Optimizing Project Cost: An insight into contractor's cash flow

By

Muhammad Adnan Alam Khan

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School of Civil and Environmental Engineering (SCEE)
National University of Sciences and Technology (NUST),
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Submitted by

Muhammad Adnan Alam Khan

(NUST201463358MSCEE15414F)

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_____

Dr. Muhammad Jamaluddin Thaheem

Supervisor,

Department of Construction Engineering and Management,

NIT-SCEE, NUST, Islamabad.

THESIS ACCEPTANCE CERTIFICATE

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Signature: _____

Supervisor: **Dr. Muhammad Jamaluddin Thaheem**

Date: _____

Signature (HOD):_____

Date: _____

Signature (Dean/Principal): _____

Date: _____

This thesis is dedicated to my father Mr. Mukhtar Hussain Khan!

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Abstract

Maintaining a healthy financial state of the project is a challenging task due to gap between cash inflows and outflows. Contractors in Pakistan face financial stress due to bureaucratic and procedural delays resulting into a low cash inflow and high cash outflows. The reason lies in the lack of proper management tools which can assist them in easing out their cash flows. This study aims at helping the contractors to optimize their cost and eventually maximizing their profit. Various factors reported in the literature have been identified to be incorporated in model which will be validated through case studies. The resulting model will help the contractor to foresee its cash flow profile right at the start of the project. The model will also help the contractor and client to negotiate for the mobilization advance and retention money to be deducted from contractors' payments. Therefore, it can also serve as the decision-making tool for contractor and client as well

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Chapter 1

INTRODUCTION

1.1 Introduction

Maintaining a healthy financial state of a project is a complex and tricky job for construction contractors (Al-Joburi et al., 2012; Liu and Wang, 2010; Lucko, 2010). It is a major challenge facing most of the construction organizations resulting into extremely tight cash flows for the major part of project duration. It has been observed that the contractor cash flow remains positive for a very short duration of time, which is during the start of the construction period when advance payments are received or at the end of the project defect liability period when retention money is released. Otherwise, during almost 70% of the total project duration, the cash flow remains on negative side (Al-Joburi et al., 2012). Apart from this, it has been inferred from the past research that sometimes the deficit gap between contractor's expenditures and reimbursements gets so large that it becomes impossible for the contractor to cover it, resulting into bankruptcy(Navon, 1996). Therefore, there is a strong need of managing the financial aspect of construction projects (Al-Joburi et al., 2012).

The first and foremost effort towards the effective management of company's financial health is precise forecasting of cash flow before the start of construction phase. This is done even before stepping into the tendering process in some cases. The cash flow forecasting can be used as a decision-making tool by the contractor to pre-decide as to when and how much financing will be required in case of owner-caused payment delays(Zayed and Liu, 2014). Apart from planning tool, it can also be used as a monitoring tool to help construction

financial managers to readily evaluate whether the deficit in the reimbursement and expense is within the acceptable limit.

Another important tool towards the project financial management is finance-based schedules. These schedules are prepared keeping in view the constraints of cash capacity of the contractor as done by Abido and Elazouni (2010), andElazouni and Metwally (2005). The finance-based schedules incorporate the cash constraints to calculate the planned duration of the activities. It is an activity level approach with cash constraint as the governing factor to control the time/duration of activities and hence the overall project. Cash flow forecasting together with the finance-based scheduling technique can help contractor to complete the project with an optimized profit.

1.2 Background

Vehicle of Pakistan's construction industry is not running at its fullest. For the financial year 2002, the compound annual growth rate (CAGR) for this industry was computed well below 2% in comparison to the CAGR of the 4% for the overall GDP during this period. It was decided by the government at that time to give a boost to this industry. Because of which this industry was able to contribute a maximum of only 18% against the country's GDP of 9% in FY 2005 using base year 2000. The industry started decline in its share towards country's GDP till 7% against 4.24% of country's overall GDP. During the period FY2002-FY 20015, this industry also faced a negative value of 8.56%,9.88% and 10.7% for FY 2011,2009 and 2004 respectively against the overall GDP of 3.62%,0.36% and 7.5% for respective years. Even for the FY 2016-17, this industry has only achieved GDP of 9.05% against the target of 13.2%(SBoP, 2015).The reason for this great variability and lagging behind the target is that due attention has not been given to explore and solve the problems of contractors because of which they become reluctant to invest more in this industry. Hameed and Woo (2007) also reported that as per the JCR (2003), construction industry has lagged behind the rest of the

economy in terms of growth, mainly due to cost and management related issues. Unfortunately, the previous research has not focused the construction industry of Pakistan. Although few studies have been carried out including Azhar et al. (2008)in which only the factors of cost overrun have been investigated. No such attempt has been made to give the solution for the problems highlighted here. Therefore, in order to make this industry influential towards the country's economic growth, there is a concrete demand of finding the root problems and devise solutions for the Pakistani construction industry (Hameed and Woo, 2007). This research will help to find out the factors for cost related issues and achieve the optimized or near-optimized cost-based model, which will eventually lead towards the optimized profit for a construction project basing on the scenarios of the Pakistan construction industry.

1.3 Significance of Study

As discussed above, construction industry is not fulfilling the due requirement of country's GDP and is quiet in effective towards the economy of Pakistan, despite being the fact that it is the most job creating industry. Therefore, the research will be an advancement towards the increase in the profit markups and cost savings of the construction industry which will add up to the country's GDP. Working in this field will be a step towards the improvement of the financial conditions of construction projects which will ultimately lead to the overall saving of the cost. In this way contractors, who are held, more responsible towards the risk of this industry' will be more willing to invest in construction industry rather than switching altogether towards the other industries.

1.4 Problem Statement

As discussed above, Pakistan's construction industry was not considered in these studies. As a matter of fact, Pakistan's construction industry is far more different in terms of construction methodologies, size of the industry, risk responsibilities and awareness, financial stability and

level of managerial strategies. So, the research models (detail of these models is given in Chapter 2) proposed by various researchers, fail to satisfy the trends observed in construction industry in Pakistan. According to Azhar et al. (2008) and Hameed and Woo (2007), Pakistan's construction industry is facing a severe pressure of financial instability and uncertainty. Therefore, there is a need for studying this industry.

1.5 Research Objectives

The main objectives of the study are;

I. To identify the factors affecting cost of project.

I. To formulate the model for cost optimization.

II. To validate the developed model.

1.6 Research Contribution

The research will be a way forward in determining the factors that take parts in controlling the cost of construction projects as far as Pakistan's industry is concerned. Furthermore, this research will be a tool for managers and owners to manage these factors in order to achieve the objective/goal of optimized profit for a project. The model so developed will also be a tool in evaluating the financial status of the project at any given time.

1.7 Thesis Scope

The area of cost optimization is very vast. It can include various stakeholders' perspective (i.e. client, consultant investor and contractor etc.). It is nearly impossible to study all the stakeholders at the same time. Doing so definitely need time and resources. Keeping in view the constraints of time and resources, the scope of this thesis will be limited to contractors' perspective i.e. analysis of cash flow from contractor's point of view, how the contractor can optimize his/her profit. Reason for limiting the scope of thesis for contractor's part only is that the contractor is at more risk than the other stakeholders as perHameed and Woo (2007).

Similarly, considering the geographic constraint of construction industry and keeping in view the fact that Pakistan construction industry is least studied by international researchers the scope will also be limited to the Pakistan construction industry. The Construction industry of Pakistan is different from the rest of the world in terms of risk assignment, the factors of cash management

1.8 Research Structure

Chapter 1 covers the 'Introduction' part of the study. It contains scope of study, problem statement and significance of the study. Chapter 2 is 'Literature Review'. It gives a brief idea about the previous studies. Chapter 3 is about the 'Methodology' to be followed in this study. Chapter 4 and 5 covers the 'Data Collection/Model Formulation and Model Implementation/Analysis', respectively. Chapter 6 will highlight the 'Results and Discussion' part of the study.

Chapter 2

Literature review

2.1 Introduction

The chapter provides a brief overview of the previous research carried out related to the study. Chapter starts with the basic definitions of keywords related to field of research. Last portion of the chapter covers a critical overview of the studied content.

2.2 Cash Flow

According to Jiang et al. (2011) cash flow is the record of cash disbursement, loans, shortage, cost of money and any type of earnings as a result of work done. They have defined cash flow in the perspective of a project. However, Liu et al. (2009) has defined the term in a different way. According to them it is the balance of what is being received at a specific time during a project and what is being spent in the form of cash. On the other hand, Chen et al. (2005) has described the cash flow at business level (which might include several projects at the same time). As per his definition cash flows are the inflows and out flows of cash which move into and out of the business. As per his statement, for a business, the inflows could be the sales flows which are comprised of income received from the client under some contractual agreements, whereas out flows are the overhead flows and disbursements. Navon (1996)proposed the simplified equation for cash flow. According to that equation cash flow are the difference between income flows, expenses and overheads. He used the word 'cost flow' instead of cash flow and has also related the term with time. According to his definition of cost/cash flow, it is the prediction of project cost as a function of time. A remarkable advancement had been made by Arif et al. (2015). Although their work does not include any model formulation for cash flow assessment but they have dug out factors which have influence on the management of cash flow. About 60 factors had been identified and were

labelled as I, O and I&O according to the effect on the inflow, outflow or both respectively. Similar effort has been done by Zayed and Liu (2014), by identifying 43 factors which can affect the cash flow. After doing the literature review it has been inferred that cash flow is a combination of two parameters;

I. Cash inflows/ Cash moving into the system/project/business
II. Cash outflows/ Cash moving out of the system/project/ business

In order to get the clear idea of what the cash flow is all about and to make a foundation for our model it is important to develop a deep insight of these to parameters. The next two sections will discuss the above-mentioned parameters.

2.2.1 Cash inflow

Abido and Elazouni (2010) defined cash inflows as those payments which a contractor is subjected to receive after the completion of work. However, Abido and Elazouni (2010) has not considered the payments as received in the form of loans or mobilization as considered by El-Kholy (2014) and Jiang (2012). Similar definition has been provided by Navon (1996), as income flows is the monetary value of contractor's earning against the work done. Jiang et al. (2011) has defined the inflow in a graphical manner. The cash flow can be depicted in form of a network containing arrows and nodes. Arrows represents the transactions of money while nodes represent the specific point in time where change in flow occurs. In this way arrows pointing towards the node can be regarded as inflows. This could be any form of cash (be it work payments as said by Abido and Elazouni (2010) or some other payments). However,Hyung-Keun (2004) used a different approach to express and derive the cash flow. According to him cash flow can be some percentage of the project expenses evaluated during the planning or bidding phase. This approach is called the moving weight method.

2.2.2 Cash outflow

Cash out flow is the term mainly used to describe the project expenses as suggested by Park et al. (2005) and Navon (1996). However, considering only the project expenses under this head does not complete the definition of cash out flow as there are other items that needs to be included within cash flow in order to complete this definition. The need was understood by Kishore et al. (2011) who included overheads, Bid cost and Disbursements within cash outflow. Along with the project cost, Liu and Wang (2008) and Elazouni (2009) also included Bid cost as part of the cash outflow for construction projects. In general, it has been agreed upon by all the researchers that cash flow can be regarded as that money which moves out of the project cash line is termed as cash flow. For those firm whose cash flow is not strong and mainly rely on the loans from bank, the cash out flow also include the cost of money paid against the loans Jiang et al. (2011)

2.3 Cash Flow Management

The importance of cash flow management cannot be neglected. According to Barbosa and Pimentel (2001)cash flow management has strategic importance for any project. Zayed and Liu (2014) has linked it with the survival of contractors. This is because cash is a resource Singh and Lokanathan (1992)and unlike other resource it starts depleting over the passage of time. Due to the lack of proper management tool to control this resource many contractors become the bankrupt. Not only this, even profitable companies start failing without proper cashflow management(Liu and Wang, 2009). The success of a project lies on the proper and efficient utilization of cash management tool. A project cannot be considered successful even though it is leading in time but its cash aspect is very weak.

Table 2.1: Summary of the research work carried out for cash flow management

Reference	Definition of cash flow	Definition of cash inflow	Definition of cash outflow	Methodology
Jiang et al. (2011)	Cash flow is the record of cash disbursement, loans, shortage, cost of money and any type of earnings as a result of work done.	Short term loans, long Term loans and owner's progress payments	Project Expenses, paid off short term loans and cost of money (including short term and long-term loans)	Pareto optimality efficiency network model
Zayed and Liu (2014)	The balance of what is being received at a specific time during a project and what is being spent in the form of cash.	The expense of the project at the specific time	Estimated expense of the project at the specific time	Integrating analytic hierarchy process (AHP)
Chen et al. (2005)	The inflows and out flows of cash which move into and out of the business.	Sales flows which are comprised of income received from the client under some contractual agreements	The overhead flows and disbursements	Pattern matching logic and factorial analysis
Navon (1996)	Cash flow is the difference between income flows, expenses and overheads.	The monetary value of contractor's earning against the work done plus additional elements like capital contributions from investors, down payments form customers, Construction loans and line of credit drawn	Cash outflow is the expense flow which is the sum of cost flow and time lag *expense flow =cost flow + time lag*	Company-level cash-flow management model
Abido and Elazouni (2010)	No clear definitions of cash flow.	The payments contractors receive, at the ends of periods, as an earned value of the accomplished works calculated based on the unit prices	Cash out-flow during a typical period encompasses costs of overheads and taxes in addition to the direct costs including the costs of materials, equipment, labor, and subcontractors	A strength pareto evolutionary algorithm SPEA
Kishore et al. (2011)	At a firm level, portfolio net cash flow is a function of the cash flows of all concurrent projects at various stages of completion.	The periodic payments received from the owner on the basis of project milestones achieved over the project's life cycle	Bid cost, preconstruction cost, materials/labor/ equipment payments and overheads	Fuzzy systems
Khosrowshahi (2000)	The timely aggregate of the cash coming in (income flow) and cash leaving (expenditure flow) the Project	Monthly payments that are based on the evaluation of the work carried out during the month, as agreed by the quantity surveyors of the contractor and the client	The cash-out (expenditure flow) consists mainly of the cost of labor, material, plant and machinery, sub- contractors, and office and site overheads	Visualization based on objective evaluation of the relationship between shape variables and project definition
Arif et al. (2015)	No discussion about cash flow management. Just identified the factor effecting the cost estimates in Pakistan construction industry.	N/A	NA	A rigorous analysis framework based on principal component analysis and regression analysis was used a two-stage statistical analysis framework
Zayed and Liu (2014)	The balance of received and spent cash on a project over a specific duration			Integrating analytic hierarchy process and simulation
Jiang (2012)	No clear definitions of cash flow.	Capitals, such as down payments from customers, front money from owners	Paid off short term loans, cost of money retainage	Multi-period dynamic optimization model
Barbosa and Pimentel (2001)		Interest gains, constrictors' earnings, Short term Loans, Long term loans	Cost forecast, Overheads	Linear programming model
Yu et al. (2017)	The project cash flow can be calculated by summing up the cost distribution per unit of time for all activities throughout the entire project duration	Contractor's payments after the completion of milestone	Direct and indirect costs such as overhead expenses	Uses fuzzy DSM based scheduling and proposes an algorithm to calculate the cash flow and overdraft at different risk levels
Purnus and Bodea (2016)	The project cash flow includes the contractor costs with labor, materials, equipment and transport, other direct costs and overhead, profit and incomes from the payments, according with contractual clauses	Profit and incomes from the payments, according with contractual clauses	Costs with labor, materials, equipment and transport, other direct costs and overhead	Multi criteria decision making
Hwee and Tiong (2002)	The net values obtained from the cash inflow curve and cash out flow curve give the predicted cash flow	Retention percentage and Limit, Payment delays form client, Defect Liability period	Monthly material cost, S. Contractor cost, Labor cost, Plant cost, Indirect cost	CAFFS (cash flow forecasting system)
Liu and Wang (2008)	The net cash flow is the sum of cumulative cash flow and payments made in a specific period. Whereas cumulative cash flow includes cash balance of previous plus the expenses of current period	Payments made for each activity	Over heads, Mobilization cost, Taxes, Bonds	Constrained programming model
Elazouni (2009)	The net balance available at the end of a specific period	Advance payments	Expenses incurred for completed activities, Mobilization Cost, Bond cost, Taxes	Heuristic method for multi projects
Elazouni and Metwally (2005)		Fraction of cash out flow (P=KE) P = Payments made monthly E= Cost disbursements K = Factor/ multiplier	Direct cost disbursements, Over heads, Taxes, Bonds	
Zayed and Liu (2014)	The mathematical sum of all cash inflows and outflows	Initial capital (IC), long term loan (LTL), and short-term loan (STL)	Project Expense, Cost of short term loan, Cost of long term loan, retainage by owner	Fuzzy linear programming

Reference	Definition of cash flow	Definition of cash inflow	Definition of cash outflow	Methodology
Park et al. (2005)	A complete history of all cash disbursement and all earnings received as a result of project execution	Cash in such as billings less retentions, retentions, claims and change orders	Bid costs, preconstruction costs engineering, design, mobilization, etc., materials and supplies, equipment and equipment rentals, payments of subcontracts, labor and overhead	Moving weight method
Kaka and Price (1991)	The net cashflow is the result of subtracting cash-out from cash-in curves	Deduced from the cash value curve which is further deduced from the cash out curve.	Labor, Plant, S. Contractor, Material, Site overheads	Net cash flow model using lotus 123 spread sheets
Purnus and Bodea (2015)	Each project cash flow is composed from the project costs and the incomes from the payments, according the time period stated in the individual contracts	Payments, financing to project	Costs with manpower, materials, equipment's, transport, other direct costs and overhead, return of financing	
Chen (2003)	Cash flows are the inflows and outflows of cash into and out of a business. From a modeling perspective, cost flows are defined as predictions of payment flows	Inflows are composed of sales flows, Sales flows represent income based on contractual agreements with clients regarding activity and project completion	Overhead flows are the disbursement of the overhead costs, field and main office as a function of time. Payment flows are disbursements	Cost-schedule integration technique
Karshenas and Haber (1990)	Net cash flow for project is the revenues less Expenses	Not considered cash inflow in his model	Resource cost is taken as the major cash out flow. Resources include Equipment, Labor and Material	Mathematical modelling of the objective function
Kaka (1996)	No proper definition of cash flow. Discusses mainly about cash in and cash out	%age of material paid for being at site (Secure advance), Value of measured work	Labor, Plant, S. Contractor, Material, Site overheads	
Hyung-Keun (2004)		Earned value is converted to the cash-in by deducting retention and applying billing time.	Different cost categories are defined for materials, labor, equipment, subcontractors, expenses (site overhead), main materials, and depreciation items	Moving weight method
Kenley (1999)		%Age value of the work completed	Labor, plant, sub-contractor, material, site overhead, cost of delay	
Chen and Chen (2000)		Not considered cash inflow in his model	Project cost, Material payable, Equipment	A Prototype integration model

Therefore, there must be some tool/ model to effectively monitor the management of cash flow. Due to its accepted importance the various researchers have worked on the cash flow management. It is difficult to discuss all, however the summary of the work carried out in past is given below in Table 2.1.

