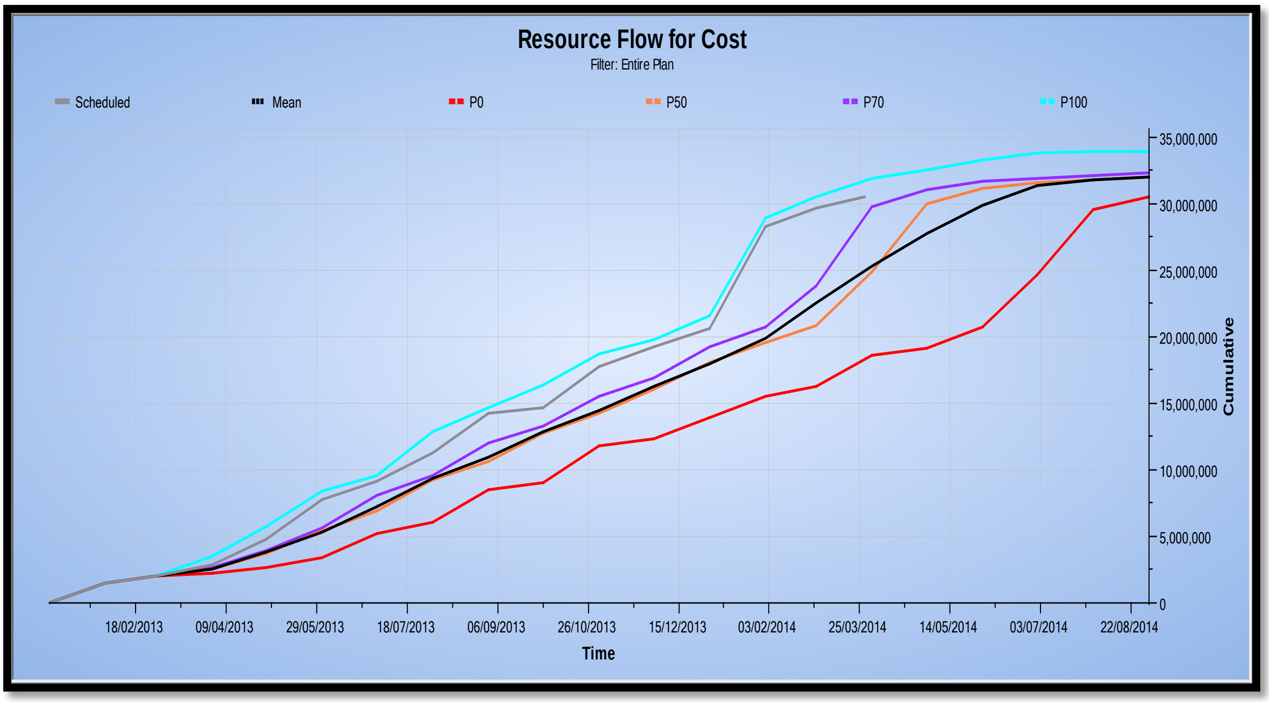

Figure 5.4: Probabilistic Cash Out

The next step is to use the developed cash in model to obtain the cash flow data that cannot be obtained from the primavera risk analysis. In this stage the inputs are the output data from the previous stage with additional variables. Such variables mainly include

Markup = 20%, Retention = 10%, Down payment = 10%, Monthly interest rate = 1%

The output of this stage will be the cash in, net cash flow and overdraft calculation for the five alternatives that were mentioned and defined above.

Table 5.1 illustrates the monthly cost for the five alternatives where Table 5.2 illustrates the cumulative costs.

Table 5.1: Monthly Costs

Month	P(0,85)	P(50,100)	P(100,50)	P(70,70)	Deterministic
0	0	0	0	0	0
1	1,480,645	1,530,000	1,530,000	1,480,645	1,530,000
2	509,483	504,923	532,000	535,141	532,000
3	189,974	480,174	1,407,280	369,535	805,264
4	437,754	1,181,921	2,288,405	1,035,663	1,964,208
5	834,288	1,670,092	2,658,057	1,286,934	2,948,058
6	1,764,508	1,546,038	1,172,913	1,452,605	1,316,433
7	794,067	2,321,490	3,302,698	2,521,681	2,156,696
8	2,517,236	1,431,158	1,817,695	932,989	2,949,607
9	546,593	2,034,747	1,608,828	2,358,735	482,035
10	2,692,908	1,562,383	2,342,703	1,019,937	3,012,645
11	547,426	1,746,024	1,122,738	1,917,528	1,525,806
12	1,596,133	2,092,737	1,770,045	1,245,840	1,425,625
13	1,562,343	1,469,882	7,309,881	1,574,786	7,589,233
14	765,792	1,268,253	1,661,050	1,566,916	1,441,667
15	2,326,247	4,063,335	1,395,281	1,115,166	800,000
16	593,071	5,083,136	638,194	1,256,631	0
17	1,515,446	1,114,748	697,986	7,030,491	0
18	3,942,934	427,139	638,911	1,913,885	0
19	4,922,163	281,185	0	840,031	0
20	949,449	128,813	0	0	0
21	0	13,928	0	0	0

Table 5.3 & Table5.4 represent the cash in calculation as table 5.3 illustrates monthly cash in and table 5.4 illustrates the cumulative cash in.

