Integrated Framework for Software Cost Estimation Models

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Final Approval

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In The Name Of Allah, The Most Beneficent, The Most Merciful

Dedicated to my dearest Nana

Abdual Rahman Khan Alizi (late),

Grand Mother, My Parents and

Brothers

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Declaration

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Project In Brief

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Undertaken By:	Ali Arshad
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Acronyms

S.No	Name	Explanation
1	**LOC**	Line of Code
2	**CBR**	Cost Based Reasoning
3	**SCEM**	Software Cost Estimation Models
4	**COCOMO**	Constructive Cost Model
5	**FFP**	Full Function Point
6	**AI**	Artificial Intelligence
7	**ANNS**	Artificial Neural Networks
8	**RCA**	Root Cause Analysis
9	**RELY**	Requirement Software Reliability
10	**CPLX**	Product Complexity
11	**DBMS**	Database Management System
12	**OS**	Operating System
13	**COTS**	Commercial off the Shelf
14	**AEXP**	Application Experience
15	**PEXP**	Platform Experience
16	**LTEX**	Language and Toot Experience
17	**PCON**	Personal Continuity
18	**CEP**	Cost Estimation Process
19	**TIME**	Execution Time Constraint
20	**STOR**	Main Storage Constraint

21	**PVOL**	Platform Volatility
22	**ACAP**	Analyst Capability
23	**PCAP**	Programmer Capability
24	**TOOL**	Use of Software Tool
25	**SITE**	Multisite Development
26	**SCED**	Required Development Schedule

Abstract

Cost Estimation has always remained a focus area for researchers of different fields. For software engineering, a better cost estimation becomes more important with the fact that two-thirds of all major projects substantially overrun their original estimates. Software cost estimation is a complex activity that requires knowledge of a number of key attributes about the project. On the other hand there are diverse kinds of techniques available to predict cost estimation, each of which is having certain pros and cons. Line of code (LOC) can be considered as one of the earliest methods used for estimation purpose, i.e. how much a lines of code a programmer/developer has written on a punch card. With the emergence of high level languages and then advancement in coding environment, the LOC became insufficient. Therefore researchers were forced to come up with new and innovative ideas in this domain. All around the world, currently many tools, techniques and strategies are being practiced. Pakistan, being one of the heavily outsourced countries, thanking to its cheap labor, has also employed some techniques for cost estimation. This study is focused on Pakistani software houses with intention of exploring the software cost estimation methods, models and techniques along with current state of practice. This study also analysis the factors which are affecting the selection of software cost estimation methods/models in Pakistan software industry.

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CHAPTER 1
INTRODUCTION

Chapter 1: Introduction

Software cost estimation is a complex activity that requires knowledge of a number of key attributes about the project for which the estimate is being constructed. Cost estimating is sometimes termed "parametric estimating" because accuracy demands understanding the relationships among scores of discrete parameters that can affect the outcomes of software projects, both individually and in concert. Creating accurate software cost estimates requires knowledge of the following parameters:

The sizes of major deliverables, such as specifications, source code, and manuals, the rate at which requirements are likely to change during development, the probable number of bugs or defects that are likely to be encountered, the capabilities of the development team, the salaries and overhead costs associated with the development team, the formal methodologies that are going to be utilized (such as the Agile methods) and he tools that are going to be utilized on the project

If scheduling is an art then costing could be considered a black art. Hence software cost estimation is used for:

- Biding
- Budgeting
- Trade off and risk analysis
- Project planning and control
- Software improvement investment analysis [1,2]

There are many models starting from Line of Code (LOC) to Case Based Reasoning (CBR), a recent development, based on Artificial Intelligence (AI) is a promising approach with accuracy, ease of use, understandability and of large applicability [3].

The Software Cost Estimation Models (SCEMs) can be divided into three main categories [4].

1. **Expert judgment:** Expert judgement is the most commonly used technique in the software industry. Cost estimation is performed by the experienced member of the company. Since expert judgement is Ad-hoc in nature therefore it is difficult to generalize.
2. **Algorithmic models:** Algorithm model play a vital role in software cost estimation, most of the new companies incorporate this cost estimation

model or technique because it produces good results in terms of accuracy. The most commonly used cost estimation in this type of algorithm is COCOMO and its variants.

3. **Machine learning:** Machine learning is based on set of algorithm that learns through experience. A number of cost estimation models are based on machine learning paradigm. The most commonly used models in this technique are fuzzy logic models, regression trees, neural networks and case-based reasoning.

1.1 Motivation

The method of this study is explorative. We have used quantitative approach to assess the impact of variables used in this study. The survey is used to gather the required data. The survey design is based on two parts, most of the data will be collected using questionnaires and there will be some interviews from selected persons. The research will be carried out in three steps:

Step I - Review of the literature:

The systematic literature review described in Barry Boehm [1] is one of the key elements for this research. The use of a systematic review will increase the confidence on the validity of the Software Cost Estimation Models (SCEMs) used in this work. Other key elements will be found from literature from 2005 onwards. The main focus of getting the data will be on industrial survey. The data from the industrial survey is analyzed, on the basis of analysis and guidelines and comprehensive Framework is proposed.

Step II - Survey:

We have selected 50 software houses listed in the appendix- IV. Data was gathered from these software houses in the form of industry survey i.e. questionnaires and structured interviews. Industry survey will be designed to specifically gather data about the cost estimation predictors and methods being used in the industry. Interviews were conducted to acquire more insight into the selection of cost estimation models by the software industry and their experiences with these models.