2.4 Cash Flow Management Models

In the past various models have been proposed for cash flow management. These models differed from each other by the input data required, objectives and the performance measuring indicators. A brief summary of the models proposed in the previous research are given in Table 2.2.

Table 2.2: Cash flow management model

Sr /No.	Publications	Study objectives	Tools and techniques
1	Jiang et al. (2011)	Optimization of profit/ final cash balance or the minimization of project cost	Pareto optimality efficiency network model
2	Zayed and Liu (2014)	Examination of the impact of factor on contractor's cash flow	Integrating analytic hierarchy process (AHP)
3	Chen et al. (2005)	To assess the accuracy of cash flow models	Pattern matching logic and factorial analysis
4	Navon (1996)	To develop the company level cash flow system	Company-level cash-flow management model
5	Abido and Elazouni (2010)	To optimize the set of two/ three objective combinations.	A strength Pareto evolutionary algorithm SPEA
6	Kishore et al. (2011)	To forecast the cash flow requirements	Fuzzy systems
7	Khosrowshahi (2000)	To provide a visual aid to contractor to optimize benefits	Visualizations are based on objective evaluation of the relationship between shape variables and project definition

Sr /No.	Publications	Study objectives	Tools and techniques
8	Arif et al. (2015)	To identify the factor influencing the accuracy of cost estimates	• A rigorous analysis framework based on principal component analysis and regression analysis was used • A two-stage statistical analysis framework
9	Zayed and Liu (2014)	To examine the impact of issues influencing the contractors' cash flow	Integrating analytic hierarchy process and simulation
10	Jiang (2012)	To maximize final cash balance by negotiating financial term	Multi-period dynamic optimization model
11	Barbosa and Pimentel (2001)	To address the problems of cash flow for a single project	Linear programming model
12	Yu et al. (2017)	To calculate cash flow and over draft at different risk levels	Uses fuzzy DSM based scheduling and proposes an algorithm to calculate the cash flow and overdraft at different risk levels
13	Purnus and Bodea (2016)	To examine the conditions of contract and to provide practical tool for decision making	Multi criteria decision making
14	Hwee and Tiong (2002)	To develop a computer program that has the ability to forecast the cash flow. To study the impact of factors on cash flow of projects	CAFFS (cash flow forecasting system)
15	Liu and Wang (2008)	To establish a resource constrained project scheduling model	Constrained Programming model
16	Elazouni (2009)	To develop a heuristic multi project scheduling subject to cash constraint	Heuristic method for multi projects
17	Elazouni and Metwally (2005)	To prepare finance based schedule to maximize the profit	Improved genetic algorithm
18	Zayed and Liu (2014)	To resolving the optimization problem of three conflicting objectives: final cash balance, cost of money, and initial cash balance	Fuzzy linear programming
19	Park et al. (2005)	To provide a tool that can be used even during the construction phase of project.	Moving weight methods
20	Kaka and Price (1991)	To develop a reliable net cash flow model	Net cash flow model using lotus 123 spread sheets
21	Purnus and Bodea (2015)	To develop a practical cash flow analysis model at project portfolio level	Cash flow analysis model

Sr /No.	Publications	Study objectives	Tools and techniques
22	Chen (2003)	To assess the accuracy of cash flow models	Cost- Schedule integration technique
23	Karshenas and Haber (1990)	To minimize the sum of all the costs of resources including time	Mathematical modelling of the objective function
24	Kaka (1996)	To predict the cash flow values	Stochastic simulation techniques
25	Hyung-Keun (2004)	To forecast the cash flow of construction project	Moving weight method
26	Kenley (1999)	To focus on the funds generated from the operations and to and positive benefits which can follow a well-managed firm	Monty Carlo simulation
27	Chen and Chen (2000)	to propose a model to solve cognitive problems of integrating money and time	A Prototype integration model

2.5 Factors Affecting Cash Flow Management

After reviewing the literature various factors have been identified which have influential effect on the management of cash flow. All of these factors are quantitative in nature. In some of the studies as done by (Zayed and Liu, 2014), Arif et al. (2015) and Liu et al. (2009) qualitative factors were identified. But these qualitative factors are beyond the scope of this research as these factors are difficult to estimate and vary subjectively based on the conditions and experience of a project managers. Also, these qualitative natured factors if used will impose accuracy problems. As far as factors in this study are concerned, these factors have been divided into two main categories i.e. Cash outflow and cash inflow. About 11 factors were sorted out under the heading of cash outflow. Likewise, 7 factors were identified in order to study the cash inflow. These factors have been used by various researchers in order to develop their models.

Table 2.3: Factors affecting the cash flow management

S/No.	Category	Factors	Papers	Frequency
1	Cash outflow	Project Expense	Jiang et al. (2011);Navon (1996);Elazouni (2009);Zayed and Liu (2014);Chen et al. (2005);Chen and Chen (2000)	6
2		Paid off short term loans	Jiang et al. (2011);Jiang (2012);Purnus and Bodea (2015)	3
3		Cost of money	Jiang et al. (2011);Jiang (2012);Purnus and Bodea (2015)	3
4		Over heads	Chen et al. (2005);Abido and Elazouni (2010);Kishore et al. (2011);Khosrowshahi (2000);Barbosa and Pimentel (2001); Yu et al. (2017);Purnus and Bodea (2016);Hwee and Tiong (2002);Liu and Wang (2008);Elazouni and Metwally (2005);Park et al. (2005);Kaka and Price (1991);Chen et al. (2005);Kaka (1996);Park (2004);Kenley (1999)	16
5		Disbursements	Chen et al. (2005);Abido and Elazouni (2010);Kishore et al. (2011);Khosrowshahi (2000);Yu et al. (2017);Purnus and Bodea (2016);Hwee and Tiong (2002);Elazouni and Metwally (2005);Park et al. (2005);Kaka and Price (1991);Purnus and Bodea (2015);Chen et al. (2003);Karshenas and Haber (1990);Kaka (1996);Park (2004);Kenley (1999)	16
6		Taxes	Abido and Elazouni (2010);Liu and Wang (2008);Elazouni (2009);Elazouni and Metwally (2005)	4
7		Bid Cost	Kishore et al. (2011);Park et al. (2005)	2
8		Pre-construction cost	Kishore et al. (2011);Park et al. (2005)	2
9		Retainage	Zayed and Liu (2014)	1
10		Bonds	Liu and Wang (2008);Elazouni (2009);Elazouni and Metwally (2005)	3
11		Cost of delays	Kenley (1999)	1
1	Cash inflow	Shor term Loans	Jiang et al. (2011); Navon (1996); Jiang (2012); Barbosa & Pimentel (2001); Zayed and Liu (2014)	5

S/No.	Category	Factors	Papers	Frequency
2		Long term loans	Jiang et al. (2011); Navon (1996); Jiang (2012); Barbosa & Pimentel (2001); Zayed and Liu (2014)	5
3		Owner's Payments	Jiang et al. (2011); Chen et al. (2005); Navon (1996); Abido and Elazouni (2010); Kishore et al. (2011); Khosrowshahi (2000); Jiang (2012); Yu et al. (2017); Purnus and Bodea (2016); Liu and Wang (2008); Park et al. (2005); Purnus and Bodea (2015); Chen et al. (2003); Kaka (1996); Kenley (1999)	15
4		Capital contribution from investors	Navon (1996); Purnus and Bodea (2015)	2
5		Down payments from customers	Navon (1996)	1
6		Front money	Jiang (2012); Elazouni (2009); Zayed and Liu (2014); Kaka (1996)	4
7		Contractor's earnings	Barbosa andPimentel, (2001); Purnus and Bodea (2016); Park et al. (2005)	3

Chapter 3

Research Methodology

This chapter briefs about the general procedure and methods which have been adopted to achieve the objectives of the study. The chapter starts with demonstration of the overall research strategy using a flow chart. The proceeding section describe the possible tools and techniques to achieve the objectives.

3.1 Research Strategy

A follow up sequence to move towards the end of the study is given in Figure 3.1. The study was divided into three main phases. The first phase comprised of the theoretical aspect of the area of study. Under this phase, an extensive literature review was carried out. This phase was a way forward in achieving the first objective of the study i.e. to identify the factors affecting the cost of the project. The second phase of the study comprised of setting constraints to the identified factor, along with the primary data collection for modelling purpose. This phase was linked to the second objective of the study i.e. to formulate the model. The third objective i.e. to validate the proposed model achieved by collecting secondary data and applying it to the model. In Table 3.1, information is given regarding the tools and techniques likely to be applied on each step mentioned in the Figure 3-1.

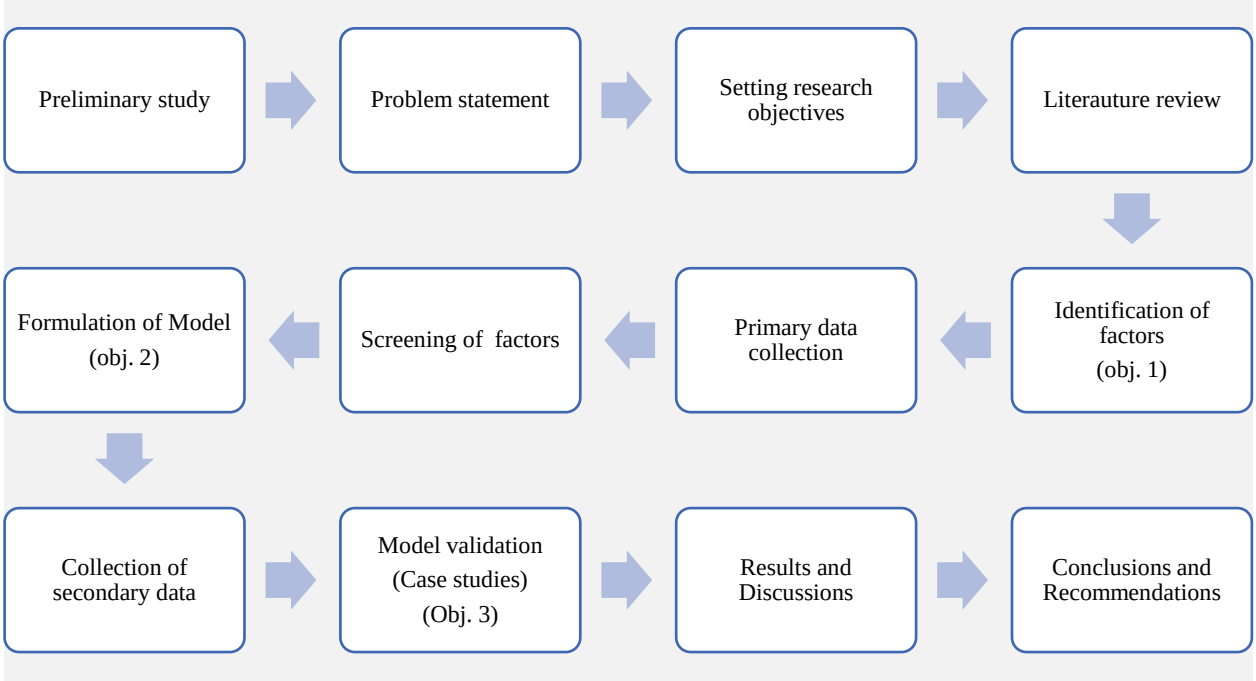

Figure 3.1: Flowchart of research methodology

3.1.1 Primary data collection

Primary data mainly encompasses the factor identified in literature review. A self-explanatory questionnaire survey was developed which was floated among the field experts. And their opinion was sought. The questionnaire consisted of two sections with first seeking the general information about the respondent. In the later section six questions were asked. Each question had sub sections. These sub sections were mainly the factor about which opinion of the respondents were required. The factors were mainly grouped into two categories i.e. (I) Factor affecting the cash inflow and (II) Factors affecting the cash out flow. With respect to the time of occurrence these factors were divided into three categories i.e. (I) Factor affecting before the start of the project, (II) Factors affecting during the execution of the project and (III) Factors affecting at the end of the project.

Keeping in view the fact that the objective of the survey was to screen the factors and not the ranking of the factors, the options were kept in the form of Yes and No. The respondent was also given freedom to express his own view regarding the factors if he/she thinks that instead

of the factors listed some other factors play role in project cost. A sample questionnaire is given at Annexure- I

3.1.2 Screening/Selection of factors

On the basis of the results obtained after the completion of the survey, %age for each option (i.e. Yes & No) against each factor was obtained. A thresh hold was set and all the factors were compared against the set thresh hold. Factors below the set thresh hold was screened out and was not taken into further consideration for the model formulation. Results of the survey will be discussed in the succeeding chapters.

3.1.3 Model formulation

There are various tools available which can be used for the purpose of model development, the simplest one being the excel add in i.e. solver. Other useful tool being MATLAB, MAPLE etc. Main shortcoming in using Excel was that its outputs were limited to single value only and solver cannot give results for entire range of the variables at one time. Therefore, it was discarded and MATLAB was selected for this purpose. MATLAB has advantage over Excel solver as said by Demuth and Beale (1993)that it can give solutions over entire range of variable and can perform iteration faster than Excel solver. Complete detail of the model is given in next chapter.

3.1.4 Secondary data collection

Actual project data was gathered from two projects. This data mainly consisted of the work plan showing the duration of the project, planned expenditure detail of project. Apart from this, certain other details like monthly turnover of the company, maximum acceptable cash gap which a company can afford, overheads of the company, expected pre-construction cost, monthly disbursements of the company in terms of %age etc. were also gathered

3.1.5 Model validation

Based on the data collected from real time projects, the developed model was validated. Data from two projects were obtained and case studies were carried out. Output of the model was checked for each case study and graph against the decision variables were developed through the MATLAB.

3.1.6 Analysis and discussion

Results obtained from the model validation were analyzed and conclusions were made. The analysis mainly consisted of various possible option that can be generated for the decision variable. Further explanation to this section is being given in next chapters.

3.1.7 Recommendations

Finally, some recommendations were made for researcher who want to further explore this area of study. The detail description is given in the recommendation section of this book.

Table 3.1: Description of tool and techniques for achieving Objective

Objective	Steps involved	Tools and techniques
To identify factors affecting cost of project	Preliminary study	Literature review, research papers, previous thesis
To develop model for cost optimization	Setting the performance indicators	Frequency analysis, ranking of the identified factors
	Primary data collection	Project data, Surveys from field experts
	Setting constraints to PIs	By expert opinion, finding the general trends in the market,
	Model formulation	Use of simulation techniques, Monte Carlo, Algorithms, MATLAB etc.
To validate the proposed model	Secondary data collection	Help from the construction companies
	Implementation of model	Case studies

Chapter 4

Data Collection

The chapter discusses the data collected for the purpose of model formulation and its validation. The data was collected in two stages i.e. at the start of the study when screening of identified factors was required and later after the formulation of model, its validation was required. The complete detail will be discussed in the proceeding sections of this chapter.

4.1 Preliminary survey

With the objective of selecting/screening the factors a preliminary survey was conducted. The aim of the survey was to select those factors which are influential, only in Pakistan construction industry. For this purpose, a questionnaire survey comprised of six questions were floated among the field experts. The general division of the questionnaire survey is given in Figure 4.1.

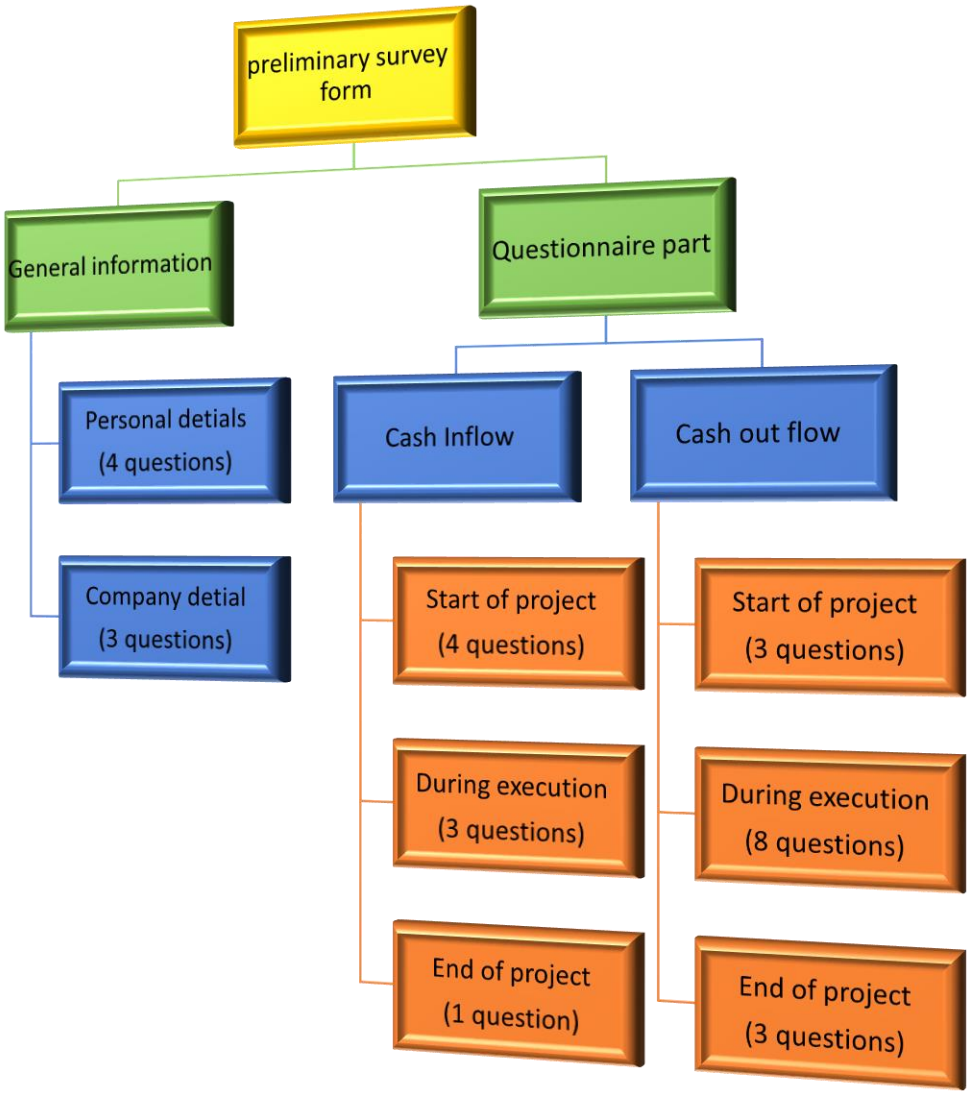

Figure 4.1: Major division of Questionnaire form

4.1.1 Characteristics and frequencies of respondents

Total of 33 responses were gathered. The detail and characteristics of the respondents are given below.