Table 5.2: Cumulative Costs

Month	P(0,85)	P(50,100)	P(100,50)	P(70,70)	Deterministic
0	0	0	0	0	0
1	1,480,645	1,530,000	1,530,000	1,480,645	1,530,000
2	1,990,128	2,034,923	2,062,000	2,015,786	2,062,000
3	2,180,102	2,515,097	3,469,280	2,385,321	2,867,264
4	2,617,856	3,697,018	5,757,685	3,420,984	4,831,472
5	3,452,144	5,367,110	8,415,742	4,707,918	7,779,530
6	5,216,652	6,913,148	9,588,655	6,160,523	9,095,963
7	6,010,719	9,234,638	12,891,353	8,682,204	11,252,659
8	8,527,955	10,665,796	14,709,048	9,615,193	14,202,266
9	9,074,548	12,700,543	16,317,876	11,973,928	14,684,301
10	11,767,456	14,262,926	18,660,579	12,993,865	17,696,946
11	12,314,882	16,008,950	19,783,317	14,911,393	19,222,752
12	13,911,015	18,101,687	21,553,362	16,157,233	20,648,377
13	15,473,358	19,571,569	28,863,243	17,732,019	28,237,610
14	16,239,150	20,839,822	30,524,293	19,298,935	29,679,277
15	18,565,397	24,903,157	31,919,574	20,414,101	30,479,277
16	19,158,468	29,986,293	32,557,768	21,670,732	
17	20,673,914	31,101,041	33,255,754	28,701,223	
18	24,616,848	31,528,180	33,894,665	30,615,108	
19	29,539,011	31,809,365		31,455,139	
20	30,488,460	31,938,178			
21		31,952,106			

Table 5.3: Monthly Cash In

Month	P(0,85)	P(50,100)	P(100,50)	P(70,70)	deterministic
0	3,658,615	3,834,253	4,067,360	3,774,617	3,657,513
1	0	0	0	0	0
2	1,421,419	1,468,800	1,468,800	1,421,419	1,468,800
3	489,104	484,726	510,720	513,735	510,720
4	182,375	460,967	1,350,989	354,754	773,053
5	420,244	1,134,644	2,196,869	994,236	1,885,640
6	800,916	1,603,288	2,551,735	1,235,457	2,830,136
7	1,693,928	1,484,196	1,125,996	1,394,501	1,263,776
8	762,304	2,228,630	3,170,590	2,420,814	2,070,428
9	2,416,547	1,373,912	1,744,987	895,669	2,831,623
10	524,729	1,953,357	1,544,475	2,264,386	462,754
11	2,585,192	1,499,888	2,248,995	979,140	2,892,139
12	525,529	1,676,183	1,077,828	1,840,827	1,464,774
13	1,532,288	2,009,028	1,699,243	1,196,006	1,368,600
14	1,499,849	1,411,087	7,017,486	1,511,795	7,285,664
15	735,160	1,217,523	1,594,608	1,504,239	1,384,000
16	2,233,197	3,900,802	1,339,470	1,070,559	4,425,513
17	569,348	4,879,811	612,666	1,206,366	0
18	1,454,828	1,070,158	670,067	6,749,271	0
19	3,785,217	410,053	4,680,714	1,837,330	0
20	4,725,276	269,938	0	4,581,046	0
21	4,570,086	123,660	0		0
22	0	3,847,624	0	0	0

Table 5.4: Cumulative Cash in

Month	P(0,85)	P(50,100)	P(100,50)	P(70,70)	deterministic
0	3,658,615	3,834,253	4,067,360	3,774,617	3,657,513
1	3,658,615	3,834,253	4,067,360	3,774,617	3,657,513
2	5,080,034	5,303,053	5,536,160	5,196,036	5,126,313
3	5,569,138	5,787,779	6,046,880	5,709,771	5,637,033
4	5,751,513	6,248,746	7,397,869	6,064,525	6,410,087
5	6,171,757	7,383,390	9,594,737	7,058,761	8,295,726
6	6,972,673	8,986,678	12,146,472	8,294,218	11,125,862
7	8,666,601	10,470,875	13,272,469	9,688,719	12,389,638
8	9,428,905	12,699,505	16,443,059	12,109,533	14,460,066
9	11,845,452	14,073,417	18,188,046	13,005,202	17,291,689
10	12,370,181	16,026,774	19,732,521	15,269,588	17,754,442
11	14,955,373	17,526,662	21,981,516	16,248,727	20,646,581
12	15,480,902	19,202,845	23,059,344	18,089,554	22,111,355
13	17,013,190	21,211,872	24,758,587	19,285,560	23,479,955
14	18,513,039	22,622,959	31,776,073	20,797,355	30,765,619
15	19,248,199	23,840,482	33,370,681	22,301,594	32,149,619
16	21,481,396	27,741,283	34,710,151	23,372,154	36,575,132
17	22,050,744	32,621,094	35,322,817	24,578,519	
18	23,505,573	33,691,252	35,992,884	31,327,791	
19	27,290,789	34,101,306	40,673,598	33,165,120	
20	32,016,066	34,371,243		37,746,167	
21	36,586,152	34,494,904			
22		38,342,527			

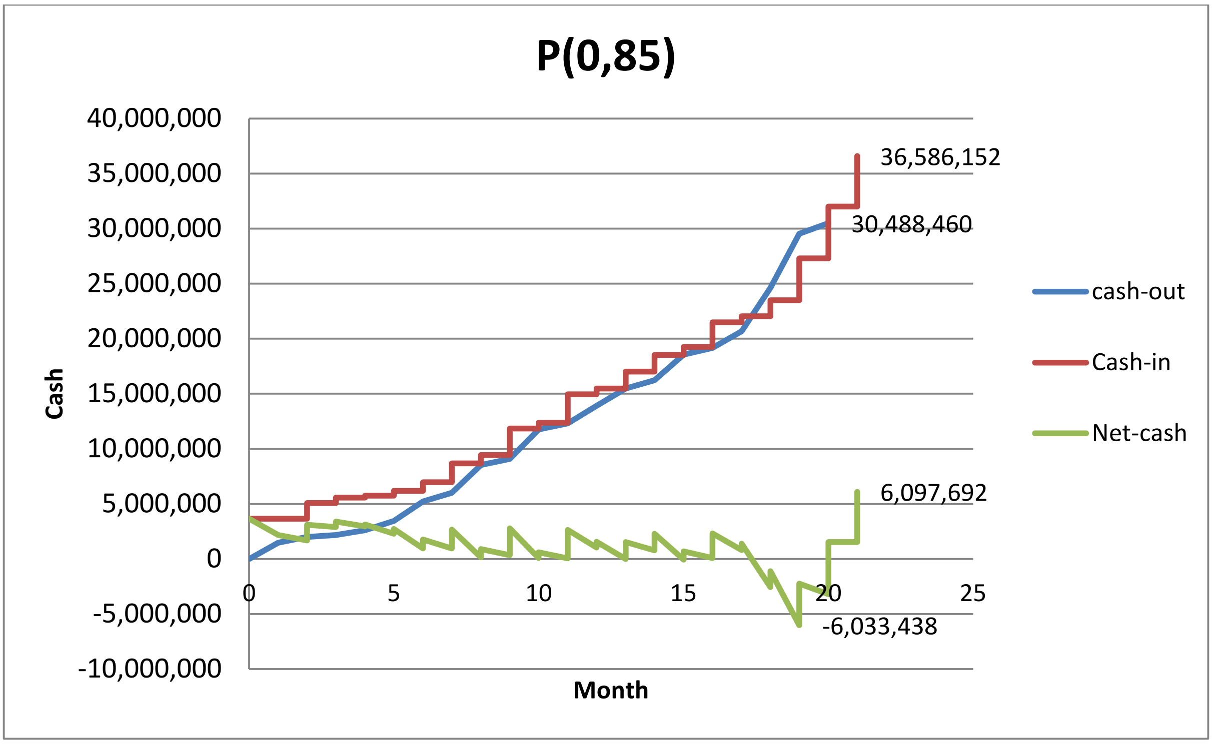

Figure 5.5: Cash Flow for Probability P (0, 85) %

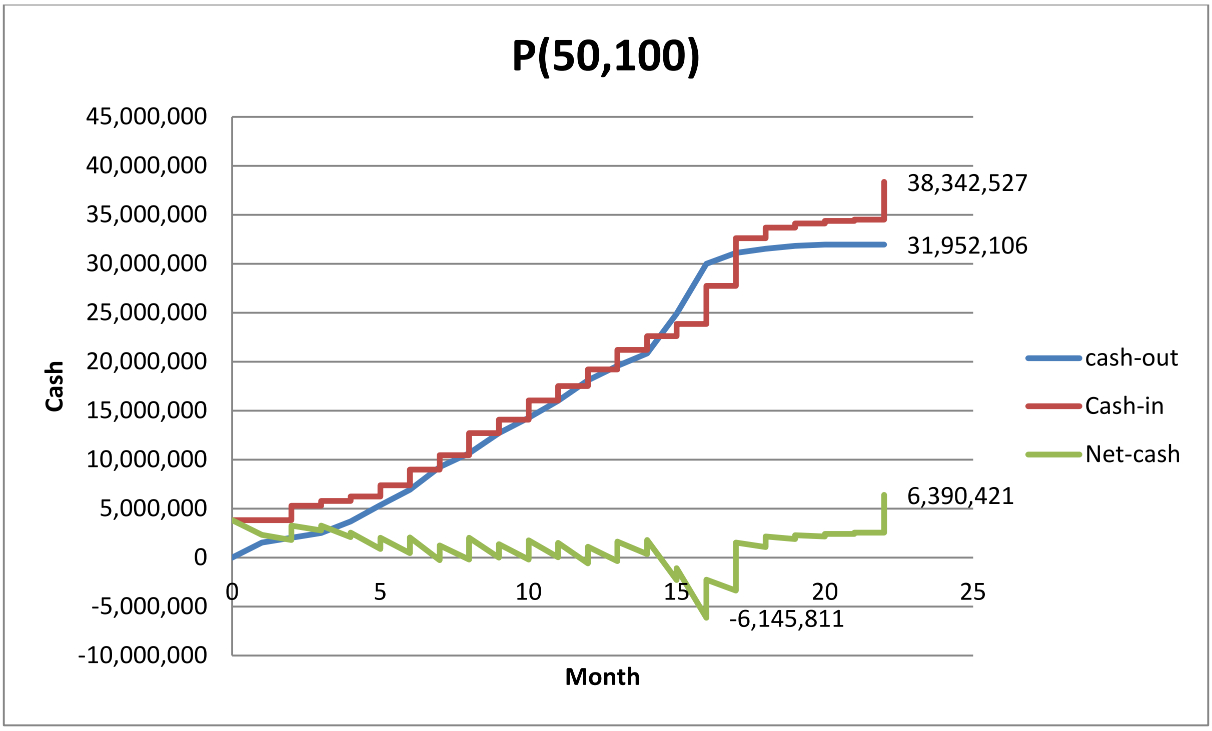

Figure 5.6: Cash Flow for Probability P (50,100) %

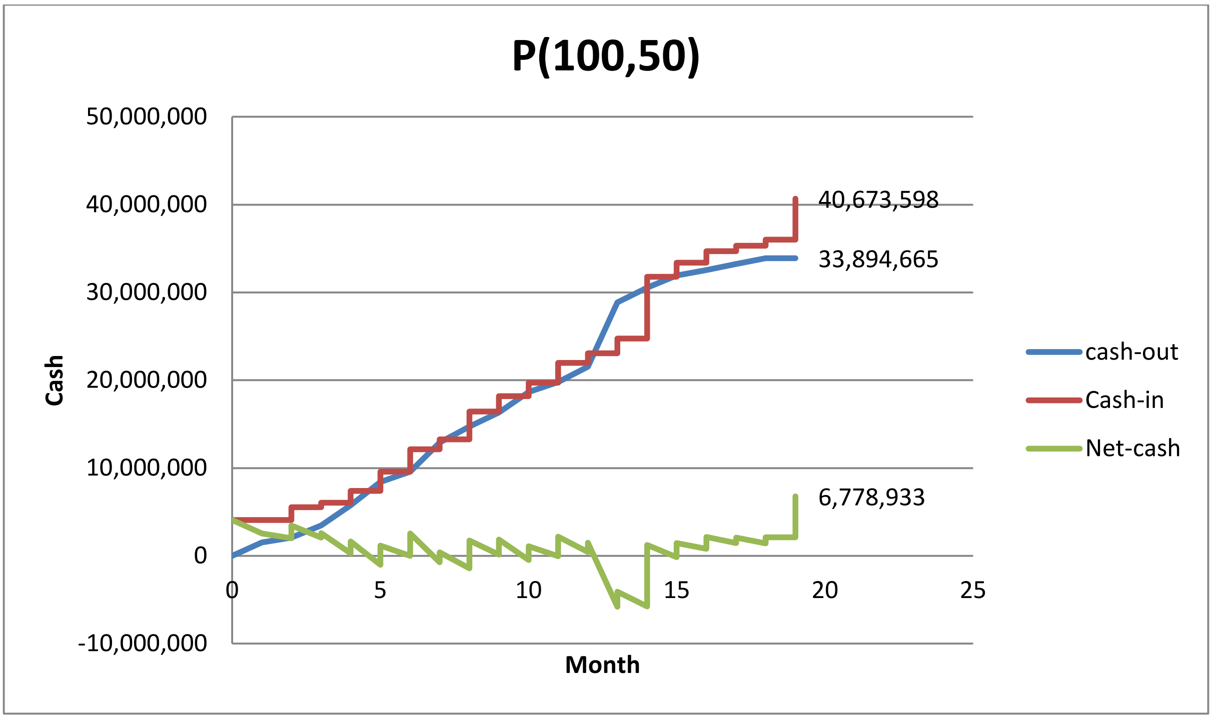

Figure 5.7: Cash Flow for Probability P (100, 50) %

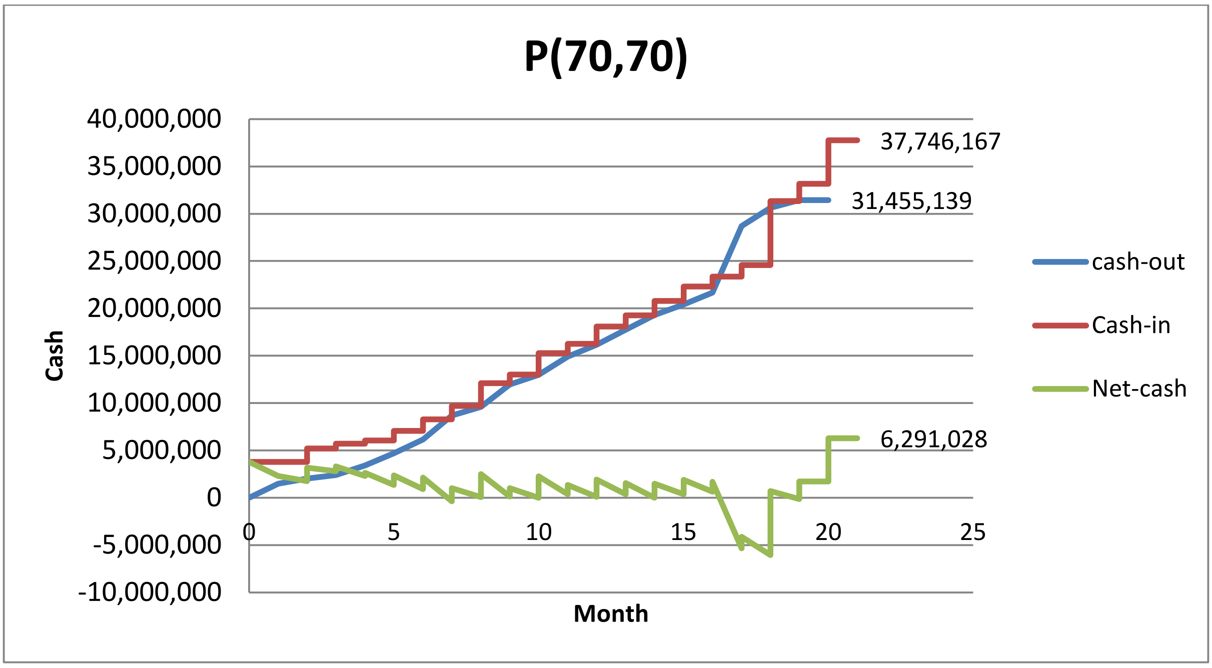

Figure 5.8: Cash Flow for Probability P (70, 70) %