4.1.1.1 Source of respondent

In order to get maximum response this activity was carried out through both the sources i.e. manually and by means of internet (i.e. Google form).Out of 33 responses, 18 (55%) respondents used online source to fill survey form whereas 15 (45%) respondents showed interest in manually filling of forms.

4.1.1.2 Sector of respondents

Complete detail of the respondent groups is given in fig 4.3.Maximum response was given by semi government organizations (like FWO, NLC, NESPAK etc.), whereas very less response was seen from public sector organization.

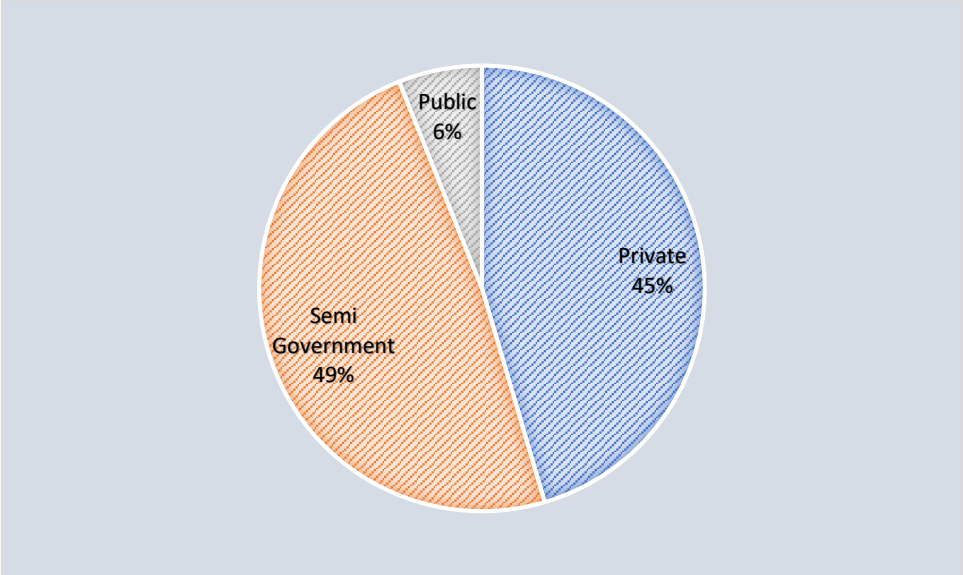

Figure 4.2: Percentage response by Sector

4.1.1.3 Experience of respondents in construction industry

Major share of response was given by respondents who fall in the category of 1-5year experience, 7 (21%) respondents had experience in between 5-15 years, 1 (3%) respondent had experience of 15 -30 years and 3 (9%) respondents had experience more than 30 years. Figure 4.3 gives the complete detail of all the categories

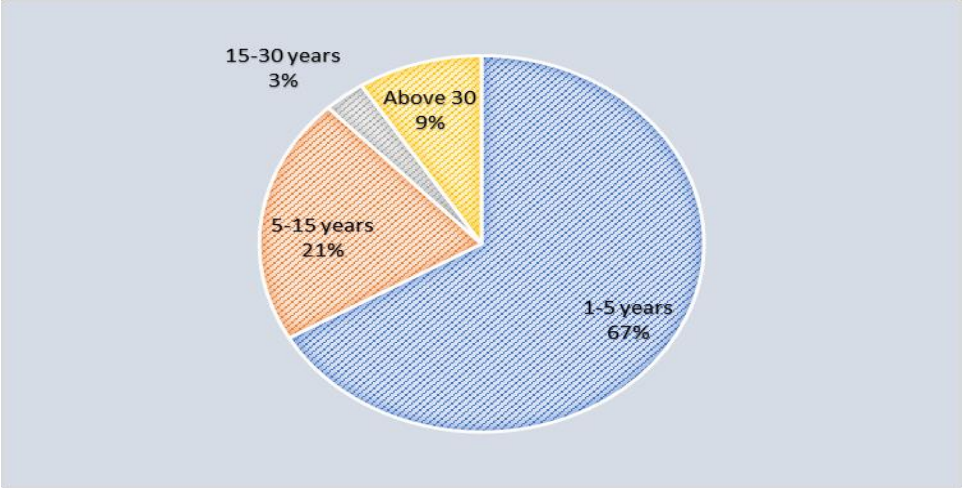

Figure 4.3: Percentage responses by experience

4.1.1.4 Positions of respondents in construction industry

Maximum number of responses were given by project managers followed by the planning managers. This is because of the fact that these key personals are more involved in planning of cash flows. Very less number of responses were given by construction managers. Some responses were also gathered from the financial analyst because these are also involved in cash flow planning process in some way or the other. The complete detail is given in figure 4.4.

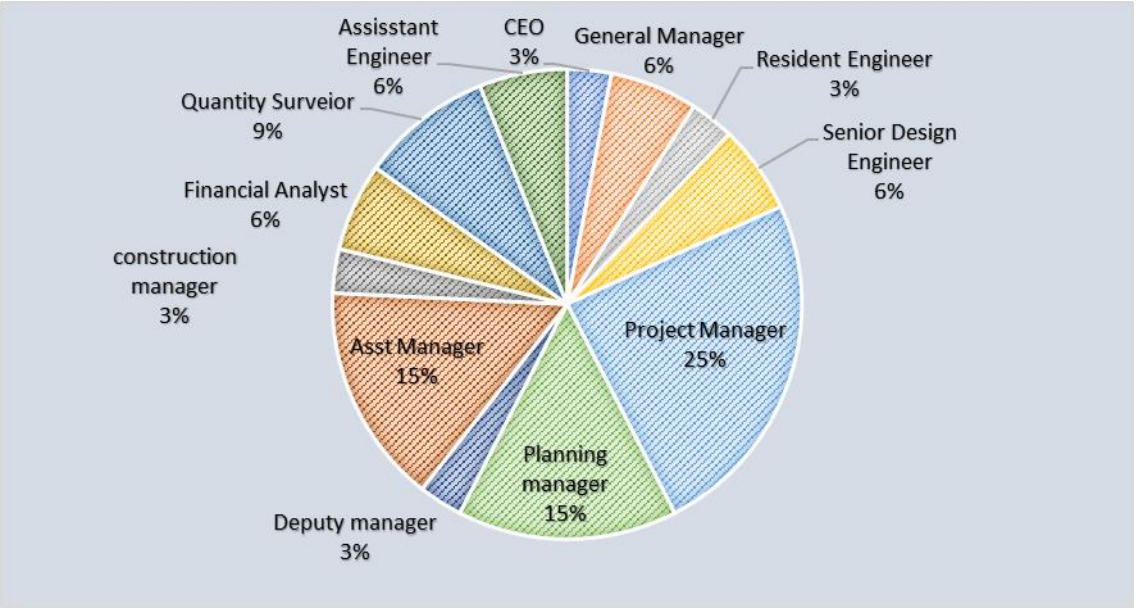

Figure 4.4: Percentage by position of respondents in construction industry

4.1.1.5 Types of Projects

Commercial and highway category contain about 9 % of respondents whereas 3 % of the respondent were involved in three types of project i.e. commercial, highways and industrial. The major portion of respondents belong to highway and road projects and that constitute about 42 % of the total respondents. Similarly, 6 % of the responses were from those respondents who were involved in only one type of project i.e. residential. Responses from residential along with commercial and residential along with infrastructure could make about 3 % in each combination type. Figure 4.5 explains the proportion of all the categories.

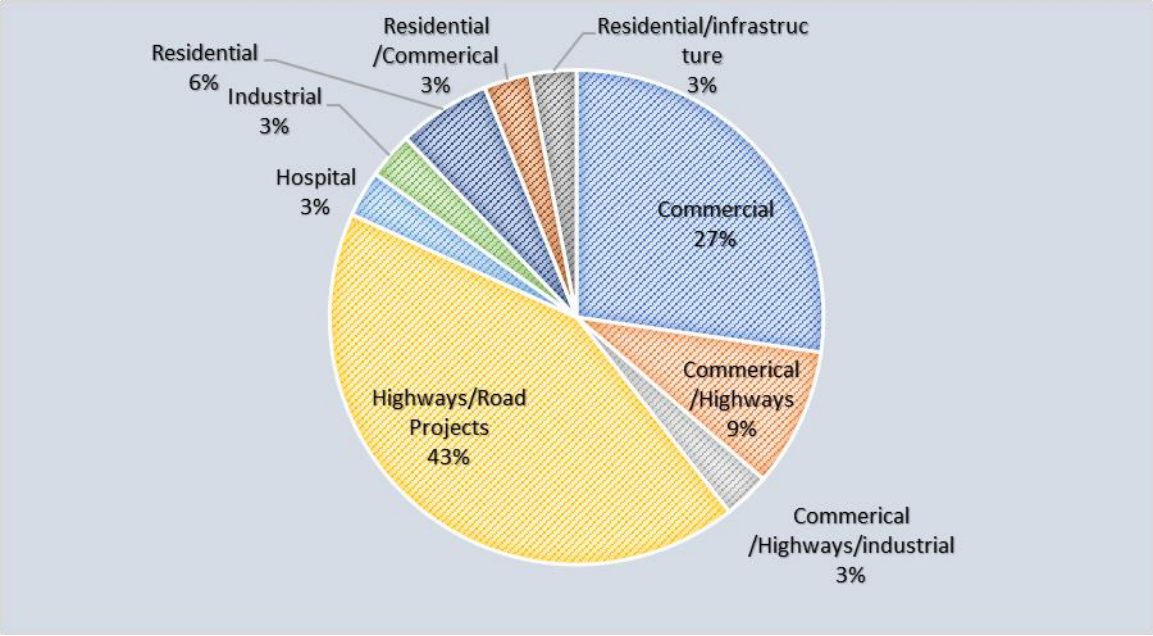

Figure 4.5: Types of Projects mostly executed

4.2 Results of the preliminary survey

Interpretation of the survey results is given in annexure-II. However, summary of the results is given in table 4-6. After getting the results a threshold of 75% was set for the screening of the factors. On the basis of this threshold, 3 factors i.e. Front money, Long term loan and short-term loans were ruled out form the list of cash inflow factors and 5 factors were

selected for model development (given in section 4.2.1). Similarly, for cash outflow 8 factors out of 14 were discarded and only 6factors (given in secton4.2.2) were chosen for modelling purpose.

4.2.1 Cash inflow factors

List of the selected factors is given below;

- Capital contribution from the investors
- Mobilization advance
- Owner's payments
- Contractors earning from other projects
- Retainage release

Out of the above factors, Capital contribution and mobilization advance are influential at the start of project. Owner's payment and contractor's earning are the source of income/cash inflow during the execution of project whereas Retainage release is the source of income at the end of project.

4.2.2 Cash outflow factors

Those factors which were selected as source of cash outflow are listed below;

- Pre-Construction cost
- Project expenditure
- Over heads
- Disbursements
- Taxes
- Demobilization cost

Pre-Construction cost take part only at the start of project. Project Expenditure, Overheads, Disbursements and Taxes are regards as source of cash outflow throughout the execution of the project whereas only one factor i.e. Demobilization cost belongs to the end phase of the project.

Table 4.1: Summary of the survey results

			Yes	No	Total	%age
Cash inflow	Start of Project	a. Capital contribution from investors	26	7	33	78.8
		b. Front money (e.g initial amount which is readily available for startup of project)	20	13	33	60.6
		c. Mobilization advance	29	4	33	87.9
		d. Long term loan	11	22	33	33.3
	Mid of Project	a. Short term loans	17	16	33	51.5
		b. Owner's payments (e.g IPCs, Payment Certificates)	30	3	33	90.9
		c. Contractors' earnings (e.g Earnings from other ongoing projects)	25	8	33	75.8
	End of Project	a. Retainage release	28	5	33	84.8
Cash outflow	Start of Project	a. Bid cost (e.g Bid Security)	24	9	33	72.7
		b. Pre-construction cost (e.g cost for equipment purchase, cost to establish site office etc)	31	2	33	93.9
		c. Bonds (e.g Performance Bonds, Bank Guarantees, Insurances etc)	22	11	33	66.7
	Mid of Project	a. Project expenditure (e.g Rents, Project staff salaries, Utility bills etc)	31	2	33	93.9
		b. Cost of long term loans (e.g interest paid against long term)	22	11	33	66.7
		c. Cost of money (e.g due to any delays, rework etc)	21	12	33	63.6
		d. Overheads (e.g permanent employee salaries, head office expenses)	29	4	33	87.9
		e. Disbursements (e.g Payments to contractors or material suppliers etc)	25	8	33	75.8
		f. Taxes	27	6	33	81.8
		g. Retainage	18	15	33	54.5
		h. Short term loans	14	19	33	42.4
	End of Project	a. Demobilization cost	25	8	33	75.8
		b. Repayments of Long term loan	23	10	33	69.7
		c. Repayment of Short term loan for the end period	19	14	33	57.6

4.3 Secondary data

In secondary data collection phase data of real projects were gathered for the purpose of case studies and model implementation. A data sheet was prepared in which necessary information required to successfully run the model was collected. This activity was mainly based on interviews with the key personal of the companies from where data was collected. The sample data sheet is given in annexure- I. Table 4.7 contains the summary of data collected from the projects. For the purpose of confidentiality, actual name of project and their details are being omitted and are given arbitrary names.

Table 4.2: Secondary Data for case studies

Project name		Project A	Project B	Project C
Contract Amount	(Mn)	1243.516,168/-	4190.390,000/-	928.690,000/-
Project duration	(months)	25	21	30
Acceptable cash gap	(Mn)	370	-	-
Overheads	(%)	2	12.64	12.64
pre-construction cost	(%)	10	10	15
Disbursements	(%)	5	7	25
Taxes	(%)	5	-	-
Demobilization cost	(%)	10	15	20
Contractors Earning	(%)	5	-	-
Annual turn over	(Mn)	1100		

4.3.1 Expenditure plan of Project A

The expenditure plane of the project A is tabulated in table 4.8. This expenditure plan was submitted to the client at the time of start of project. The expenditure plan contains detail regarding planned monthly expenditure based on the planned work followed by percentage monthly expenditure which is further followed by Accumulative expenditure and accumulative percentage respectively.

4.3.2 Expenditure plan of Project B

Table 4.9 contains the expenditure plan of project B. It contains detail similar to project A i.e. planned monthly expenditure, percentage monthly expenditure, accumulative expenditure and percentage accumulative expenditure.

4.3.3 Expenditure plan of Project C

Expenditure plan of project C, is given in table 4.10. Like Project A and Project B, this plan contains monthly expenditure plan provided by the client along with the percentage monthly progress, accumulative and accumulative percentage for the plan.

Table 4.3:Expenditure Plan for Project A

S/No.	Month	Amount	%age	Accumulative	Accumulative %age
1	May-17	1,616,571.00	0.13%	1,616,571.00	0.13%
2	Jun-17	6,963,691.00	0.56%	8,580,262.00	0.69%
3	Jul-17	8,953,316.00	0.72%	17,533,578.00	1.41%
4	Aug-17	12,932,568.00	1.04%	30,466,146.00	2.45%
5	Sep-17	15,917,007.00	1.28%	46,383,153.00	3.73%
6	Oct-17	21,885,885.00	1.76%	68,269,038.00	5.49%
7	Nov-17	28,973,927.00	2.33%	97,242,965.00	7.82%
8	Dec-17	44,890,934.00	3.61%	142,133,899.00	11.43%
9	Jan-18	60,807,941.00	4.89%	202,941,840.00	16.32%
10	Feb-18	71,502,180.00	5.75%	274,444,020.00	22.07%
11	Mar-18	82,942,528.00	6.67%	357,386,548.00	28.74%
12	Apr-18	94,755,932.00	7.62%	452,142,480.00	36.36%

13	May-18	99,729,997.00	8.02%	551,872,477.00	44.38%
14	Jun-18	99,481,293.00	8.00%	651,353,770.00	52.38%
15	Jul-18	94,258,526.00	7.58%	745,612,296.00	59.96%
16	Aug-18	72,372,641.00	5.82%	817,984,937.00	65.78%
17	Sep-18	86,424,374.00	6.95%	904,409,311.00	72.73%
18	Oct-18	84,932,154.00	6.83%	989,341,465.00	79.56%
19	Nov-18	74,735,322.00	6.01%	1,064,076,787.00	85.57%
20	Dec-18	64,165,434.00	5.16%	1,128,242,221.00	90.73%
21	Jan-19	47,377,966.00	3.81%	1,175,620,187.00	94.54%
22	Feb-19	30,714,849.00	2.47%	1,206,335,036.00	97.01%
23	Mar-19	22,258,939.00	1.79%	1,228,593,975.00	98.80%
24	Apr-19	12,310,810.00	0.99%	1,240,904,785.00	99.79%
25	May-19	2,611,384.00	0.21%	1,243,516,169.00	100.00%

Table 4.4: Expenditure plan for project B

S/No.	Month	Amount	%age	Accumulative	Accumulative %age
1	Nov-14	0.08	0.0019%	0.078	0.0019%
2	Dec-14	139.78	3.3345%	139.86	3.34%
3	Jan-15	166.31	3.9672%	306.17	7.30%
4	Feb-15	270.99	6.4644%	577.15	13.77%
5	Mar-15	316.79	7.5571%	893.95	21.33%
6	Apr-15	330.98	7.8955%	1224.93	29.22%
7	May-15	252.51	6.0236%	1477.44	35.24%
8	Jun-15	212.80	5.0762%	1690.23	40.32%
9	Jul-15	262.21	6.2551%	1952.45	46.58%
10	Aug-15	167.30	3.9909%	2119.74	50.57%
11	Sep-15	167.94	4.0062%	2287.68	54.57%
12	Oct-15	166.29	3.9668%	2453.97	58.54%
13	Nov-15	166.29	3.9668%	2620.26	62.51%

14	Dec-15	166.29	3.9668%	2786.55	66.47%
15	Jan-16	437.31	10.4321%	3223.86	76.90%
16	Feb-16	357.74	8.5339%	3581.60	85.44%
17	Mar-16	271.02	6.4653%	3852.62	91.90%
18	Apr-16	204.81	4.8857%	4057.43	96.79%
19	May-16	44.32	1.0572%	4101.75	97.85%
20	Jun-16	44.32	1.0572%	4146.06	98.90%
21	Jul-16	44.32	1.0573%	4190.39	99.96%

Table 4.5: Expenditure plan for Project C

S/No.	Month	Amount	%age	Accumulative	Accumulative %age
1	Aug-12	3.616	0.39%	3.616	0.39%
2	Sep-12	4.361	0.47%	7.98	0.86%
3	Oct-12	3.575	0.39%	11.55	1.24%
4	Nov-12	34.427	3.71%	45.98	4.95%
5	Dec-12	34.539	3.72%	80.52	8.67%
6	Jan-13	3.575	0.39%	84.09	9.06%
7	Feb-13	3.575	0.39%	87.67	9.44%
8	Mar-13	3.575	0.39%	91.25	9.83%
9	Apr-13	3.575	0.39%	94.82	10.21%
10	May-13	45.305	4.88%	140.13	15.09%
11	Jun-13	70.482	7.59%	210.61	22.68%
12	Jul-13	93.369	10.05%	303.98	32.73%
13	Aug-13	104.979	11.30%	408.96	44.04%
14	Sep-13	110.130	11.86%	519.09	55.89%
15	Oct-13	113.957	12.27%	633.04	68.17%
16	Nov-13	59.692	6.43%	692.73	74.59%
17	Dec-13	10.938	1.18%	703.67	75.77%
18	Jan-14	1.449	0.16%	705.12	75.93%
19	Feb-14	1.449	0.16%	706.57	76.08%
20	Mar-14	2.311	0.25%	708.88	76.33%
21	Apr-14	10.112	1.09%	718.99	77.42%
22	May-14	30.848	3.32%	749.84	80.74%

23	Jun-14	38.064	4.10%	787.90	84.84%
24	Jul-14	39.161	4.22%	827.06	89.06%
25	Aug-14	39.350	4.24%	866.41	93.29%
26	Sep-14	27.981	3.01%	894.40	96.31%
27	Oct-14	14.477	1.56%	908.87	97.87%
28	Nov-14	10.871	1.17%	919.74	99.04%
29	Dec-14	7.501	0.81%	927.24	99.84%
30	Jan-15	1.449	0.16%	928.69	100.00%

Chapter 5

Results and Analysis

This chapter discusses about the model formulation process. The chapter begins with a comparative statement about the available tool for model formulation followed by description of the prerequisites for the selected tool and finally the main script of the model.

5.1 Comparison of available tools for model formulation

There are various tools available which can be used for the model making and simulation purpose. The choice of these tools mainly depends on the type of data available, the nature of output and limitations of any tool to perform the calculations.

5.1.1 Excel

Excel is the simplest and easy to use for any model making. It falls in the category of simple modelling tools where iterations are very less. Majority of the beginner level modeler use excel for routine models. An Add-in in excel named Solver is widely used for model making. It is mainly used for optimization and equation solving purpose. However, solver has limitations that it only gives the result for one single time meaning that model can only be run for one single scenario and also input has to be given by every time we run the model. Therefore, its use in our modeling process was discarded.

5.1.2 MATLAB

MATLAB is the acronym of ‘matrix laboratory, it is simple and advance than excel. The advantage of this tool is that it can be used for very large iterations. Almost all mathematical models are developed on MATLAB. It also has advantage over other simulation and modeling tools that its language is very simple an easy to understand and a beginner level modeler can learn quicker than other simulation software. It can perform simulations and iterations faster than excel. Keeping in view the simplicity of language and faster rate of results and scenario generation by MATLAB, it was selected for our modeling process.

5.2 Pre-requisites for model

5.2.1 Limitations to model

Our model has certain limitations which are given below;

1. Payment for the expenditure will be made within the same period in which expense occur.
2. Over heads, taxes, contractors' earnings, retainage and disbursement are distributed equally throughout the project period
3. Pre-Construction cost, Capital contribution from investor and mobilization advance will be calculated once only before the start of project.
4. Demobilization cost and retainage release will occur once only at the end of project.

5.2.2 Predefined external input parameters

Certain factors were taken as external predefined external inputs, meaning that the values of these were known to the model. These values were defined by the field experts. Table 5-1 contains the list of predefined input parameter and the values selected for these parameters.

Table 5.1: Detail of predefined external inputs

S/No.	Description	Project A	Project B	Project C
1	over heads	5%	12.64%	12.64%
2	Pre-Construction Cost	10%	10%	15%
3	Disbursements	5%	7%	25%
4	Taxes	8%	0% (tax exempted)	0%(tax exempted)
5	Demobilization Cost	10%	15%	20%
6	Contractors' Earning	5%	0%	0%

5.2.3 Decision variable

There were three decision variables. The values of these variables were given a range over which their values will change for each iteration and the corresponding value of the output parameter were calculated. In our model, we defined three factors i.e. Retainage percentage, mobilization advance and capital contribution from investors as are decision variables. The ranges for these were set in between 0 and 100 percent.

5.2.4 Output parameter

The cash gap was defined as the output parameter i.e. its values were calculated by varying the values of decision variables.

5.3 Syntax of the model

Using MATLAB, a code was developed for our model. This took few attempts to reach the final code. Below is the description of each attempt along with the results obtained by respective attempt.

5.3.1 First attempt

The complete syntax of the very first attempt to develop the model is given is given in Annexure-III. The results obtained from this code are represented in graphical form in figure 5-1. The main objective was to develop a graphical representation of all the variables in single plot. Blue lines are representing the retainage whereas green and red lines are depicting mobilization and capital investment respectively.

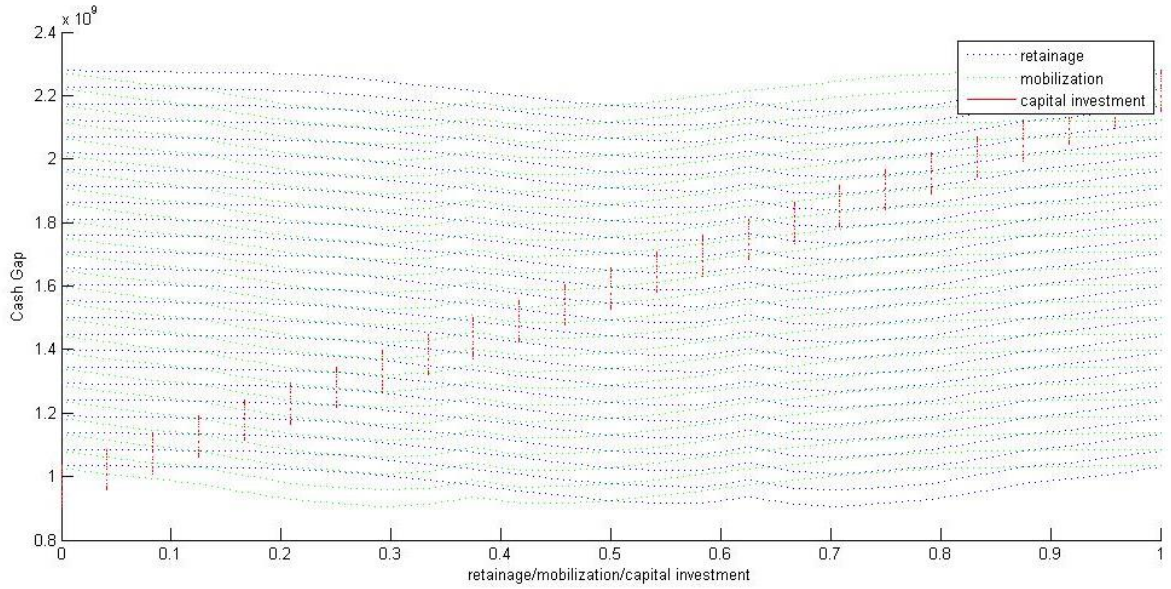

Figure 5.1:Results of the First attempt:

5.3.2 Second attempt

The complete syntax of the second attempt to develop the model is given is given in Annexure-III. The results obtained from this code are represented in graphical form in figure 5-2. In this attempt the

main focus was to make three separate graph sheets and transform the result of one sheet to another one, in order to find the value of other variables

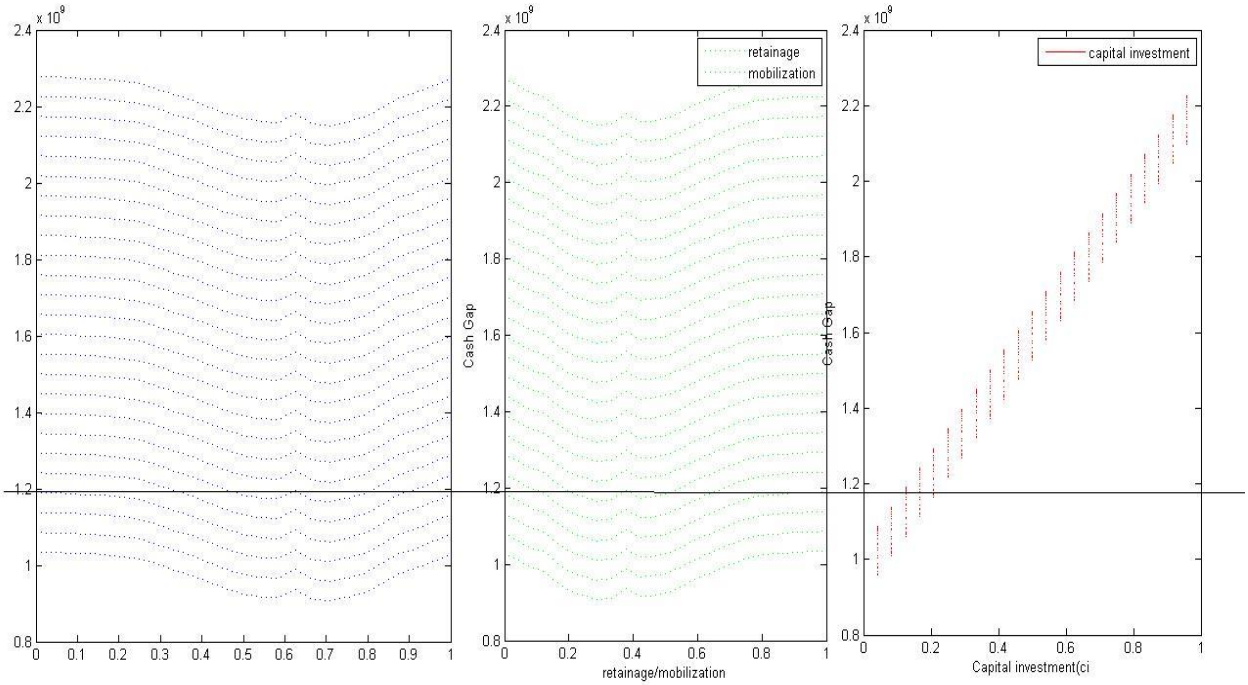

Figure 5.2: Results of the second attempt

5.3.3 Third attempt

The complete syntax of the third attempt to develop the model is given is given in Annexure-III. The results obtained from this code are represented in graphical form in figure 5-3. In this attempt use of color codes was applied to differentiate between various in figure 5-3 blue lines show the scenario where mobilization is zero, whereas green and red lines are representing m=0.5 and m=1. Each successive line has increment of capital investment.

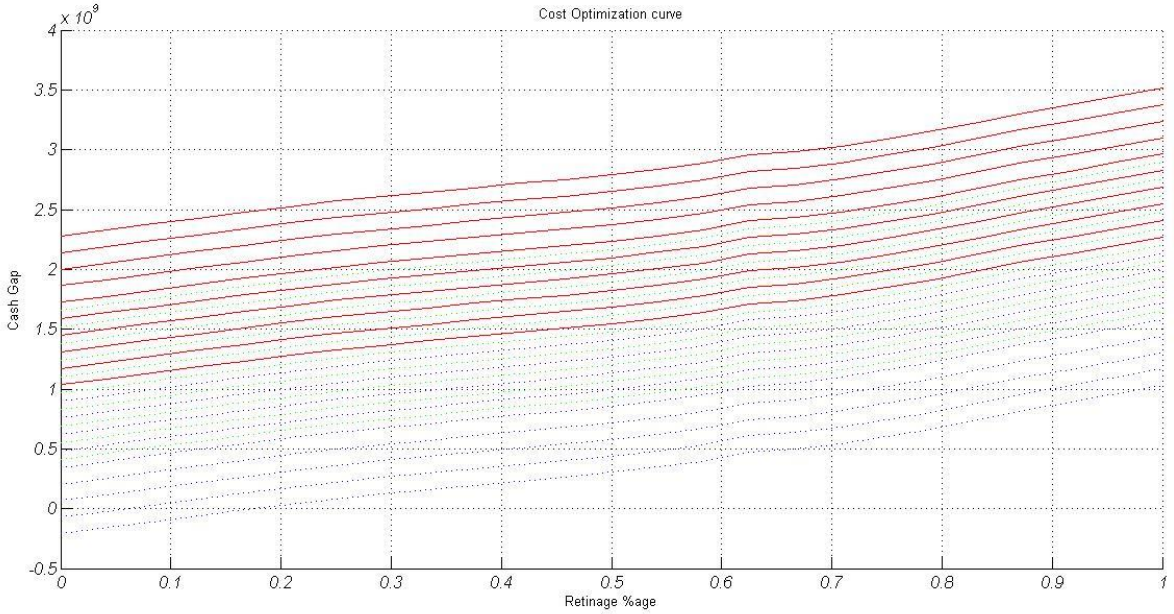

Figure 5.3: Results of the final attempt

5.3.4 Final attempt

The complete syntax of the Final attempt to develop the model is given is given in Annexure-III. In this attempt the main focus was on the depiction of data. This was done by generating variable in workspace of MATLAB and then exporting it to excel files. It was also analyzed for a given scenario that at what point in time the cash flow will get negative. The summary of the results for each case study are given in table 5.2 through figure 5.4. The complete results for each case study (A and B) are given as per annexure– IV.