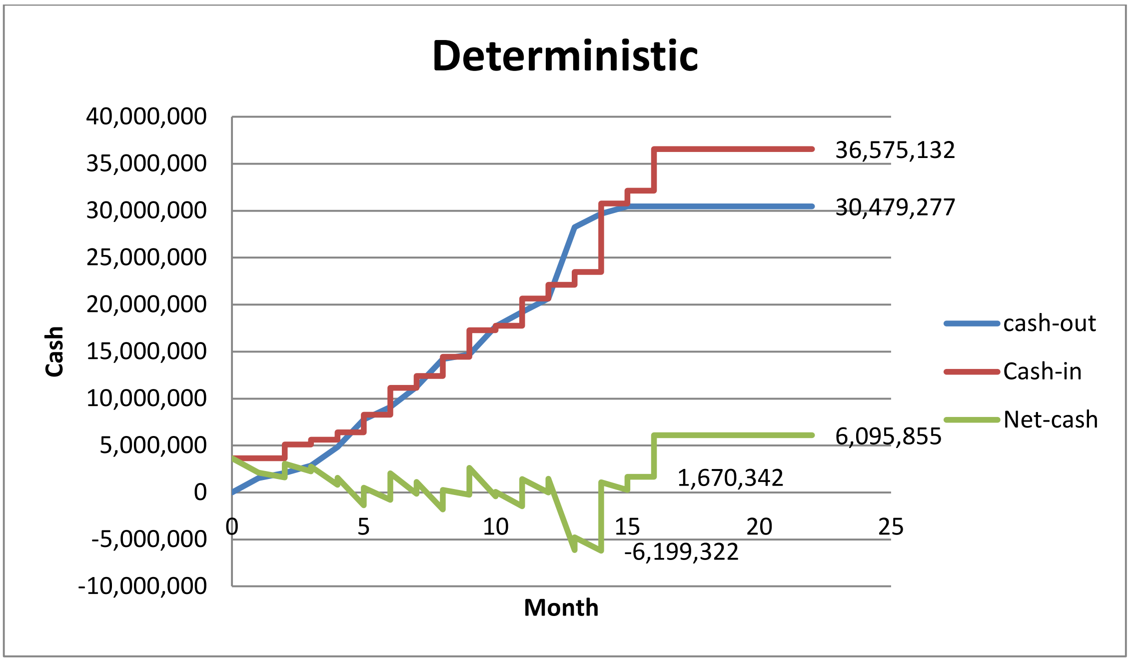

Figure 5.9: Cash Flow for Deterministic Probability

The final step is the overdraft calculation (based on an assumed monthly interest rate of 1%). In this step the input data are the output data from the cash flow calculation. The following tables illustrate the overdraft calculations.