Table 5.2: Summary of the results for case study A

			project duration																									
ci	m	r	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
0	0	0	(124,351,616.80)	(184,202,049.96)	(244,862,841.23)	(306,155,753.08)	(368,673,528.39)	(432,474,197.93)	(498,683,143.90)	(568,150,620.33)	(644,767,019.42)	(729,792,437.57)	(822,104,083.26)	(922,918,529.45)	(1,033,341,210.78)	(1,150,374,735.12)	(1,271,203,055.84)	(1,392,552,617.66)	(1,502,449,913.42)	(1,625,516,563.75)	(1,750,850,817.17)	(1,871,262,042.36)	(1,985,625,115.31)	(2,087,559,244.39)	(2,175,851,223.59)	(2,257,149,719.60)	(2,329,277,543.27)	(2,391,708,272.53)	(2,516,059,889.33)
	0	0.5	(124,351,616.80)	(185,010,335.46)	(249,152,972.23)	(314,922,542.08)	(383,906,601.39)	(455,665,774.43)	(532,817,662.90)	(616,772,102.83)	(715,833,968.92)	(831,263,357.57)	(959,326,093.26)	(1,101,611,803.45)	(1,259,412,450.78)	(1,426,310,973.62)	(1,596,879,940.84)	(1,765,358,765.66)	(1,911,442,381.92)	(2,077,721,219.25)	(2,245,521,549.67)	(2,403,300,435.86)	(2,549,746,225.81)	(2,675,369,337.89)	(2,779,018,741.59)	(2,871,446,707.10)	(2,949,729,935.77)	(3,013,466,357.03)	(2,516,059,889.83)
	0	1	(124,351,616.80)	(185,818,620.96)	(253,443,103.23)	(323,689,331.08)	(399,139,674.39)	(478,857,350.93)	(566,952,181.90)	(665,393,585.33)	(786,900,918.42)	(932,734,277.57)	(1,096,548,103.26)	(1,280,305,077.45)	(1,485,483,690.78)	(1,702,247,212.12)	(1,922,556,825.84)	(2,138,164,913.66)	(2,320,434,850.42)	(2,529,925,874.75)	(2,740,192,282.17)	(2,935,338,829.36)	(3,113,867,336.31)	(3,263,179,431.39)	(3,382,186,259.59)	(3,485,743,694.60)	(3,570,182,328.27)	(3,635,224,441.53)	(2,516,059,890.33)
	0.5	0	497,406,467.20	437,556,034.04	376,895,242.77	315,602,330.92	253,084,555.61	189,283,886.07	123,074,940.10	53,607,463.67	(23,008,935.42)	(108,034,353.57)	(200,345,999.26)	(301,160,445.45)	(411,583,126.78)	(528,616,651.12)	(649,444,971.84)	(770,794,533.66)	(880,691,829.42)	(1,003,758,479.75)	(1,129,092,733.17)	(1,249,503,958.36)	(1,363,867,031.31)	(1,465,801,160.39)	(1,554,093,139.59)	(1,635,391,635.60)	(1,707,519,459.27)	(1,769,950,188.53)	(1,894,301,805.33)
	0.5	0.5	497,406,467.20	436,747,748.54	372,605,111.77	306,835,541.92	237,851,482.61	166,092,309.57	88,940,421.10	4,985,981.17	(94,075,884.92)	(209,505,273.57)	(337,568,009.26)	(479,853,719.45)	(637,654,366.78)	(804,552,889.62)	(975,121,856.84)	(1,143,600,681.66)	(1,289,684,297.92)	(1,455,963,135.25)	(1,623,763,465.67)	(1,781,542,351.86)	(1,927,988,141.81)	(2,053,611,253.89)	(2,157,260,657.59)	(2,249,688,623.10)	(2,327,971,851.77)	(2,391,708,273.03)	(1,894,301,805.83)
	0.5	1	497,406,467.20	435,939,463.04	368,314,980.77	298,068,752.92	222,618,409.61	142,900,733.07	54,805,902.10	(43,635,501.33)	(165,142,834.42)	(310,976,193.57)	(474,790,019.26)	(658,546,993.45)	(863,725,606.78)	(1,080,489,128.12)	(1,300,798,741.84)	(1,516,406,829.66)	(1,698,676,766.42)	(1,908,167,790.75)	(2,118,434,198.17)	(2,313,580,745.36)	(2,492,109,252.31)	(2,641,421,347.39)	(2,760,428,175.59)	(2,863,985,610.60)	(2,948,424,244.27)	(3,013,466,357.53)	(1,894,301,806.33)
	1	0	1,119,164,551.20	1,059,314,118.04	998,653,326.77	937,360,414.92	874,842,639.61	811,041,970.07	744,833,024.10	675,365,547.67	598,749,148.58	513,723,730.43	421,412,084.74	320,597,638.55	210,174,957.22	93,141,432.88	(27,686,887.84)	(149,036,449.66)	(258,933,745.42)	(382,000,395.75)	(507,334,649.17)	(627,745,874.36)	(742,108,947.31)	(844,043,076.39)	(932,335,055.59)	(1,013,633,551.60)	(1,085,761,375.27)	(1,148,192,104.53)	(1,272,543,721.33)
	1	0.5	1,119,164,551.20	1,058,505,832.54	994,363,195.77	928,593,625.92	859,609,566.61	787,850,393.57	710,698,505.10	626,744,065.17	527,682,199.08	412,252,810.43	284,190,074.74	141,904,364.55	(15,896,282.78)	(182,794,805.62)	(353,363,772.84)	(521,842,597.66)	(667,926,213.92)	(834,205,051.25)	(1,002,005,381.67)	(1,159,784,267.86)	(1,306,230,057.81)	(1,431,853,169.89)	(1,535,502,573.59)	(1,627,930,539.10)	(1,706,213,767.77)	(1,769,950,189.03)	(1,272,543,721.83)
	1	1	1,119,164,551.20	1,057,697,547.04	990,073,064.77	919,826,836.92	844,376,493.61	764,658,817.07	676,563,986.10	578,122,582.67	456,615,249.58	310,781,890.43	146,968,064.74	(36,788,909.45)	(241,967,522.78)	(458,731,044.12)	(679,040,657.84)	(894,648,745.66)	(1,076,918,682.42)	(1,286,409,706.75)	(1,496,676,114.17)	(1,691,822,661.36)	(1,870,351,168.31)	(2,019,663,263.39)	(2,138,670,091.59)	(2,242,227,526.60)	(2,326,666,160.27)	(2,391,708,273.53)	(1,272,543,722.33)
0.5	0	0	497,406,467.20	437,556,034.04	376,895,242.77	315,602,330.92	253,084,555.61	189,283,886.07	123,074,940.10	53,607,463.67	(23,008,935.42)	(108,034,353.57)	(200,345,999.26)	(301,160,445.45)	(411,583,126.78)	(528,616,651.12)	(649,444,971.84)	(770,794,533.66)	(880,691,829.42)	(1,003,758,479.75)	(1,129,092,733.17)	(1,249,503,958.36)	(1,363,867,031.31)	(1,465,801,160.39)	(1,554,093,139.59)	(1,635,391,635.60)	(1,707,519,459.27)	(1,769,950,188.53)	(1,894,301,805.33)
	0	0.5	497,406,467.20	436,747,748.54	372,605,111.77	306,835,541.92	237,851,482.61	166,092,309.57	88,940,421.10	4,985,981.17	(94,075,884.92)	(209,505,273.57)	(337,568,009.26)	(479,853,719.45)	(637,654,366.78)	(804,552,889.62)	(975,121,856.84)	(1,143,600,681.66)	(1,289,684,297.92)	(1,455,963,135.25)	(1,623,763,465.67)	(1,781,542,351.86)	(1,927,988,141.81)	(2,053,611,253.89)	(2,157,260,657.59)	(2,249,688,623.10)	(2,327,971,851.77)	(2,391,708,273.03)	(1,894,301,805.83)
	0	1	497,406,467.20	435,939,463.04	368,314,980.77	298,068,752.92	222,618,409.61	142,900,733.07	54,805,902.10	(43,635,501.33)	(165,142,834.42)	(310,976,193.57)	(474,790,019.26)	(658,546,993.45)	(863,725,606.78)	(1,080,489,128.12)	(1,300,798,741.84)	(1,516,406,829.66)	(1,698,676,766.42)	(1,908,167,790.75)	(2,118,434,198.17)	(2,313,580,745.36)	(2,492,109,252.31)	(2,641,421,347.39)	(2,760,428,175.59)	(2,863,985,610.60)	(2,948,424,244.27)	(3,013,466,357.53)	(1,894,301,806.33)
	0.5	0	1,119,164,551.20	1,059,314,118.04	998,653,326.77	937,360,414.92	874,842,639.61	811,041,970.07	744,833,024.10	675,365,547.67	598,749,148.58	513,723,730.43	421,412,084.74	320,597,638.55	210,174,957.22	93,141,432.88	(27,686,887.84)	(149,036,449.66)	(258,933,745.42)	(382,000,395.75)	(507,334,649.17)	(627,745,874.36)	(742,108,947.31)	(844,043,076.39)	(932,335,055.59)	(1,013,633,551.60)	(1,085,761,375.27)	(1,148,192,104.53)	(1,272,543,721.33)
	0.5	0.5	1,119,164,551.20	1,058,505,832.54	994,363,195.77	928,593,625.92	859,609,566.61	787,850,393.57	710,698,505.10	626,744,065.17	527,682,199.08	412,252,810.43	284,190,074.74	141,904,364.55	(15,896,282.78)	(182,794,805.62)	(353,363,772.84)	(521,842,597.66)	(667,926,213.92)	(834,205,051.25)	(1,002,005,381.67)	(1,159,784,267.86)	(1,306,230,057.81)	(1,431,853,169.89)	(1,535,502,573.59)	(1,627,930,539.10)	(1,706,213,767.77)	(1,769,950,189.03)	(1,272,543,721.83)
	0.5	1	1,119,164,551.20	1,057,697,547.04	990,073,064.77	919,826,836.92	844,376,493.61	764,658,817.07	676,563,986.10	578,122,582.67	456,615,249.58	310,781,890.43	146,968,064.74	(36,788,909.45)	(241,967,522.78)	(458,731,044.12)	(679,040,657.84)	(894,648,745.66)	(1,076,918,682.42)	(1,286,409,706.75)	(1,496,676,114.17)	(1,691,822,661.36)	(1,870,351,168.31)	(2,019,663,263.39)	(2,138,670,091.59)	(2,242,227,526.60)	(2,326,666,160.27)	(2,391,708,273.53)	(1,272,543,722.33)
	1	0	1,740,922,635.20	1,681,072,202.04	1,620,411,410.77	1,559,118,498.92	1,496,600,723.61	1,432,800,054.07	1,366,591,108.10	1,297,123,631.67	1,220,507,232.58	1,135,481,814.43	1,043,170,168.74	942,355,722.55	831,933,041.22	714,899,516.88	594,071,196.16	472,721,634.34	362,824,338.58	239,757,688.25	114,423,434.83	(5,987,790.36)	(120,350,863.31)	(222,284,992.39)	(310,576,971.59)	(391,875,467.60)	(464,003,291.27)	(526,434,020.53)	(650,785,637.33)
	1	0.5	1,740,922,635.20	1,680,263,916.54	1,616,121,279.77	1,550,351,709.92	1,481,367,650.61	1,409,608,477.57	1,332,456,589.10	1,248,502,149.17	1,149,440,283.08	1,034,010,894.43	905,948,158.74	763,662,448.55	605,861,801.22	438,963,278.38	268,394,311.16	99,915,486.34	(46,168,129.92)	(212,446,967.25)	(380,247,297.67)	(538,026,183.86)	(684,471,973.81)	(810,095,085.89)	(913,744,489.59)	(1,006,172,455.10)	(1,084,455,683.77)	(1,148,192,105.03)	(650,785,637.83)
	1	1	1,740,922,635.20	1,679,455,631.04	1,611,831,148.77	1,541,584,920.92	1,466,134,577.61	1,386,416,901.07	1,298,322,070.10	1,199,880,666.67	1,078,373,333.58	932,539,974.43	768,726,148.74	584,969,174.55	379,790,561.22	163,027,039.88	(57,282,573.84)	(272,890,661.66)	(455,160,598.42)	(664,651,622.75)	(874,918,030.17)	(1,070,064,577.36)	(1,248,593,084.31)	(1,397,905,179.39)	(1,516,912,007.59)	(1,620,469,442.60)	(1,704,908,076.27)	(1,769,950,189.53)	(650,785,638.33)
1	0	0	1,119,164,551.20	1,059,314,118.04	998,653,326.77	937,360,414.92	874,842,639.61	811,041,970.07	744,833,024.10	675,365,547.67	598,749,148.58	513,723,730.43	421,412,084.74	320,597,638.55	210,174,957.22	93,141,432.88	(27,686,887.84)	(149,036,449.66)	(258,933,745.42)	(382,000,395.75)	(507,334,649.17)	(627,745,874.36)	(742,108,947.31)	(844,043,076.39)	(932,335,055.59)	(1,013,633,551.60)	(1,085,761,375.27)	(1,148,192,104.53)	(1,272,543,721.33)
	0	0.5	1,119,164,551.20	1,058,505,832.54	994,363,195.77	928,593,625.92	859,609,566.61	787,850,393.57	710,698,505.10	626,744,065.17	527,682,199.08	412,252,810.43	284,190,074.74	141,904,364.55	(15,896,282.78)	(182,794,805.62)	(353,363,772.84)	(521,842,597.66)	(667,926,213.92)	(834,205,051.25)	(1,002,005,381.67)	(1,159,784,267.86)	(1,306,230,057.81)	(1,431,853,169.89)	(1,535,502,573.59)	(1,627,930,539.10)	(1,706,213,767.77)	(1,769,950,189.03)	(1,272,543,721.83)
	0	1	1,119,164,551.20	1,057,697,547.04	990,073,064.77	919,826,836.92	844,376,493.61	764,658,817.07	676,563,986.10	578,122,582.67	456,615,249.58	310,781,890.43	146,968,064.74	(36,788,909.45)	(241,967,522.78)	(458,731,044.12)	(679,040,657.84)	(894,648,745.66)	(1,076,918,682.42)	(1,286,409,706.75)	(1,496,676,114.17)	(1,691,822,661.36)	(1,870,351,168.31)	(2,019,663,263.39)	(2,138,670,091.59)	(2,242,227,526.60)	(2,326,666,160.27)	(2,391,708,273.53)	(1,272,543,722.33)
	0.5	0	1,740,922,635.20	1,681,072,202.04	1,620,411,410.77	1,559,118,498.92	1,496,600,723.61	1,432,800,054.07	1,366,591,108.10	1,297,123,631.67	1,220,507,232.58	1,135,481,814.43	1,043,170,168.74	942,355,722.55	831,933,041.22	714,899,516.88	594,071,196.16	472,721,634.34	362,824,338.58	239,757,688.25	114,423,434.83	(5,987,790.36)	(120,350,863.31)	(222,284,992.39)	(310,576,971.59)	(391,875,467.60)	(464,003,291.27)	(526,434,020.53)	(650,785,637.33)
	0.5	0.5	1,740,922,635.20	1,680,263,916.54	1,616,121,279.77	1,550,351,709.92	1,481,367,650.61	1,409,608,477.57	1,332,456,589.10	1,248,502,149.17	1,149,440,283.08	1,034,010,894.43	905,948,158.74	763,662,448.55	605,861,801.22	438,963,278.38	268,394,311.16	99,915,486.34	(46,168,129.92)	(212,446,967.25)	(380,247,297.67)	(538,026,183.86)	(684,471,973.81)	(810,095,085.89)	(913,744,489.59)	(1,006,172,455.10)	(1,084,455,683.77)	(1,148,192,105.03)	(650,785,637.83)
	0.5	1	1,740,922,635.20	1,679,455,631.04	1,611,831,148.77	1,541,584,920.92	1,466,134,577.61	1,386,416,901.07	1,298,322,070.10	1,199,880,666.67	1,078,373,333.58	932,539,974.43	768,726,148.74	584,969,174.55	379,790,561.22	163,027,039.88	(57,282,573.84)	(272,890,661.66)	(455,160,598.42)	(664,651,622.75)	(874,918,030.17)	(1,070,064,577.36)	(1,248,593,084.31)	(1,397,905,179.39)	(1,516,912,007.59)	(1,620,469,442.60)	(1,704,908,076.27)	(1,769,950,189.53)	(650,785,638.33)
	1	0	2,362,680,719.20	2,302,830,286.04	2,242,169,494.77	2,180,876,582.92	2,118,358,807.61	2,054,558,138.07	1,988,349,192.10	1,918,881,715.67	1,842,265,316.58	1,757,239,898.43	1,664,928,252.74	1,564,113,806.55	1,453,691,125.22	1,336,657,600.88	1,215,829,280.16	1,094,479,718.34	984,582,422.58	861,515,772.25	736,181,518.83	615,770,293.64	501,407,220.69	399,473,091.61	311,181,112.41	229,882,616.40	157,754,792.73	95,324,063.47	(29,027,553.33)
	1	0.5	2,362,680,719.20	2,302,022,000.54	2,237,879,363.77	2,172,109,793.92	2,103,125,734.61	2,031,366,561.57	1,954,214,673.10	1,870,260,233.17	1,771,198,367.08	1,655,768,978.43	1,527,706,242.74	1,385,420,532.55	1,227,619,885.22	1,060,721,362.38	890,152,395.16	721,673,570.34	575,589,954.08	409,311,116.75	241,510,786.33	83,731,900.14	(62,713,889.81)	(188,337,001.89)	(291,986,405.59)	(384,414,371.10)	(462,697,599.77)	(526,434,021.03)	(29,027,553.83)
	1	1	2,362,680,719.20	2,301,213,715.04	2,233,589,232.77	2,163,343,004.92	2,087,892,661.61	2,008,174,985.07	1,920,080,154.10	1,821,638,750.67	1,700,131,417.58	1,554,298,058.43	1,390,484,232.74	1,206,727,258.55	1,001,548,645.22	784,785,123.88	564,475,510.16	348,867,422.34	166,597,485.58	(42,893,538.75)	(253,159,946.17)	(448,306,493.36)	(626,835,000.31)	(776,147,095.39)	(895,153,923.59)	(998,711,358.60)	(1,083,149,992.27)	(1,148,192,105.53)	(29,027,554.33)

Table 5.3: Summary of the results for case study B

			project duration																					
ci	m	r	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
0	0	0	(335,231,200.00)	(864,896,496.01)	(1,394,561,808.29)	(1,924,227,131.40)	(2,453,892,484.17)	(2,983,557,861.27)	(3,513,223,257.39)	(4,042,888,641.52)	(4,572,554,021.68)	(5,102,219,433.58)	(5,631,884,811.30)	(6,161,550,197.15)	(6,691,215,589.84)	(7,220,880,990.27)	(7,750,546,398.43)	(8,280,212,009.74)	(8,809,877,580.30)	(9,339,543,096.92)	(9,869,208,569.15)	(10,398,873,905.35)	(10,928,539,243.60)	(11,458,204,583.92)	(12,086,763,083.92)
	0	0.5	(335,231,200.00)	(864,896,496.04)	(1,394,561,878.22)	(1,924,227,284.48)	(2,453,892,772.75)	(2,983,558,308.24)	(3,513,223,869.85)	(4,042,889,380.23)	(4,572,554,866.79)	(5,102,220,409.80)	(5,631,885,871.17)	(6,161,551,340.99)	(6,691,216,816.83)	(7,220,882,300.40)	(7,750,547,791.71)	(8,280,213,621.67)	(8,809,879,371.10)	(9,339,545,023.23)	(9,869,210,597.87)	(10,398,875,956.22)	(10,928,541,316.64)	(11,458,206,679.12)	(9,991,570,179.12)
	0	1	(335,231,200.00)	(864,896,496.08)	(1,394,561,948.15)	(1,924,227,437.57)	(2,453,893,061.32)	(2,983,558,755.22)	(3,513,224,482.32)	(4,042,890,118.95)	(4,572,555,711.91)	(5,102,221,386.02)	(5,631,886,931.04)	(6,161,552,484.83)	(6,691,218,043.81)	(7,220,883,610.53)	(7,750,549,184.98)	(8,280,215,233.59)	(8,809,881,161.90)	(9,339,546,949.54)	(9,869,212,626.59)	(10,398,878,007.10)	(10,928,543,389.67)	(11,458,208,774.31)	(7,896,377,274.31)
	0.5	0	1,759,963,800.00	1,230,298,503.99	700,633,191.71	170,967,868.60	(358,697,484.17)	(888,362,861.27)	(1,418,028,257.39)	(1,947,693,641.52)	(2,477,359,021.68)	(3,007,024,433.58)	(3,536,689,811.30)	(4,066,355,197.15)	(4,596,020,589.84)	(5,125,685,990.27)	(5,655,351,398.43)	(6,185,017,009.74)	(6,714,682,580.30)	(7,244,348,096.92)	(7,774,013,569.15)	(8,303,678,905.35)	(8,833,344,243.60)	(9,363,009,583.92)	(9,991,568,083.92)
	0.5	0.5	1,759,963,800.00	1,230,298,503.96	700,633,121.78	170,967,715.52	(358,697,772.75)	(888,363,308.24)	(1,418,028,869.85)	(1,947,694,380.23)	(2,477,359,866.79)	(3,007,025,409.80)	(3,536,690,871.17)	(4,066,356,340.99)	(4,596,021,816.83)	(5,125,687,300.40)	(5,655,352,791.71)	(6,185,018,621.67)	(6,714,684,371.10)	(7,244,350,023.23)	(7,774,015,597.87)	(8,303,680,956.22)	(8,833,346,316.64)	(9,363,011,679.12)	(7,896,375,179.12)
	0.5	1	1,759,963,800.00	1,230,298,503.92	700,633,051.85	170,967,562.43	(358,698,061.32)	(888,363,755.22)	(1,418,029,482.32)	(1,947,695,118.95)	(2,477,360,711.91)	(3,007,026,386.02)	(3,536,691,931.04)	(4,066,357,484.83)	(4,596,023,043.81)	(5,125,688,610.53)	(5,655,354,184.98)	(6,185,020,233.59)	(6,714,686,161.90)	(7,244,351,949.54)	(7,774,017,626.59)	(8,303,683,007.10)	(8,833,348,389.67)	(9,363,013,774.31)	(5,801,182,274.31)
	1	0	3,855,158,800.00	3,325,493,503.99	2,795,828,191.71	2,266,162,868.60	1,736,497,515.83	1,206,832,138.73	677,166,742.61	147,501,358.48	(382,164,021.68)	(911,829,433.58)	(1,441,494,811.30)	(1,971,160,197.15)	(2,500,825,589.84)	(3,030,490,990.27)	(3,560,156,398.43)	(4,089,822,009.74)	(4,619,487,580.30)	(5,149,153,096.92)	(5,678,818,569.15)	(6,208,483,905.35)	(6,738,149,243.60)	(7,267,814,583.92)	(7,896,373,083.92)
	1	0.5	3,855,158,800.00	3,325,493,503.96	2,795,828,121.78	2,266,162,715.52	1,736,497,227.25	1,206,831,691.76	677,166,130.15	147,500,619.77	(382,164,866.79)	(911,830,409.80)	(1,441,495,871.17)	(1,971,161,340.99)	(2,500,826,816.83)	(3,030,492,300.40)	(3,560,157,791.71)	(4,089,823,621.67)	(4,619,489,371.10)	(5,149,155,023.23)	(5,678,820,597.87)	(6,208,485,956.22)	(6,738,151,316.64)	(7,267,816,679.12)	(5,801,180,179.12)
	1	1	3,855,158,800.00	3,325,493,503.92	2,795,828,051.85	2,266,162,562.43	1,736,496,938.68	1,206,831,244.78	677,165,517.68	147,499,881.05	(382,165,711.91)	(911,831,386.02)	(1,441,496,931.04)	(1,971,162,484.83)	(2,500,828,043.81)	(3,030,493,610.53)	(3,560,159,184.98)	(4,089,825,233.59)	(4,619,491,161.90)	(5,149,156,949.54)	(5,678,822,626.59)	(6,208,488,007.10)	(6,738,153,389.67)	(7,267,818,774.31)	(3,705,987,274.31)
0.5	0	0	1,759,963,800.00	1,230,298,503.99	700,633,191.71	170,967,868.60	(358,697,484.17)	(888,362,861.27)	(1,418,028,257.39)	(1,947,693,641.52)	(2,477,359,021.68)	(3,007,024,433.58)	(3,536,689,811.30)	(4,066,355,197.15)	(4,596,020,589.84)	(5,125,685,990.27)	(5,655,351,398.43)	(6,185,017,009.74)	(6,714,682,580.30)	(7,244,348,096.92)	(7,774,013,569.15)	(8,303,678,905.35)	(8,833,344,243.60)	(9,363,009,583.92)	(9,991,568,083.92)
	0	0.5	1,759,963,800.00	1,230,298,503.96	700,633,121.78	170,967,715.52	(358,697,772.75)	(888,363,308.24)	(1,418,028,869.85)	(1,947,694,380.23)	(2,477,359,866.79)	(3,007,025,409.80)	(3,536,690,871.17)	(4,066,356,340.99)	(4,596,021,816.83)	(5,125,687,300.40)	(5,655,352,791.71)	(6,185,018,621.67)	(6,714,684,371.10)	(7,244,350,023.23)	(7,774,015,597.87)	(8,303,680,956.22)	(8,833,346,316.64)	(9,363,011,679.12)	(7,896,375,179.12)
	0	1	1,759,963,800.00	1,230,298,503.92	700,633,051.85	170,967,562.43	(358,698,061.32)	(888,363,755.22)	(1,418,029,482.32)	(1,947,695,118.95)	(2,477,360,711.91)	(3,007,026,386.02)	(3,536,691,931.04)	(4,066,357,484.83)	(4,596,023,043.81)	(5,125,688,610.53)	(5,655,354,184.98)	(6,185,020,233.59)	(6,714,686,161.90)	(7,244,351,949.54)	(7,774,017,626.59)	(8,303,683,007.10)	(8,833,348,389.67)	(9,363,013,774.31)	(5,801,182,274.31)
	0.5	0	3,855,158,800.00	3,325,493,503.99	2,795,828,191.71	2,266,162,868.60	1,736,497,515.83	1,206,832,138.73	677,166,742.61	147,501,358.48	(382,164,021.68)	(911,829,433.58)	(1,441,494,811.30)	(1,971,160,197.15)	(2,500,825,589.84)	(3,030,490,990.27)	(3,560,156,398.43)	(4,089,822,009.74)	(4,619,487,580.30)	(5,149,153,096.92)	(5,678,818,569.15)	(6,208,483,905.35)	(6,738,149,243.60)	(7,267,814,583.92)	(7,896,373,083.92)
	0.5	0.5	3,855,158,800.00	3,325,493,503.96	2,795,828,121.78	2,266,162,715.52	1,736,497,227.25	1,206,831,691.76	677,166,130.15	147,500,619.77	(382,164,866.79)	(911,830,409.80)	(1,441,495,871.17)	(1,971,161,340.99)	(2,500,826,816.83)	(3,030,492,300.40)	(3,560,157,791.71)	(4,089,823,621.67)	(4,619,489,371.10)	(5,149,155,023.23)	(5,678,820,597.87)	(6,208,485,956.22)	(6,738,151,316.64)	(7,267,816,679.12)	(5,801,180,179.12)
	0.5	1	3,855,158,800.00	3,325,493,503.92	2,795,828,051.85	2,266,162,562.43	1,736,496,938.68	1,206,831,244.78	677,165,517.68	147,499,881.05	(382,165,711.91)	(911,831,386.02)	(1,441,496,931.04)	(1,971,162,484.83)	(2,500,828,043.81)	(3,030,493,610.53)	(3,560,159,184.98)	(4,089,825,233.59)	(4,619,491,161.90)	(5,149,156,949.54)	(5,678,822,626.59)	(6,208,488,007.10)	(6,738,153,389.67)	(7,267,818,774.31)	(3,705,987,274.31)
	1	0	5,950,353,800.00	5,420,688,503.99	4,891,023,191.71	4,361,357,868.60	3,831,692,515.83	3,302,027,138.73	2,772,361,742.61	2,242,696,358.48	1,713,030,978.32	1,183,365,566.42	653,700,188.70	124,034,802.85	(405,630,589.84)	(935,295,990.27)	(1,464,961,398.43)	(1,994,627,009.74)	(2,524,292,580.30)	(3,053,958,096.92)	(3,583,623,569.15)	(4,113,288,905.35)	(4,642,954,243.60)	(5,172,619,583.92)	(5,801,178,083.92)
	1	0.5	5,950,353,800.00	5,420,688,503.96	4,891,023,121.78	4,361,357,715.52	3,831,692,227.25	3,302,026,691.76	2,772,361,130.15	2,242,695,619.77	1,713,030,133.21	1,183,364,590.20	653,699,128.83	124,033,659.01	(405,631,816.83)	(935,297,300.40)	(1,464,962,791.71)	(1,994,628,621.67)	(2,524,294,371.10)	(3,053,960,023.23)	(3,583,625,597.87)	(4,113,290,956.22)	(4,642,956,316.64)	(5,172,621,679.12)	(3,705,985,179.12)
	1	1	5,950,353,800.00	5,420,688,503.92	4,891,023,051.85	4,361,357,562.43	3,831,691,938.68	3,302,026,244.78	2,772,360,517.68	2,242,694,881.05	1,713,029,288.09	1,183,363,613.98	653,698,068.96	124,032,515.17	(405,633,043.81)	(935,298,610.53)	(1,464,964,184.98)	(1,994,630,233.59)	(2,524,296,161.90)	(3,053,961,949.54)	(3,583,627,626.59)	(4,113,293,007.10)	(4,642,958,389.67)	(5,172,623,774.31)	(1,610,792,274.31)
1	0	0	3,855,158,800.00	3,325,493,503.99	2,795,828,191.71	2,266,162,868.60	1,736,497,515.83	1,206,832,138.73	677,166,742.61	147,501,358.48	(382,164,021.68)	(911,829,433.58)	(1,441,494,811.30)	(1,971,160,197.15)	(2,500,825,589.84)	(3,030,490,990.27)	(3,560,156,398.43)	(4,089,822,009.74)	(4,619,487,580.30)	(5,149,153,096.92)	(5,678,818,569.15)	(6,208,483,905.35)	(6,738,149,243.60)	(7,267,814,583.92)	(7,896,373,083.92)
	0	0.5	3,855,158,800.00	3,325,493,503.96	2,795,828,121.78	2,266,162,715.52	1,736,497,227.25	1,206,831,691.76	677,166,130.15	147,500,619.77	(382,164,866.79)	(911,830,409.80)	(1,441,495,871.17)	(1,971,161,340.99)	(2,500,826,816.83)	(3,030,492,300.40)	(3,560,157,791.71)	(4,089,823,621.67)	(4,619,489,371.10)	(5,149,155,023.23)	(5,678,820,597.87)	(6,208,485,956.22)	(6,738,151,316.64)	(7,267,816,679.12)	(5,801,180,179.12)
	0	1	3,855,158,800.00	3,325,493,503.92	2,795,828,051.85	2,266,162,562.43	1,736,496,938.68	1,206,831,244.78	677,165,517.68	147,499,881.05	(382,165,711.91)	(911,831,386.02)	(1,441,496,931.04)	(1,971,162,484.83)	(2,500,828,043.81)	(3,030,493,610.53)	(3,560,159,184.98)	(4,089,825,233.59)	(4,619,491,161.90)	(5,149,156,949.54)	(5,678,822,626.59)	(6,208,488,007.10)	(6,738,153,389.67)	(7,267,818,774.31)	(3,705,987,274.31)
	0.5	0	5,950,353,800.00	5,420,688,503.99	4,891,023,191.71	4,361,357,868.60	3,831,692,515.83	3,302,027,138.73	2,772,361,742.61	2,242,696,358.48	1,713,030,978.32	1,183,365,566.42	653,700,188.70	124,034,802.85	(405,630,589.84)	(935,295,990.27)	(1,464,961,398.43)	(1,994,627,009.74)	(2,524,292,580.30)	(3,053,958,096.92)	(3,583,623,569.15)	(4,113,288,905.35)	(4,642,954,243.60)	(5,172,619,583.92)	(5,801,178,083.92)
	0.5	0.5	5,950,353,800.00	5,420,688,503.96	4,891,023,121.78	4,361,357,715.52	3,831,692,227.25	3,302,026,691.76	2,772,361,130.15	2,242,695,619.77	1,713,030,133.21	1,183,364,590.20	653,699,128.83	124,033,659.01	(405,631,816.83)	(935,297,300.40)	(1,464,962,791.71)	(1,994,628,621.67)	(2,524,294,371.10)	(3,053,960,023.23)	(3,583,625,597.87)	(4,113,290,956.22)	(4,642,956,316.64)	(5,172,621,679.12)	(3,705,985,179.12)
	0.5	1	5,950,353,800.00	5,420,688,503.92	4,891,023,051.85	4,361,357,562.43	3,831,691,938.68	3,302,026,244.78	2,772,360,517.68	2,242,694,881.05	1,713,029,288.09	1,183,363,613.98	653,698,068.96	124,032,515.17	(405,633,043.81)	(935,298,610.53)	(1,464,964,184.98)	(1,994,630,233.59)	(2,524,296,161.90)	(3,053,961,949.54)	(3,583,627,626.59)	(4,113,293,007.10)	(4,642,958,389.67)	(5,172,623,774.31)	(1,610,792,274.31)
	1	0	8,045,548,800.00	7,515,883,503.99	6,986,218,191.71	6,456,552,868.60	5,926,887,515.83	5,397,222,138.73	4,867,556,742.61	4,337,891,358.48	3,808,225,978.32	3,278,560,566.42	2,748,895,188.70	2,219,229,802.85	1,689,564,410.16	1,159,899,009.73	630,233,601.57	100,567,990.26	(429,097,580.30)	(958,763,096.92)	(1,488,428,569.15)	(2,018,093,905.35)	(2,547,759,243.60)	(3,077,424,583.92)	(3,705,983,083.92)
	1	0.5	8,045,548,800.00	7,515,883,503.96	6,986,218,121.78	6,456,552,715.52	5,926,887,227.25	5,397,221,691.76	4,867,556,130.15	4,337,890,619.77	3,808,225,133.21	3,278,559,590.20	2,748,894,128.83	2,219,228,659.01	1,689,563,183.17	1,159,897,699.60	630,232,208.29	100,566,378.33	(429,099,371.10)	(958,765,023.23)	(1,488,430,597.87)	(2,018,095,956.22)	(2,547,761,316.64)	(3,077,426,679.12)	(1,610,790,179.12)
	1	1	8,045,548,800.00	7,515,883,503.92	6,986,218,051.85	6,456,552,562.43	5,926,886,938.68	5,397,221,244.78	4,867,555,517.68	4,337,889,881.05	3,808,224,288.09	3,278,558,613.98	2,748,893,068.96	2,219,227,515.17	1,689,561,956.19	1,159,896,389.47	630,230,815.02	100,564,766.41	(429,101,161.90)	(958,766,949.54)	(1,488,432,626.59)	(2,018,098,007.10)	(2,547,763,389.67)	(3,077,428,774.31)	484,402,725.69