Table 5.6 to Table 5.10 illustrate the overdraft for all the single cash flows with their cost of finance which compose the probabilistic overdraft calculation.

Table 5.6: Overdraft Calculation for P (0, 85) %

P (0, 85) %					
Month	**Expenses**	**Payment**	**Overdraft**	**Interest**	**Total**
0	0	3,658,615	-3,658,615	0	-3,658,615
1	1,480,645	0	-2,177,970	0	-2,177,970
2	509,483	1,421,419	-1,668,487	0	-1,668,487
3	189,974	489,104	-2,899,932	0	-2,899,932
4	437,754	182,375	-2,951,282	0	-2,951,282
5	834,288	420,244	-2,299,369	0	-2,299,369
6	1,764,508	800,916	-955,105	0	-955,105
7	794,067	1,693,928	-961,954	0	-961,954
8	2,517,236	762,304	-138,646	0	-138,646
9	546,593	2,416,547	-354,357	0	-354,357
10	2,692,908	524,729	-77,996	0	-77,996
11	547,426	2,585,192	-55,299	0	-55,299
12	1,596,133	525,529	-1,044,358	0	-1,044,358
13	1,562,343	1,532,288	-7,544	0	-7,544
14	765,792	1,499,849	-774,040	0	-774,040
15	2,326,247	735,160	52,358	524	52,882
16	593,071	2,233,197	-89,208	0	-89,208
17	1,515,446	569,348	-806,959	0	-806,959
18	3,942,934	1,454,828	2,566,627	25,666	2,592,293
19	4,922,163	3,785,217	6,059,628	60,596	6,120,224
20	949,449	4,725,276	3,284,457	32,845	3,317,301
21	0	4,570,086	-1,407,975	0	-1,407,975
				119,631	

Table 5.7: Overdraft Calculation for P (50, 100) %

P (50, 100) %					
Month	**Expenses**	**Payment**	**Overdraft**	**Interest**	**Total**
0	0	3,834,253	-3,834,253	0	-3,834,253
1	1,530,000	0	-2,304,253	0	-2,304,253
2	504,923	1,468,800	-1,799,330	0	-1,799,330
3	480,174	484,726	-2,787,956	0	-2,787,956
4	1,181,921	460,967	-2,090,761	0	-2,090,761
5	1,670,092	1,134,644	-881,636	0	-881,636
6	1,546,038	1,603,288	-470,242	0	-470,242
7	2,321,490	1,484,196	247,960	2,480	250,439
8	1,431,158	2,228,630	197,401	1,974	199,375
9	2,034,747	1,373,912	5,491	55	5,546
10	1,562,383	1,953,357	194,018	1,940	195,958
11	1,746,024	1,499,888	-11,375	0	-11,375
12	2,092,737	1,676,183	581,474	5,815	587,289
13	1,469,882	2,009,028	380,988	3,810	384,798
14	1,268,253	1,411,087	-355,977	0	-355,977
15	4,063,335	1,217,523	2,296,271	22,963	2,319,234
16	5,083,136	3,900,802	6,184,847	61,848	6,246,696
17	1,114,748	4,879,811	3,460,642	34,606	3,495,248
18	427,139	1,070,158	-957,423	0	-957,423
19	281,185	410,053	-1,746,396	0	-1,746,396
20	128,813	269,938	-2,027,637	0	-2,027,637
21	13,928	123,660	-2,283,646	0	-2,283,646
22	0	3,847,624	-2,407,307	0	-2,407,307
				135,491	

Table 5.8: Overdraft Calculation for P (100, 50) %

P (100, 50) %					
Month	**Expenses**	**Payment**	**Overdraft**	**Interest**	**Total**
0	0	4,067,360	-4,067,360	0	-4,067,360
1	1,530,000	0	-2,537,360	0	-2,537,360
2	532,000	1,468,800	-2,005,360	0	-2,005,360
3	1,407,280	510,720	-2,066,880	0	-2,066,880
4	2,288,405	1,350,989	-289,195	0	-289,195
5	2,658,057	2,196,869	1,017,873	10,179	1,028,052
6	1,172,913	2,551,735	4,096	41	4,137
7	3,302,698	1,125,996	755,101	7,551	762,652
8	1,817,695	3,170,590	1,454,350	14,544	1,468,894
9	1,608,828	1,744,987	-92,868	0	-92,868
10	2,342,703	1,544,475	504,847	5,048	509,896
11	1,122,738	2,248,995	88,159	882	89,041
12	1,770,045	1,077,828	-389,909	0	-389,909
13	7,309,881	1,699,243	5,842,143	58,421	5,900,565
14	1,661,050	7,017,486	5,862,371	58,624	5,920,995
15	1,395,281	1,594,608	298,790	2,988	301,778
16	638,194	1,339,470	-654,636	0	-654,636
17	697,986	612,666	-1,296,120	0	-1,296,120
18	638,911	670,067	-1,269,875	0	-1,269,875
19	0	4,680,714	-1,939,941	0	-1,939,941
				158,277	

Table 5.9: Overdraft Calculation for P (70, 70) %

P (70, 70) %					
Month	**Expenses**	**Payment**	**Overdraft**	**Interest**	**Total**
0	0	3,774,617	-3,774,617	0	-3,774,617
1	1,480,645	0	-2,293,972	0	-2,293,972
2	535,141	1,421,419	-1,758,831	0	-1,758,831
3	369,535	513,735	-2,810,715	0	-2,810,715
4	1,035,663	354,754	-2,288,787	0	-2,288,787
5	1,286,934	994,236	-1,356,607	0	-1,356,607
6	1,452,605	1,235,457	-898,238	0	-898,238
7	2,521,681	1,394,501	387,986	3,880	391,866
8	932,989	2,420,814	-69,646	0	-69,646
9	2,358,735	895,669	-131,725	0	-131,725
10	1,019,937	2,264,386	-7,457	0	-7,457
11	1,917,528	979,140	-354,315	0	-354,315
12	1,245,840	1,840,827	-87,614	0	-87,614
13	1,574,786	1,196,006	-353,655	0	-353,655
14	1,566,916	1,511,795	17,255	173	17,427
15	1,115,166	1,504,239	-379,202	0	-379,202
16	1,256,631	1,070,559	-626,810	0	-626,810
17	7,030,491	1,206,366	5,333,122	53,331	5,386,453
18	1,913,885	6,749,271	6,093,972	60,940	6,154,912
19	840,031	1,837,330	245,672	2,457	248,128
20	0	4,581,046	-1,589,201	0	-1,589,201
				120,780	

Table 5.10: Overdraft calculation for Deterministic

Deterministic					
Month	**Expenses**	**Payment**	**Overdraft**	**Interest**	**Total**
0	0	3,657,513	-3,657,513	0	-3,657,513
1	1,530,000	0	-2,127,513	0	-2,127,513
2	532,000	1,468,800	-1,595,513	0	-1,595,513
3	805,264	510,720	-2,259,049	0	-2,259,049
4	1,964,208	773,053	-805,561	0	-805,561
5	2,948,058	1,885,640	1,369,443	13,694	1,383,138
6	1,316,433	2,830,136	813,931	8,139	822,070
7	2,156,696	1,263,776	148,631	1,486	150,117
8	2,949,607	2,070,428	1,835,948	18,359	1,854,308
9	482,035	2,831,623	265,915	2,659	268,574
10	3,012,645	462,754	449,596	4,496	454,092
11	1,525,806	2,892,139	1,517,144	15,171	1,532,316
12	1,425,625	1,464,774	65,802	658	66,460
13	7,589,233	1,368,600	6,190,919	61,909	6,252,828
14	1,441,667	7,285,664	6,325,895	63,259	6,389,154
15	800,000	1,384,000	-96,510	0	-96,510
16	0	4,425,513	-1,480,510	0	-1,480,510
				189,832	

5.3 summary and Conclusions

In this chapter, a case study application was implemented by the proposed cash flow model Such case involved three stages, scheduling, risk implementation and cash flow prediction. It clearly shows the success of the model to produce the proposed output. The actual cost and duration are about 31 million and 19 months which in the range of the probabilistic output. It proves that the probabilistic prediction is more accurate than the deterministic one. Since it can provide the user with different cash-flow scenarios with their corresponding probabilities.

CHAPTER 6

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

In this study, a model has been developed to produce a probabilistic cash flow prediction. The model consists of three stages planning, risk modeling and probabilistic cash flow prediction. These stages can be conducted through three different programs, primavera p6, primavera risk analysis and MS-excel macro sheet. The model takes into consideration the main risk factors affecting the construction project. These factors were determined through literature review and a questionnaire survey. Through the questionnaire the factors have been evaluated according to their frequency and impact. The questionnaire was distributed on contractors, owners and consultants. The model objectives were to incorporate the effect of the selected risk factors on the cash flow analysis to produce the affected cash flow elements cash out, cash in and net cash flow in a probabilistic form. This can provide the user with a broader picture regarding the different scenarios of the expected cash flow. As the model has been validated through a small construction project with the available at completion data. The project has been carried out through the three stages of the model and the probabilistic outputs were produced. It was found that the probabilistic output, cost and time have a higher level of accuracy of the planned data. A real life case study was applied trough the model as well.

6.2 Conclusions

In this study, a probabilistic cash flow risk model was developed. The developed model can be used to produce a probabilistic cash flow elements. Some remarks were concluded and listed below:

- The main risk factors affecting the construction project cash flow were found to be :
  Agreeing interim valuations on site, receiving interim certificates, Delays in payments from client, Consultant’s Instructions, Provisions for phased handover, Delay in agreeing variation, Provision for fluctuation payments, Delay in settling claims, Material delay, Retention, Accidents & theft and Estimating error.
- The use of probabilistic cash flow model is more beneficial than deterministic one, this may be attributed to the fact that it can provide decision maker with a broader picture regarding the expected cash flow of his project.
- Through the comparison between the actual and the probabilistic output, it was noticed that with respect to the time it is a perfect fit and goes in the boundary of the maximum and minimum and closest to the mean. In the case of the cost the difference between the actual and deterministic is a small for successful project and around the average generally.
- Probabilistic cash flow present a lot of scenarios of what cash flow would be.

- Probabilistic cash flow model can help the user to incorporate the effect of the different risk factors on the expected project cash flow.

6.3 Recommendation

The developed model is highly recommended to be used for cash flow prediction. Since it can provide a broader picture regarding the different cash flow scenarios. It can seriously improve the decision making process regarding the different cash flow problems.

6.4 Recommendations for Future Work

- The Proposed model should be augmented to include the following
  - Different type of construction projects.
  - Other risk factors that can be shown in this study.

- Future work is recommended to Integrate the risk factors on the cash inflow as some of the studied risk factors have a higher effect on it and it will provide a highly detailed cash flow.

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APPENDIX (A)

DATA COLLECTION QUESTIONNAIRE

(RISK FACTORS THAT AFFECT THE CASH FLOW)

السيد / المهندس..............................

في البداية, أود أن أشكركم على مشاركتكم في ملء هذا الاستبيان الذي يهدف الى تقييم و تحديد عوامل الخطر التى تؤثر على الدراسة المالية و التدفق النقدى لمشروعات التشييد.