Table 5.4: summary of the results for case study C

			project duration																												
ci	m	r	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
0	0	0	(139,303,500.00)	(256,689,916.90)	(374,076,334.11)	(491,462,751.19)	(608,849,178.45)	(726,235,606.67)	(843,622,024.03)	(961,008,441.48)	(1,078,394,859.02)	(1,195,781,276.65)	(1,313,167,714.52)	(1,430,554,166.37)	(1,547,940,632.28)	(1,665,327,107.10)	(1,782,713,587.66)	(1,900,100,073.41)	(2,017,486,527.49)	(2,134,872,950.75)	(2,252,259,367.75)	(2,369,645,784.78)	(2,487,032,202.50)	(2,604,418,626.25)	(2,721,805,066.72)	(2,839,191,513.89)	(2,956,577,962.98)	(3,073,964,413.24)	(3,191,350,854.32)	(3,308,737,283.68)	(3,426,123,709.99)	(3,543,510,133.29)	(3,660,896,550.74)	(3,846,634,550.74)
		0.5	(139,303,500.00)	(256,689,918.77)	(374,076,338.23)	(491,462,757.16)	(608,849,202.25)	(726,235,648.32)	(843,622,067.53)	(961,008,486.82)	(1,078,394,906.21)	(1,195,781,325.70)	(1,313,167,787.00)	(1,430,554,275.31)	(1,547,940,789.51)	(1,665,327,318.63)	(1,782,713,856.15)	(1,900,100,400.84)	(2,017,486,885.80)	(2,134,873,314.72)	(2,252,259,732.46)	(2,369,646,150.25)	(2,487,032,569.16)	(2,604,418,998.15)	(2,721,805,454.57)	(2,839,191,921.43)	(2,956,578,390.77)	(3,073,964,861.38)	(3,191,351,316.94)	(3,308,737,753.79)	(3,426,124,185.72)	(3,543,510,612.90)	(3,660,897,031.10)	(3,366,278,134.55)
		1	(139,303,500.00)	(256,689,920.52)	(374,076,342.08)	(491,462,762.74)	(608,849,224.44)	(726,235,687.19)	(843,622,108.12)	(961,008,529.15)	(1,078,394,950.26)	(1,195,781,371.47)	(1,313,167,854.65)	(1,430,554,376.98)	(1,547,940,936.25)	(1,665,327,516.06)	(1,782,714,106.74)	(1,900,100,706.45)	(2,017,487,220.22)	(2,134,873,654.42)	(2,252,260,087.87)	(2,369,646,491.35)	(2,487,032,911.38)	(2,604,419,345.25)	(2,721,805,816.56)	(2,839,192,301.80)	(2,956,578,790.04)	(3,073,965,279.65)	(3,191,351,748.72)	(3,308,738,192.55)	(3,426,124,629.73)	(3,543,511,060.54)	(3,660,897,479.44)	(2,917,945,479.44)
	0.5	0	341,053,396.55	223,666,979.65	106,280,562.44	(11,105,854.63)	(128,492,281.91)	(245,878,710.12)	(363,265,127.48)	(480,651,544.92)	(598,037,962.47)	(715,424,380.10)	(832,810,817.97)	(950,197,269.82)	(1,067,583,735.72)	(1,184,970,210.55)	(1,302,356,691.11)	(1,419,743,176.86)	(1,537,129,630.94)	(1,654,516,054.20)	(1,771,902,471.20)	(1,889,288,888.23)	(2,006,675,305.95)	(2,124,061,729.70)	(2,241,448,170.17)	(2,358,834,617.34)	(2,476,221,066.43)	(2,593,607,516.69)	(2,710,993,957.77)	(2,828,380,387.13)	(2,945,766,813.44)	(3,063,153,236.74)	(3,180,539,654.19)	(3,366,277,654.19)
		0.5	341,053,396.55	223,666,977.78	106,280,558.32	(11,105,860.61)	(128,492,305.69)	(245,878,751.77)	(363,265,170.97)	(480,651,590.27)	(598,038,009.66)	(715,424,429.15)	(832,810,890.45)	(950,197,378.76)	(1,067,583,892.95)	(1,184,970,422.08)	(1,302,356,959.60)	(1,419,743,504.29)	(1,537,129,989.25)	(1,654,516,418.16)	(1,771,902,835.91)	(1,889,289,253.70)	(2,006,675,672.61)	(2,124,062,101.60)	(2,241,448,558.02)	(2,358,835,024.88)	(2,476,221,494.22)	(2,593,607,964.83)	(2,710,994,420.39)	(2,828,380,857.23)	(2,945,767,289.17)	(3,063,153,716.35)	(3,180,540,134.55)	(2,885,921,238.00)
		1	341,053,396.55	223,666,976.03	106,280,554.47	(11,105,866.19)	(128,493,327.89)	(245,878,790.64)	(363,265,211.57)	(480,651,632.60)	(598,038,053.71)	(715,424,474.92)	(832,810,958.10)	(950,197,480.43)	(1,067,584,039.70)	(1,184,970,619.50)	(1,302,357,210.19)	(1,419,743,809.90)	(1,537,130,323.67)	(1,654,516,757.87)	(1,771,903,176.32)	(1,889,289,594.80)	(2,006,676,014.83)	(2,124,062,448.70)	(2,241,448,920.01)	(2,358,835,405.25)	(2,476,221,893.49)	(2,593,608,383.10)	(2,710,994,852.17)	(2,828,381,296.00)	(2,945,767,733.18)	(3,063,154,163.99)	(3,180,540,582.88)	(2,437,588,582.88)
	1	0	789,386,500.00	672,000,083.10	554,613,665.89	437,227,248.81	319,840,821.54	202,454,393.33	85,067,975.97	(32,318,441.48)	(149,704,859.02)	(267,091,276.65)	(384,477,714.52)	(501,864,166.37)	(619,250,632.28)	(736,637,107.10)	(854,023,587.66)	(971,410,073.41)	(1,088,796,527.49)	(1,206,182,950.75)	(1,323,569,367.75)	(1,440,955,784.78)	(1,558,342,202.50)	(1,675,728,626.25)	(1,793,115,066.72)	(1,910,501,513.89)	(2,027,887,962.98)	(2,145,274,413.24)	(2,262,660,854.32)	(2,380,047,283.68)	(2,497,433,709.99)	(2,614,820,133.29)	(2,732,206,550.74)	(2,917,944,550.74)
		0.5	789,386,500.00	672,000,081.23	554,613,661.77	437,227,242.84	319,840,797.75	202,454,351.68	85,067,932.47	(32,318,486.82)	(149,704,906.21)	(267,091,325.70)	(384,477,787.00)	(501,864,275.31)	(619,250,789.51)	(736,637,318.63)	(854,023,856.15)	(971,410,400.84)	(1,088,796,885.80)	(1,206,183,314.72)	(1,323,569,732.46)	(1,440,956,150.25)	(1,558,342,569.16)	(1,675,728,998.15)	(1,793,115,454.57)	(1,910,501,921.43)	(2,027,888,390.77)	(2,145,274,861.38)	(2,262,661,316.94)	(2,380,047,753.79)	(2,497,434,185.72)	(2,614,820,612.90)	(2,732,207,031.10)	(2,437,588,134.55)
		1	789,386,500.00	672,000,079.48	554,613,657.92	437,227,237.26	319,840,775.56	202,454,312.81	85,067,891.88	(32,318,529.15)	(149,704,950.26)	(267,091,371.47)	(384,477,854.65)	(501,864,376.98)	(619,250,936.25)	(736,637,516.06)	(854,024,106.74)	(971,410,706.45)	(1,088,797,220.12)	(1,206,183,654.42)	(1,323,570,072.87)	(1,440,956,491.35)	(1,558,342,911.38)	(1,675,729,345.25)	(1,793,115,816.56)	(1,910,502,301.80)	(2,027,888,790.04)	(2,145,275,279.65)	(2,262,661,748.72)	(2,380,048,192.55)	(2,497,434,629.73)	(2,614,821,060.54)	(2,732,207,479.44)	(1,989,255,479.44)
0.5	0	0	325,041,500.00	207,655,083.10	90,268,665.89	(27,117,751.19)	(144,504,178.45)	(261,890,606.67)	(379,277,024.03)	(496,663,441.48)	(614,049,859.02)	(731,436,276.65)	(848,822,714.52)	(966,209,166.37)	(1,083,595,632.28)	(1,200,982,107.10)	(1,318,368,587.66)	(1,435,755,073.41)	(1,553,141,527.49)	(1,670,527,950.75)	(1,787,914,367.75)	(1,905,300,784.78)	(2,022,687,202.50)	(2,140,073,626.25)	(2,257,460,066.72)	(2,374,846,513.89)	(2,492,232,962.98)	(2,609,619,413.24)	(2,727,005,854.32)	(2,844,392,283.68)	(2,961,778,709.99)	(3,079,165,133.29)	(3,196,551,550.74)	(3,196,551,550.74)
		0.5	325,041,500.00	207,655,081.23	90,268,661.77	(27,117,757.16)	(144,504,202.25)	(261,890,648.32)	(379,277,067.53)	(496,663,486.82)	(614,049,906.21)	(731,436,325.70)	(848,822,787.00)	(966,209,275.31)	(1,083,595,789.51)	(1,200,982,318.63)	(1,318,368,856.15)	(1,435,755,400.84)	(1,553,141,885.80)	(1,670,528,314.72)	(1,787,914,732.46)	(1,905,301,150.25)	(2,022,687,569.16)	(2,140,073,998.15)	(2,257,460,454.57)	(2,374,846,921.43)	(2,492,233,390.77)	(2,609,619,861.38)	(2,727,006,316.94)	(2,844,392,753.79)	(2,961,779,185.72)	(3,079,165,612.90)	(3,196,552,031.10)	(3,196,552,031.10)
		1	325,041,500.00	207,655,079.48	90,268,657.92	(27,117,762.74)	(144,504,224.44)	(261,890,687.19)	(379,277,108.12)	(496,663,529.15)	(614,049,950.26)	(731,436,371.47)	(848,822,854.65)	(966,209,376.98)	(1,083,595,936.25)	(1,200,982,516.06)	(1,318,369,106.74)	(1,435,755,706.45)	(1,553,142,220.22)	(1,670,528,654.42)	(1,787,915,072.87)	(1,905,301,491.35)	(2,022,687,911.38)	(2,140,074,345.25)	(2,257,460,816.56)	(2,374,847,301.80)	(2,492,233,790.04)	(2,609,620,279.65)	(2,727,006,748.72)	(2,844,393,192.55)	(2,961,779,629.73)	(3,079,166,060.54)	(3,196,552,479.44)	(3,196,552,479.44)
	0.5	0	805,398,396.55	688,011,979.65	570,625,562.44	453,239,145.37	335,852,718.09	218,466,289.88	101,079,872.52	(16,306,544.92)	(133,692,962.47)	(251,079,380.10)	(368,465,817.97)	(485,852,269.82)	(603,238,735.72)	(720,625,210.55)	(838,011,691.11)	(955,398,176.86)	(1,072,784,630.94)	(1,190,171,054.20)	(1,307,557,471.20)	(1,424,943,888.23)	(1,542,330,305.95)	(1,659,716,729.70)	(1,777,103,170.17)	(1,894,489,617.34)	(2,011,876,066.43)	(2,129,262,516.69)	(2,246,648,957.77)	(2,364,035,387.13)	(2,481,421,813.44)	(2,598,808,236.74)	(2,716,194,654.19)	(2,716,194,654.19)
		0.5	805,398,396.55	688,011,977.78	570,625,538.32	453,239,139.39	335,852,694.31	218,466,248.23	101,079,829.03	(16,306,590.27)	(133,693,009.66)	(251,079,429.15)	(368,465,890.45)	(485,852,378.76)	(603,238,892.95)	(720,625,422.08)	(838,011,959.60)	(955,398,504.29)	(1,072,784,989.25)	(1,190,171,418.16)	(1,307,557,835.91)	(1,424,944,253.70)	(1,542,330,672.61)	(1,659,717,101.60)	(1,777,103,558.02)	(1,894,490,024.88)	(2,011,876,494.22)	(2,129,262,964.83)	(2,246,649,420.39)	(2,364,035,857.23)	(2,481,422,289.17)	(2,598,808,716.35)	(2,716,195,134.55)	(2,716,195,134.55)
		1	805,398,396.55	688,011,976.03	570,625,554.47	453,239,133.81	335,852,672.11	218,466,209.36	101,079,788.43	(16,306,632.60)	(133,693,053.71)	(251,079,474.92)	(368,465,958.10)	(485,852,480.43)	(603,239,039.70)	(720,625,619.50)	(838,012,210.19)	(955,398,809.90)	(1,072,785,333.67)	(1,190,171,757.87)	(1,307,558,176.32)	(1,424,944,594.80)	(1,542,331,014.83)	(1,659,717,448.70)	(1,777,103,920.01)	(1,894,490,405.25)	(2,011,876,893.49)	(2,129,263,383.10)	(2,246,649,852.17)	(2,364,036,296.00)	(2,481,422,733.18)	(2,598,809,163.99)	(2,716,195,582.88)	(2,716,195,582.88)
	1	0	1,253,731,500.00	1,136,345,083.10	1,018,958,665.89	901,572,248.81	784,185,821.54	666,799,393.33	549,412,975.97	432,026,558.52	314,640,140.98	197,253,723.35	79,867,285.48	(37,519,166.37)	(154,905,632.28)	(272,292,107.10)	(389,678,587.66)	(507,065,073.41)	(624,451,527.49)	(741,837,950.75)	(859,224,367.75)	(976,610,784.78)	(1,093,997,202.50)	(1,211,383,626.25)	(1,328,770,066.72)	(1,446,156,513.89)	(1,563,542,962.98)	(1,680,929,413.24)	(1,798,315,854.32)	(1,915,702,283.68)	(2,033,088,709.99)	(2,150,475,133.29)	(2,267,861,550.74)	(2,267,861,550.74)
		0.5	1,253,731,500.00	1,136,345,081.23	1,018,958,661.77	901,572,242.84	784,185,797.75	666,799,351.68	549,412,932.47	432,026,513.18	314,640,093.79	197,253,674.30	79,867,213.00	(37,519,275.31)	(154,905,789.51)	(272,292,318.63)	(389,678,856.15)	(507,065,400.84)	(624,451,885.80)	(741,838,314.72)	(859,224,732.46)	(976,611,150.25)	(1,093,997,569.16)	(1,211,383,998.15)	(1,328,770,454.57)	(1,446,156,921.43)	(1,563,543,390.77)	(1,680,929,861.38)	(1,798,316,316.94)	(1,915,702,753.79)	(2,033,089,185.72)	(2,150,475,612.90)	(2,267,862,031.10)	(2,267,862,031.10)
		1	1,253,731,500.00	1,136,345,079.48	1,018,958,657.92	901,572,237.26	784,185,775.56	666,799,312.81	549,412,891.88	432,026,470.85	314,640,049.74	197,253,628.53	79,867,145.35	(37,519,376.98)	(154,905,936.25)	(272,292,516.06)	(389,679,106.74)	(507,065,706.45)	(624,452,220.22)	(741,838,654.42)	(859,225,072.87)	(976,611,491.35)	(1,093,997,911.38)	(1,211,384,345.25)	(1,328,770,816.56)	(1,446,157,301.80)	(1,563,543,790.04)	(1,680,930,279.65)	(1,798,316,748.72)	(1,915,703,192.55)	(2,033,089,629.73)	(2,150,476,060.54)	(2,267,862,479.44)	(2,267,862,479.44)
1	0	0	789,386,500.00	672,000,083.10	554,613,665.89	437,227,248.81	319,840,821.54	202,454,393.33	85,067,975.97	(32,318,441.48)	(149,704,859.02)	(267,091,276.65)	(384,477,714.52)	(501,864,166.37)	(619,250,632.28)	(736,637,107.10)	(854,023,587.66)	(971,410,073.41)	(1,088,796,527.49)	(1,206,182,950.75)	(1,323,569,367.75)	(1,440,955,784.78)	(1,558,342,202.50)	(1,675,728,626.25)	(1,793,115,066.72)	(1,910,501,513.89)	(2,027,887,962.98)	(2,145,274,413.24)	(2,262,660,854.32)	(2,380,047,283.68)	(2,497,433,709.99)	(2,614,820,133.29)	(2,732,206,550.74)	(2,732,206,550.74)
		0.5	789,386,500.00	672,000,081.23	554,613,661.77	437,227,242.84	319,840,797.75	202,454,351.68	85,067,932.47	(32,318,486.82)	(149,704,906.21)	(267,091,325.70)	(384,477,787.00)	(501,864,275.31)	(619,250,789.51)	(736,637,318.63)	(854,023,856.15)	(971,410,400.84)	(1,088,796,885.80)	(1,206,183,314.72)	(1,323,569,732.46)	(1,440,956,150.25)	(1,558,342,569.16)	(1,675,728,998.15)	(1,793,115,454.57)	(1,910,501,921.43)	(2,027,888,390.77)	(2,145,274,861.38)	(2,262,661,316.94)	(2,380,047,753.79)	(2,497,434,185.72)	(2,614,820,612.90)	(2,732,207,031.10)	(2,732,207,031.10)
		1	789,386,500.00	672,000,079.48	554,613,657.92	437,227,237.26	319,840,775.56	202,454,312.81	85,067,891.88	(32,318,529.15)	(149,704,950.26)	(267,091,371.47)	(384,477,854.65)	(501,864,376.98)	(619,250,936.25)	(736,637,516.06)	(854,024,106.74)	(971,410,706.45)	(1,088,797,220.12)	(1,206,183,654.42)	(1,323,570,072.87)	(1,440,956,491.35)	(1,558,342,911.38)	(1,675,729,345.25)	(1,793,115,816.56)	(1,910,502,301.80)	(2,027,888,790.04)	(2,145,275,279.65)	(2,262,661,748.72)	(2,380,048,192.55)	(2,497,434,629.73)	(2,614,821,060.54)	(2,732,207,479.44)	(2,732,207,479.44)
	0.5	0	1,269,743,396.55	1,152,356,979.65	1,034,970,562.44	917,584,145.37	800,197,718.09	682,811,289.88	565,424,872.52	448,038,455.08	330,652,037.53	213,265,619.90	95,879,182.03	(21,507,269.82)	(138,893,735.72)	(256,280,210.55)	(373,666,691.11)	(491,053,176.86)	(608,439,630.94)	(725,826,054.20)	(843,212,471.20)	(960,598,888.23)	(1,077,985,305.95)	(1,195,371,729.70)	(1,312,758,170.17)	(1,430,144,617.34)	(1,547,531,066.43)	(1,664,917,516.69)	(1,782,303,957.77)	(1,899,690,387.13)	(2,017,076,813.44)	(2,134,463,236.74)	(2,251,849,654.19)	(2,251,849,654.19)
		0.5	1,269,743,396.55	1,152,356,977.78	1,034,970,558.32	917,584,139.39	800,197,694.31	682,811,248.23	565,424,829.03	448,038,409.73	330,651,990.34	213,265,570.85	95,879,109.55	(21,507,378.76)	(138,893,892.95)	(256,280,422.08)	(373,666,959.60)	(491,053,504.29)	(608,439,989.25)	(725,826,418.16)	(843,212,835.91)	(960,599,253.70)	(1,077,985,672.61)	(1,195,372,101.60)	(1,312,758,558.02)	(1,430,145,024.88)	(1,547,531,494.22)	(1,664,917,964.83)	(1,782,304,420.39)	(1,899,690,857.23)	(2,017,077,289.17)	(2,134,463,716.35)	(2,251,850,134.55)	(2,251,850,134.55)
		1	1,269,743,396.55	1,152,356,976.03	1,034,970,554.47	917,584,133.81	800,197,672.11	682,811,209.36	565,424,788.43	448,038,367.40	330,651,946.29	213,265,525.08	95,879,041.90	(21,507,480.43)	(138,894,039.70)	(256,280,619.50)	(373,667,210.19)	(491,053,809.90)	(608,440,333.67)	(725,826,757.87)	(843,213,176.32)	(960,599,594.80)	(1,077,986,014.83)	(1,195,372,448.70)	(1,312,758,920.01)	(1,430,145,405.25)	(1,547,531,893.49)	(1,664,918,383.10)	(1,782,304,853.17)	(1,899,691,296.00)	(2,017,077,733.18)	(2,134,464,163.99)	(2,251,850,582.88)	(2,251,850,582.88)
	1	0	1,718,076,500.00	1,600,690,083.10	1,483,303,665.89	1,365,917,248.81	1,248,530,821.54	1,131,144,393.33	1,013,757,975.97	896,371,558.52	778,985,140.98	661,598,723.35	544,212,285.48	426,825,833.63	309,439,367.72	192,052,892.90	74,666,412.34	(42,720,073.41)	(160,106,527.49)	(277,492,950.75)	(394,879,367.75)	(512,265,784.78)	(629,652,202.50)	(747,038,626.25)	(864,425,066.72)	(981,811,513.89)	(1,099,197,962.98)	(1,216,584,413.24)	(1,333,970,854.32)	(1,451,357,283.68)	(1,568,743,709.99)	(1,686,130,133.29)	(1,803,516,550.74)	(1,803,516,550.74)
		0.5	1,718,076,500.00	1,600,690,081.23	1,483,303,661.77	1,365,917,242.84	1,248,530,797.75	1,131,144,351.68	1,013,757,932.47	896,371,513.18	778,985,093.79	661,598,674.30	544,212,213.00	426,825,724.69	309,439,210.49	192,052,681.37	74,666,143.85	(42,720,400.84)	(160,106,885.80)	(277,493,314.72)	(394,879,732.46)	(512,266,150.25)	(629,652,569.16)	(747,038,998.15)	(864,425,454.57)	(981,811,921.43)	(1,099,198,390.77)	(1,216,584,861.38)	(1,333,971,316.94)	(1,451,357,753.79)	(1,568,744,185.72)	(1,686,130,612.90)	(1,803,517,031.10)	(1,803,517,031.10)
		1	1,718,076,500.00	1,600,690,079.48	1,483,303,657.92	1,365,917,237.26	1,248,530,775.56	1,131,144,312.81	1,013,757,891.88	896,371,470.85	778,985,049.74	661,598,628.53	544,212,145.35	426,825,623.02	309,439,063.75	192,052,483.94	74,665,893.26	(42,720,706.45)	(160,107,220.22)	(277,493,654.42)	(394,880,072.87)	(512,266,491.35)	(629,652,911.38)	(747,039,345.25)	(864,425,816.56)	(981,812,301.80)	(1,099,198,790.04)	(1,216,585,279.65)	(1,333,971,748.72)	(1,451,358,192.55)	(1,568,744,629.73)	(1,686,131,060.54)	(1,803,517,479.44)	(1,803,517,479.44)

Chapter 6
Conclusion and Recommendations

6.1 Conclusion

The study aimed at developing a tool which could help contractor to have an insight into his cashflow and to justify its demand of capital investment from investors. The study will also help contractor and client to negotiate a reasonable bench mark between mobilization advance and retainage. The developed model was also validated by three case studies. The succeeding paragraphs presents some conclusions drawn after validating the proposed model.

As the capital investment increases, the cash flow is likely to get less negative. It is also affected by the percentage of retainage and mobilization. However, a general trend in increase in positive cash has been observed for all the case studies. The utilization of capital investment is also dependent on the expenditure plan for the execution of project. More work during the start will incur heavy expense at the start of the project which will result into an early negative cash flow.

Mobilization advance and capital investment has the same characteristics for a given expenditure plan. The only difference is that mobilization advance needs to be negotiated with the client and capital investment has to be procured by the contractor at its own. The client has nothing to deal with it. A contractor will always go for maximum mobilization advance whereas client will go for opposite situation. The result of this trade off will dictate that how much capital is required by contractor to overcome the left-over deficiency

Retainage or retention money has negative impact on cash flow. This effect the execution part of project. The less the retainage is the more positive cash flow one can have. However, on the other hand the more the retainage is during the execution phase the more the pay back will be at the end of the project in the form of retainage release.

The model can work as an effective tool to get a complete picture of how a cash flow will vary through the course of project. By providing various scenario for capital investment, mobilization advance and retainage money, the model can act as a decision-making tool to select and justify the capital contribution form investors and mobilization advance from client. The model will also give a clear idea of when and at what time the cash flow is likely to become negative during the course of project.

6.2 Recommendations

Although the model, gives a good representation of the factors used in Pakistan construction industry, still it is a limited representation of actual projects. As the construction industry is evolving day by day, the future researchers can aim at using more factors which are likely to evolve in future.

Certain assumptions were made in the development of model. Future researchers can work on these assumptions so that the model could be further refined. Some factor like overheads, contractors earning etc., were assumed to be equally distributed throughout the project duration. Variation of factors w.r.t to time can be the topic of future research.

References

Abido, M., & Elazouni, A. M. (2010). Multiobjective evolutionary finance-based scheduling: Entire projects' portfolio. *Journal of Computing in Civil Engineering, 25*(1), 85-97.

Al-Joburi, K. I., Al-Aomar, R., & Bahri, M. E. (2012). Analyzing the impact of negative cash flow on construction performance in the Dubai area. *Journal of management in Engineering, 28*(4), 382-390.

Arif, F., Lodi, S. H., & Azhar, N. (2015). Factors influencing accuracy of construction project cost estimates in Pakistan: Perception and reality. *International Journal of Construction Management, 15*(1), 59-70.

Azhar , N. F., Rizwan U, A., & Syed, M. (2008). *Cost overrun factors in construction industry of Pakistan.* Paper presented at the First International Conference on Construction In Developing Countries (ICCIDC–I), Advancing and Integrating Construction Education, Research & Practice.

Barbosa, P. S., & Pimentel, P. R. (2001). A linear programming model for cash flow management in the Brazilian construction industry. *Construction management and Economics, 19*(5), 469-479.

Chen, H.-L., & Chen, W.-T. (2000). An interactive cost-schedule/payment schedule prototype integration model for cost-flow forecasting and controlling. *17th International Association for Automation and Robotics in Construction*.

Chen, H.-L., O'Brien, W. J., & Herbsman, Z. J. (2005). Assessing the accuracy of cash flow models: The significance of payment conditions. *Journal of Construction Engineering and Management, 131*(6), 669-676.

Chen, H. (2003). Development of a systematic integration approach for multi-level cost flow prediction and management.

Demuth, H., & Beale, M. (1993). Neural Network Toolbox For Use with Matlab--User'S Guide Verion 3.0.

El-Kholy. (2014). A Multi-Objective Fuzzy Linear Programming Model for Cash Flow Management.

Elazouni, A. (2009). Heuristic method for multi-project finance-based scheduling. *Construction management and Economics, 27*(2), 199-211.

Elazouni , A. M., & Metwally, F. G. (2005). Finance-based scheduling: Tool to maximize project profit using improved genetic algorithms. *Journal of Construction Engineering and Management, 131*(4), 400-412.

Hameed, A., & Woo, S. (2007). Risk importance and allocation in the Pakistan Construction Industry: A contractors' perspective. *KSCE Journal of Civil Engineering, 11*(2), 73-80.

Hwee, N. G., & Tiong, R. L. (2002). Model on cash flow forecasting and risk analysis for contracting firms. *International Journal of Project Management, 20*(5), 351-363.

Hyung-Keun, P. (2004). Cash flow forecasting in construction project. *KSCE Journal of Civil Engineering, 8*(3), 265-271.

JCR. (2003). Real Estate Developers *Credit Rating Company Limited, Pakistan.* (pp. 10).

Jiang, A. (2012). Negotiating Construction Contracts through Practical Cash Flow Planning and Analysis Model. *International Journal of Construction Management, 12*(2), 23-33.

Jiang, A., Issa, R. R., & Malek, M. (2011). Construction project cash flow planning using the Pareto optimality efficiency network model. *Journal of Civil Engineering and Management, 17*(4), 510-519.

Kaka, A. P. (1996). Towards more flexible and accurate cash flow forecasting. *Construction management and Economics, 14*(1), 35-44.

Kaka, A. P., & Price, A. D. (1991). Net cashflow models: Are they reliable? *Construction management and Economics, 9*(3), 291-308.
Karshenas, S., & Haber, D. (1990). Economic optimization of construction project scheduling. *Construction management and Economics, 8*(2), 135-146.
Kenley, R. (1999). Cash farming in building and construction: a stochastic analysis. *Construction Management & Economics, 17*(3), 393-401.
Khosrowshahi, F. (2000). *Information visualisation in aid of construction project cash flow management.* Paper presented at the Information Visualization, 2000. Proceedings. IEEE International Conference on.
Kishore, V., Abraham, D. M., & Sinfield, J. V. (2011). Portfolio cash assessment using fuzzy systems theory. *Journal of Construction Engineering and Management, 137*(5), 333-343.
Liu , S.-S., & Wang, C.-J. (2008). Resource-constrained construction project scheduling model for profit maximization considering cash flow. *Automation in Construction, 17*(8), 966-974.
Liu , S.-S., & Wang, C.-J. (2010). Profit optimization for multiproject scheduling problems considering cash flow. *Journal of Construction Engineering and Management, 136*(12), 1268-1278.
Liu, S.-S., & Wang, C. J. (2009). Two-stage profit optimization model for linear scheduling problems considering cash flow. *Construction management and Economics, 27*(11), 1023-1037.
Liu , Y., Zayed, T., & Li, S. (2009). *Cash flow analysis of construction projects.* Paper presented at the Paper presented at the Canadian Society of Civil Engineering (CSCE) Conference.
Lucko, G. (2010). Optimizing cash flows for linear schedules modeled with singularity functions by simulated annealing. *Journal of Construction Engineering and Management, 137*(7), 523-535.
Navon, R. (1996). Company-level cash-flow management. *Journal of Construction Engineering and Management, 122*(1), 22-29.
Park, H. K., Han, S. H., & Russell, J. S. (2005). Cash flow forecasting model for general contractors using moving weights of cost categories. *Journal of management in Engineering, 21*(4), 164-172.
Purnus, A., & Bodea, C.-N. (2015). Financial management of the construction projects: A proposed cash flow analysis model at project portfolio level. *Organization, technology & management in construction: an international journal, 7*(1), 1217-1227.
Purnus, A., & Bodea, C.-N. (2016). Multi-criteria Cash Flow Analysis in Construction Projects. *Procedia Engineering, 164*, 98-105.
SBoP. (2015). Analysis Report of Economic Survey of Pakistan
Singh, S., & Lokanathan, G. (1992). Computer-based cash flow model. *AACE International Transactions, 2*, R. 5.1.
Yu, M.-C., Dang, V.-L., & Yeh, H.-C. (2017). Measuring cash flow and overdraft for fuzzy project networks with overlapping activities. *Journal of Civil Engineering and Management, 23*(4), 487-498.
Zayed, T., & Liu, Y. (2014). Cash flow modeling for construction projects. *Engineering, Construction and Architectural Management, 21*(2), 170-189.

Annexure – I
(Survey form/Data sheet)

Optimizing Project Cost: An insight into contractor's profit

Respected Sir/Madam,

Department of Construction Engineering and Management at School of Civil and Environmental Engineering (SCEE), National University of Sciences and Technology (NUST) is conducting a research titled 'Optimizing the Project Cost: An insight into contractor's profit'. The research aims at developing a model to help contractors to optimize their profit while keeping their cash gap within the acceptable limits.

In order to develop this model, we are in need of the factors that affect the cash flow (inflow/ outflow) of a project. Through extensive literature review, various factors have been identified which can possibly affect the cash flow of a project. These factors are reported in studies carried out in countries other than Pakistan. The factors are grouped into three categories depending upon the phase of the project (start/ execution / end). In order to proceed further with these factors, their application in the construction industry of Pakistan needs to be confirmed. For this purpose, we solicit your opinion regarding the applicability of identified factors using the attached questionnaire. The questionnaire is simple and easy to understand. It has been divided into two parts. Part I comprises of general information whereas Part II has six questions with sub parts in each question (three questions for cash inflow and three questions for cash outflow). Please answer the questions in the form of Yes/No against each factor. In case you don't agree with given factors, please enlist the additional factors to the best of your knowledge and experience.

We assure you that, keeping in view the code of ethics for research work, we will keep your identity in strict secrecy. Personal and professional information will not be disclosed at any stage of the research or at any forum. The sole purpose to get such information is to contact you if there is further need of your assistance at later stage. In case you have any query, you can contact the undersigned at any time.

Forwarding for you kind consideration, please.

M. Adnan Alam Khan
Postgraduate student
0302-7474454/03006387878
adnan_alam29@hotmail.com
Department of construction Engineering and Management (CE&M)
School of Civil and Environmental Engineering (SCEE)
National University of Science and Technology (NUST)

General information

1. General information about the person filling the survey form. **(the information will be kept confidential and will be used solely for educational purpose)**	
a. Designation	☐ General Manager ☐ Project Manager ☐ Cost Control Manager ☐ Quantity Survey ☐ Other (Please mention) _____
b. Working experience in construction industry	☐ 1-5 years ☐ 5-15 years ☐ 15-30 years ☐ Above 30
c. Qualification	☐ PhD. ☐ Post-graduation ☐ Graduation ☐ B. Tech ☐ DAE
d. Email id	
2. General information about the firm where the respondent is currently working or is attached with	
a. Name of Company	
b. Type	☐ Private ☐ Semi Government ☐ Public
c. Project type mostly executed	☐ Residential ☐ Commercial ☐ Educational ☐ Industrial ☐ Highways/Road Projects

Questionnaire form

1. In your opinion, whether the given factors could be the possible source of income at the start of a project?		
a. Capital contribution from investors	☐ Yes	☐ No
b. Front money	☐ Yes	☐ No
c. Mobilization advance	☐ Yes	☐ No
d. Long term loan	☐ Yes	☐ No
e. Any other not listed above (you can write as many as you can)	1.	2.
	3.	4.
	5.	6.
2. In your opinion whether the given factors could be the possible source of income during the project execution?		
a. Short term loans	☐ Yes	☐ No
b. Owner's payments	☐ Yes	☐ No
c. Contractors' earnings	☐ Yes	☐ No
d. Any other not listed above (you can write as many as you can)	1.	2.
	3.	4.
	5.	6.
3. In your opinion whether the given factors could be the possible source of income at the end of a project?		
a. Retainage release	☐ Yes	☐ No
b. Any other not listed above (you can write as many as you can)	1.	2.
	3.	4.
	5.	6.
4. In your opinion whether the given factors could be the possible sources of expenditure at the start project?		
a. Bid cost	☐ Yes	☐ No
b. Pre-construction cost	☐ Yes	☐ No
c. Bonds	☐ Yes	☐ No
d. Any other not listed above (you can write as many as you can)	1.	2.
	3.	4.
	5.	6.
5. In your opinion whether the given factors could be the possible source of expenditure while the project is in execution phase?		
a. Project expenditure	☐ Yes	☐ No
b. Cost of long term loans	☐ Yes	☐ No
c. Cost of money	☐ Yes	☐ No

d. Overheads	☐ Yes	☐ No
e. Disbursements	☐ Yes	☐ No
f. Taxes	☐ Yes	☐ No
g. Retainage	☐ Yes	☐ No
h. Short term loans	☐ Yes	☐ No
i. Any other not listed above (you can write as many as you can)	1.	2.
	3.	4.
	5.	6.
6. In your opinion, whether the given factors could be the possible sources of expenditure at the end of the project?		
a. Demobilization cost	☐ Yes	☐ No
b. Long term loan	☐ Yes	☐ No
c. Short term loan for the end period	☐ Yes	☐ No
d. Any other not listed above (you can write as many as you can)	1.	2.
	3.	4.
	5.	6.

Annexure – II
(Results of Survey)

Annexure-III
(Syntax of the MATLAB code)

First Attempt

```
clc
% this model will work on optimization
CA=input('enter the value of contract cost ');
AG=input('enter the value of accetible cash gap ');
h=input('enter the value of overheads ');
pcc=input('enter the value of pre-construction cost ');
d=input('enter the value of disbursments ');
DM=input('enter the value of demobilization cost ');
ce=input('enter the value of contractors earning from other
projects(if any) ');
tx=input('enter the value of tax deduction ');
t = input('enter the value of project duration ');
r=linspace(0,1,t); %Percentage retainage
m =linspace(1,0,t);  %Percentage Mobilization
ci =linspace(0,1,t); %percentage capital contribution
dataset = xlsread('B1.xls','E','A1:Y1');
E = dataset(:,:)
R= r.*E;
OP = E-R
for n=1:t;
    OH(n) = CA*h;
end
OH
for n=1:t;
    CE(n)=(ce*CA)/max(t);
end
CE
%for n=1:t;
    D=OP.*d;
%end
D
%for n=1:t;
    PCC=pcc*CA;
%end
PCC
%for n=1:t;
    TX=tx.*E;
%end
TX
%for n=1:t;
    R= r.*E;  % objective funtion for minimization
%end
R
OP = E-R
OF = OH+D+ TX+E + PCC+(DM*CA)+ R;
IF = OP+CE+ (ci*CA) + (m*CA)+(r.*CA);
G = (OP+CE+ (ci*CA) + (m*CA)+(r.*CA)) - (OH+D+ TX+E +
PCC+(DM*CA)+ R);

for ci= linspace(0,1,t)
    hold on
    r=linspace(0,1,t)
```

```
    hold on
    m =linspace(1,0,t)
    hold on
  G = (OP+CE+ (ci*CA) + (m*CA)+(r.*CA)) - (OH+D+ TX+E +
PCC+(DM*CA)+ R)
  plot(r,G,'b:',m,G,'g:',ci,G,'r-')
  legend('retainage','mobilization','capital investment')
  xlabel('retainage/mobilization/capital investment')
  ylabel ('Cash Gap')
  hold off
  hold off
  hold off
end
```

Second Attempt

```
clc
% this model will work on optimization
CA=input('enter the value of contract cost ');
AG=input('enter the value of accetible cash gap ');
h=input('enter the value of overheads ');
pcc=input('enter the value of pre-construction cost ');
d=input('enter the value of disbursments ');
DM=input('enter the value of demobilization cost ');
ce=input('enter the value of contractors earning from other
projects(if any) ');
tx=input('enter the value of tax deduction ');
t = input('enter the value of project duration ');
r=linspace(0,1,t); %Percentage retainage
m =linspace(1,0,t);  %Percentage Mobilization
ci =linspace(0,1,t); %percentage capital contribution
dataset = xlsread('B1.xls','E','A1:Y1');
E = dataset(:,:)
R= r.*E;
OP = E-R
for n=1:t;
    OH(n) = CA*h;
end
OH
for n=1:t;
    CE(n)=(ce*CA)/max(t);
end
CE
%for n=1:t;
    D=OP.*d;
%end
D
%for n=1:t;
    PCC=pcc*CA;
%end
PCC
%for n=1:t;
    TX=tx.*E;
%end
TX
%for n=1:t;
    R= r.*E;  % objective funtion for minimization
%end
R
OP = E-R
OF = OH+D+ TX+E + PCC+(DM*CA)+ R;
IF = OP+CE+ (ci*CA) + (m*CA)+(r.*CA);
G = (OP+CE+ (ci*CA) + (m*CA)+(r.*CA)) - (OH+D+ TX+E +
PCC+(DM*CA)+ R);

for ci= linspace(0,1,t)
    hold on
    r=linspace(0,1,t)
    hold on
    m =linspace(1,0,t)
    hold on
```

```
  G = (OP+CE+ (ci*CA) + (m*CA)+(r.*CA)) - (OH+D+ TX+E +
PCC+(DM*CA)+ R)
  subplot(3,3,1)
  plot(r,G,'b:')
  hold on
  subplot(3,3,2)
  plot(G,m,'g:')
  hold on
  legend('retainage','mobilization')
  xlabel('retainage/mobilization')
  ylabel ('Cash Gap')
  subplot(3,3,3)
  plot(ci,G,'r-')
  legend('capital investment')
  xlabel('Capital investment(ci')
  ylabel('Cash Gap')
  hold off
  hold off
  hold off
  hold off
end
```

Third Attempt

```
clc
% this model will work on optimization
CA=1243516168 %input('enter the value of contract cost ');
AG= 370000000%input('enter the value of accetible cash gap ');
h=0.02%input('enter the value of overheads ');
pcc=0.05%input('enter the value of pre-construction cost ');
d=0.05%input('enter the value of disbursments ');
DM=0.1%input('enter the value of demobilization cost ');
ce=0.05%input('enter the value of contractors earning from
other projects(if any) ');
tx=0.08%input('enter the value of tax deduction ');
t = 25%input('enter the value of project duration ');
r=linspace(0,1,t); %Percentage retainage
m =linspace(1,0,t);  %Percentage Mobilization
ci =linspace(0,1,t); %percentage capital contribution
dataset = xlsread('B1.xls','E','A1:Y1');
E = dataset(:,:)
R= r.*E;
OP = E-R
for n=1:t;
    OH(n) = CA*h;
end
OH
for n=1:t;
    CE(n)=(ce*CA)/max(t);
end
CE
%for n=1:t;
    D=OP.*d;
%end
D
%for n=1:t;
    PCC=pcc*CA;
%end
PCC
%for n=1:t;
    TX=tx.*E;
%end
TX
%for n=1:t;
    R= r.*E;  % objective funtion for minimization
%end
R
OP = E-R
OF = OH+D+ TX+E + PCC+(DM*CA)+ R;
IF = OP+CE+ (ci*CA) + (m*CA)+(r.*CA);
G = (OP+CE+ (ci*CA) + (m*CA)+(r.*CA)) - (OH+D+ TX+E +
PCC+(DM*CA)+ R);

for ci=linspace(0,1,10)
    r=linspace(0,1,t)
    hold on
    m =0
```

```
  G = (OP+CE+ (ci*CA) + (m*CA)+(r.*CA)) - (OH+D+ TX+E +
PCC+(DM*CA)+ R)
  plot(r,G,'b:')
  hold on
  legend('Ci= 0-1/M=0')
  xlabel('Capital investment(ci')
  ylabel('Cash Gap')
for ci=linspace(0,1,10)
      r=linspace(0,1,t)
      hold on
      m=0.5
       G = (OP+CE+ (ci*CA) + (m*CA)+(r.*CA)) - (OH+D+ TX+E +
PCC+(DM*CA)+ R)
  plot(r,G,'g:')
  hold on
  legend('Ci= 0-1/M=0.5')
  xlabel('Capital investment(ci')
  ylabel('Cash Gap')
for ci=linspace(0,1,10)
    r=linspace(0,1,t)
    m=1
   G = (OP+CE+ (ci*CA) + (m*CA)+(r.*CA)) - (OH+D+ TX+E +
PCC+(DM*CA)+ R)
  plot(r,G,'r-')
  hold on
  legend('Ci= 0-1/M=1')
  xlabel('Capital investment(ci')
  ylabel('Cash Gap')
end
end
end
  hold off
  hold off
  hold off
  hold off
```

Final Attempt

```
clc
clear all
% this model will work on optimization
CA=1243516168 %input('enter the value of contract cost ');
AG= 370000000%input('enter the value of accetible cash gap ');
h=0.05%input('enter the value of overheads ');
pcc=0.1%input('enter the value of pre-construction cost ');
d=0.05%input('enter the value of disbursments ');
DM=0.1%input('enter the value of demobilization cost ');
ce=0.05%input('enter the value of contractors earning from
other projects(if any) ');
tx=0.08%input('enter the value of tax deduction ');
t = 25%input('enter the value of project duration ');
r=linspace(0,1,t); %Percentage retainage
m =linspace(1,0,t);  %Percentage Mobilization
%ci =linspace(0,1,t); %percentage capital contribution

dataset = xlsread('B1.xls','E','A1:Y1');
E = dataset(:,:)
R= r.*E;
OP = E-R
for n=1:t;
    OH(n) = CA*h;
end
OH
for n=1:t;
    CE(n)=(ce*CA)/max(t);
end
CE
%for n=1:t;
    D=OP.*d;
%end
D
%for n=1:t;
    PCC=pcc*CA;
%end
PCC
%for n=1:t;
    TX=tx.*E;
%end
TX
%for n=1:t;
    R= r.*E;  % objective funtion for minimization
%end
R
za=1;
z1=1;
for m =linspace(0,1,t)
  ci = 1
for r = linspace(0,1,t)
% m
%ci
%r
```

```
    G1 =(ci*CA) + (m*CA) - (PCC)
    G2 = (OP+CE) - (OH+D+ TX+E+(r.*E))
    G3=(r*CA) - (DM*CA)

    Aa2(za,:)=G2
    Aa3(za,:)=G3
    za=za+1;


end

  Aa1(z1,:)=G1
z1=z1+1;
end
  plot(t,G1,'b--',t,G2,'b--',t,G3,'b--')
  hold on
  legend('Ci= 0-1/M=0')
  xlabel('Capital investment(ci)')
  ylabel('Cash Gap')
  hold off
  hold off
  hold off
  zb=1;
  z2=1;
```

Annexure - IV
(Complete results of Case studies)

(Look for case studies folder in the CD)