تمثل الدراسة المالية جانب مهم للغاية في مجال صناعة التشييد و ذلك من الناحية الاقتصادية ولكل مشروع تدفق نقدى مختلف لاختلاف العوامل المؤثرة على كل مشروع و من خلال هذا الاستبيان نهدف الى تحديد اهم هذه العوامل و مقدار تأثيرها.

هذا الاستبيان هو جزء من الرسالة المقدمة من الباحث / أحمد رفعت البحيرى لنيل درجة الماجستير في ادارة مشروعات التشييد , بكلية الهندسة و التكنولوجيا تحت رعاية الأكاديمية العربية للعلوم و التكنولوجيا و النقل البحري.

في النهاية , نؤكد على سرية و خصوصية المعلومات التي سوف تتقدمون بها و التي سيكون الاطلاع عليها للجهة البحثية فقط , و ان شاء الله سنوافيكم بملخص نتائج البحث بعد انتهائه , شاكرين و مقدرين حسن تعاونكم.

الباحث

م / أحمد رفعت البحيرى

اذا كان لديكم أي معلومات اضافية , أو استفسارات أو اقتراحات , نرجو التكرم بالأتصال بالباحث كالآتي:

م / أحمد رفعت البحيرى – تليفون : 01005708333 – بريد الكتروني : Eng.elbeheri@gmail.com

أولا: البيانات الشخصية :

الاسم : .... **التليفون :** ....

جهة العمل: .... **المحمول :** ....

العنوان : .... **البريد الالكتروني:** ....

ثانيا : بيانات جهة العمل :

❖ تصنيف جهة العمل :

☐ مالك ☐ استشاري ☐ مقاول

❖ قطاع جهة العمل :

☐ عام ☐ خاص

❖ خبرتك السابقة في صناعة التشييد :

☐ 1 -5 سنوات ☐ 5 -10 سنوات

☐ 10 -15 سنة ☐ 15 -20 سنة فأكثر

❖ متوسط حجم العمل السنوي :

☐ أقل من مليون جنيه ☐ من 1 مليون الى 5 مليون جنيه

☐ من 5 مليون الى 20 مليون جنيه ☐ من 20 مليون الى 50 مليون جنيه

☐ من 50 مليون الى 100 مليون جنيه ☐ أكثر من 100 مليون جنيه

ثالثا : تقييم معاملات الخطر :

ارشادات:

- تزداد القيمة تدريجيا من الرقم 1الى الرقم 5 حيث يمثل الرقم 1 اقل قيمة و الرقم 5 اعلى قيمة.

Risk factors		Frequency(نسبة الحدوث)					Impact(قوة التأثير)				
		1	2	3	4	5	1	2	3	4	5
Site Related	Problems with the foundations (مشاكل في الأساسات)										
	Listed buildings(مباني ذو علاقة تاريخية)										
	Archaeological remains (بقايا اثرية)										
	Inclement weather(الظروف المناخية المتقلبة)										
	Accidents & theft (الحوادث و السرقات)										
Project Related	Extent of float in contract schedule(مدى السماحية فى مدة العقد)										
Owner Related	Receiving interim certificates(استلام الدفعات النقدية للمستخلص)										
	Retention (احتجاز نسبة من الدفعات النقدية من المالك)										
	Delays in payments from client (التاخر فى تدفق الدفعات النقدية من المالك)										
	Provision for fluctuation payments(تذبذب استلام الدفعات النقدية)										
Economic Conditions	Changes in currency exchange rates (اسعار في التغير العملات)										
	Strikes(الاضرابات)										
	Level of inflation(معدل التضخم)										
	Changes in interest rates(التغير فى نسبة الفائدة البنكية)										
Contractor Related	Estimating error (خطا في التقدير)										
	Penalty due to the violation of Authority regulation and rules (العقوبات لمخالفة اللوائح و القوانين)										
	Provision for interim certificate (تقديم مستخلص الاعمال المنفذة للمالك)										
	Material delay (تأخر المواد)										
	Error in execution & rework خطأ فى التنفيذ و اعادة العمل مرة أخرى)										
	Equipment breakdown (أعطال المعدات)										
	Bankruptcy of subcontractor (تعثر و افلاس مقاولى الباطن)										
	Tender unbalancing (التلاعب باسعار العطاء لتحقيق مكسب مبكر)										

Consultant Related	Consultant's Instructions (تعليمات الاستشارى)										
	Agreeing interim valuations on site (موافقة الاستشارى على الاعمال المنفذة)										
	Delay in agreeing variation(تأخيرفي الموافقة على التغيرات										
	Delay in settling claims (التأخر فى فض المطالبات)										
	Provisions for phased handover (اعتماد تسليم مرحلة او المشروع بأكمله)										
	Any other suggestions (…………..)										

<u>رابعا : أي إضافات أو تعليقات :</u>

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APPENDIX B

CASE STUDY PROJECT DATA

Table B.1: Activities and relationships

Activity ID	Activity name	Predecessor
A1000	Project preparation	none
A1010	Excavation	A1000
A1020	Soil replacement	A1010
A1030	Compaction	A1020
A1040	Form Works of P.C	A1030
A1050	P.c casting	A1040
A1060	P.c shuttering removal	A1050
A1070	Form Works of R.C	A1060
A1080	Form Works of Retaining wall footing	A1030
A1090	Steel fixation of RC footing	A1070
A1100	Steel Fixation of Retaining Wall footing	A1080
A1110	R.C footing Casting	A1090
A1120	R.C. casting for retaining wall footing	A1100
A1130	Shuttering removal OF R.C FOOTING	A1110
A1140	Shuttering removal of R.W. footing	A1120
A1150	Hot applied Bituminous paint foundation	A1130
A1160	Cold applied Bituminous paint foundation	A1150
A1170	Isolation of retaining wall footing	A1140
A1180	Form Works of upstand neck Columns	A1160
A1190	Steel Fixation of upstand neck column	A1180
A1200	Anchor bolts installing	A1190
A1210	Upstand neck Columns Casting	A1200
A1220	Form work of retaining wall	A1170
A1230	Steel fixation of retaining wall	A1220
A1240	R.C. casting of retaining wall	A1230

Table B.1: Activities and relationships (Continued)

Activity ID	Activity name	Predecessor
A1250	Retaining Wall formwork Removal	A1240
A1260	Isolation of Retaining wall	A1250
A1270	Backfilling above footing	A1210
A1280	Plastering r.w.	A1260
A1290	Form work of r.c core columns	A1270
A1300	Steel eriction of rc columns	A1290
A1310	Rc columns casting	A1300
A1320	Shuttering removal	A1310
A1330	Form work of slab and stairs	A1320
A1340	Steel eriction of slabs and stairs	A1330
A1350	Rc casting of slabs and stairs	A1370
A1360	Shuttering removal	A1350
A1370	Anchor bolts installation	A1340
A1380	Steel columns installation	A1210
A1390	Steel beams installation	A1370,A1380,A1360
A1400	Connection between columns and beams	A1390
A1410	Installation of precasted slab	A1400
A1420	Form work of covering precast slabs	A1410
A1430	Electric pipe installation	A1420
A1440	Steel eriction	A1430
A1450	Rc casting	A1440
A1460	Shuttering removal	A1450
A1470	Form work of r.c core columns	A1460
A1480	Steel eriction of rc columns	A1470
A1490	Rc columns casting	A1480
A1500	Shuttering removal	A1490
A1510	Form work of slab and stairs	A1500
A1520	Steel eriction of slabs and stairs	A1510
A1530	Rc casting of slabs and stairs	A1520
A1540	Shuttering removal	A1530
A1550	Anchor bolts of installation	A1520

Table B.1: Activities and relationships (Continued)

Activity ID	Activity name	Predecessor
A1560	Steel columns installation	A1410
A1570	Steel beams installation	A1560,A1550,A1540
A1580	Connection between columns and beams	A1570
A1590	Installation of precasted slab	A1580
A1600	Form work of covering precast slabs	A1590
A1610	Electric pipe installation	A1600
A1620	Steel eriction	A1610
A1630	Rc casting	A1620
A1640	Shuttering removal	A1630
A1650	Form work of r.c core columns	A1640
A1660	Steel eriction of rc columns	A1650
A1670	Rc columns casting	A1660
A1680	Shuttering removal	A1670
A1690	Form work of slab and stairs	A1680
A1700	Steel eriction of slabs and stairs	A1690
A1710	Rc casting of slabs and stairs	A1700
A1720	Shuttering removal	A1710
A1730	Anchor bolts of installation	A1700
A1740	Steel columns installation	A1590
A1750	Steel beams installation	A1740,A1730,A1720
A1760	Connection between columns and beams	A1750
A1770	Installation of precasted slab	A1760
A1780	Form work of covering precast slabs	A1770
A1790	Electric pipe installation	A1780
A1800	Steel eriction	A1790
A1810	Rc casting	A1800
A1820	Shuttering removal	A1810
A1830	Form work of r.c core columns	A1820
A1840	Steel eriction of rc columns	A1830
A1850	Rc columns casting	A1840
A1860	Shuttering removal	A1850

Table B.1: Activities and relationships (Continued)

Activity ID	Activity name	Predecessor
A1870	Form work of slab and stairs	A1860
A1880	Steel eriction of slabs and stairs	A1870
A1890	Rc casting of slabs and stairs	A1880
A1900	Shuttering removal	A1890
A1910	Anchor bolts of installation	A1880
A1920	Steel columns installation	A1770
A1930	Steel beams installation	A1920,A1910,A1900
A1940	Connection between columns and beams	A1930
A1950	Installation of precasted slab	A1940
A1960	Form work of covering precast slabs	A1950
A1970	Electric pipe installation	A1960
A1980	Steel eriction	A1970
A1990	Rc casting	A1980
A2000	Shuttering removal	A1990
A2010	Form work of r.c core columns	A2000
A2020	Steel eriction of rc columns	A2010
A2030	Rc columns casting	A2020
A2040	Shuttering removal	A2030
A2050	Form work of slab and stairs	A2040
A2060	Steel eriction of slabs and stairs	A2050
A2070	Rc casting of slabs and stairs	A2060
A2080	Shuttering removal	A2070
A2090	Anchor bolts of installation	A2060
A2100	Steel columns installation	A1950
A2110	Steel beams installation	A2100,A2090,A2080
A2120	Connection between columns and beams	A2110
A2130	Installation of precasted slab	A2120
A2140	Form work of covering precast slabs	A2130
A2150	Electric pipe installation	A2140
A2160	Steel eriction	A2150
A2170	Rc casting	A2160

Table B.1: Activities and relationships (Continued)

Activity ID	Activity name	Predecessor
A2180	Shuttering removal	A2170
A2190	Wall building	A1460
A2200	Installation of electricity pipes and wires	A2190
A2210	Plastering	A2200
A2220	Wall building	A1640
A2230	Installation of electricity pipes and wires	A2220
A2240	Plastering	A2230
A2250	Wall building	A1820
A2260	Installation of electricity pipes and wires	A2250
A2270	Plastering	A2260
A2280	Wall building	A2000
A2290	Installation of electricity pipes and wires	A2280
A2300	Plastering	A2290
A2310	Wall building	A2180
A2320	Installation of electricity pipes and wires	A2310
A2330	Plastering	A2320
A2340	Fire systen installation	A2330,A2210,A2240,A2270,A2300
A2350	Light and system installation	A2320,A2410,A2430
A2360	Water pumps installation	A2320,A2320
A2370	Elevator installation	A2320
A2380	Plumbing pipes installation	A2310
A2390	Bathroom accessories eriction	A2380A2420
A2400	Windows and doors framers installation	A2310
A2410	Indoor painting	A2330
A2420	Tilling	A2330
A2430	Finishing of electricity work	A2320,A2410
A2440	Outdoor painting	A2310
A2450	Windows and doors installation	A2400,A2410
A2460	Painting	A2340