Step III - Data Collection:

Once data were gathered this data was utilized to validate our framework. The results of the data gathered in the form of questionnaire and interview were analyzed on the basis of analysis of data and a set of guidelines, Framework was proposed.

1.2 Problem Statement

In introduction part, many factors having association with the Software Cost Estimation Models (SCEM) are being highlighted. There are many such studies which have been discussed in Chapter 2. There are such studies conducted in this area which have been performed in western world and their results are valid for western world only because they presented only the western view on SCEM which have been used in their software houses. We did not find any study having association with SCEM in Pakistani Industry before.

1.3 Research Question and Objectives

The software cost estimation is one of the most important areas which had been neglected for quite a long time by the software engineers Due to unawareness of cost estimation a number of problems arise such as delay in the development of the software, wrong or incorrect cost estimation and poor quality of software. There were numbers of cost estimation models which were proposed in the literature and all of these methods are practiced in the industry.

The work is divided into two parts; first part of the research is related to gathering the required data from industry with the help of the questionnaires and the second part is the statistical and theoretical analysis of data. Following objectives will be addressed by our study.

Objective 1

Assess the state of practice of Software Cost Estimation Models (SCEMs) in Pakistani software industry. Therefore the questions related to this objective can be.

Q 1. Is cost estimation model being followed in Pakistani software industry?

Q 2. What are the SCEMs being used?

Q 3. To determine the changes in adaptation of software cost estimation models (SCEMs) over time, if any?

Objective 2

Determine the factors that can affect the selection of Software Cost Estimation Models (SCEMs). Therefore the questions related to this objective can be.

Q 4. Which factors are considered before selecting a software cost estimation models (SCEMs)?

Q 5. What are the constraints associated with each SCEM?

Q 6. What are the advantages of each SCEM?

1.4 Thesis Organization

This thesis consists of 7 chapters. The chapter 1 is the introduction in which the motivation, problem statement, research question and objective has to be covered. Chapter 2 will cover the Literature Review of software cost estimation with the support and detail of existing software cost estimation methods. Chapter 3 focuses on the problem area. Chapter 4 focuses on the results of the conducted survey conducted. In chapter 5, software cost estimation method results are analyzed and discussed, and these results are compared with literature available. In chapter 6, the software cost estimation guidelines and framework will be provided. In Chapter 7, a brief conclusion and future work has been presented.

CHAPTER 2
LITRATURE REVIEW

Chapter 2: Literature Review

The numbers of software cost estimation models (SCEMs) which were open as well as proprietary models were discussed one by one in literature and it was shown in research work of Barry Boehm et. al [5]. This work identified the applicability of the SCEMs type of product. Function point analysis was preferred by the companies to use in the evaluation of management information system domain but in the real-time system it faces problems therefore functionality based cost estimation was used to evaluate software related to embedded and real time system. This was in turn to open SCEM which was meant for general use. After describing the SCEMs the paper takes a turn and starts a new discussion which may probably contains the information regarding the data collection or of coming new trends or towards the future research areas. This portion describes the usefulness of the case studies and throws light on neural networks i.e. this area must be under consideration for the future development of why those can be useful. Whereas this study does not describe the source of all this analysis i.e. its availability through literature but the findings of this study are based on the industrial surveys. In any case this study makes no comparison of the literature and the practices used in the industry. The main focus seemed to throw light on SCEMs and future work. The work of Boehm at all. [6] lays a strong foundation to study (SCEMs).

A very structured paper written by Capers Jones [5] on 2D structure of projects which define activities carried on various projects, the paper also calculated through industrial survey, theoretical analysis and total number of the activities. After this the author describes the areas on which the estimations are carried out and mentions the groups which are involved in the software development. At the end the Capers Jones addresses the areas which are still in dark and needed to be highlighted. These areas were the data mining, fusion of SCEMs and project management tools. Author states that no techniques have the potential to predict accurately the cost for development.

Many studies were being conducted by researchers and different companies to monitor the performance of the industry i.e. how much effort had been done in the industry. This discussion ranges from counting the total number of projects being done, the amount spent, number of successful projects and products etc. such a

survey was conducted in 2003, this study compared the figures provided by various companies and their own findings based on their own questions. The strong point of that paper was not only targeted the findings of the various companies but also various researchers, that helped them to identify the week areas on which there is room for development. Like training of project managers keeping in view the cost estimation techniques, most frequently used SCEM i.e. expert judgment but fails to identify the reasons that why there are frequent over runs [7].

In 2005 another study was conducted to find the cause of over runs and they found an interesting reason and it was that the terminology used was incorrect. Once they reported an interesting and related point i.e. the government projects have usually higher estimates then private projects in Norway, this resulted in debates and investigations. Authors found themselves in a very difficult position, as they were not a part of fact finding mission. So they had to witness to an estimate done by them which went wrong but at the end they managed to control the damage and deliver their project. They ended up with the guidelines for authors, researchers and practitioners that one would be clear regarding the terminologies being used. This research was based on the strong theoretical review along with the industrial study such studies show the similarities and the differences between the theory and practice [3].

The factors which are needed to be addressed were the applicability of the SCEMs, induction of new technologies. So the rapid changes in the industry can be handled, which is according to most of the researchers, the factor for over running. Such an effort has been done by Sherif M. Tawfik, Marwa M. Abd-Elghany and Stewart Green; they had addressed the issue of SCEMs with respect to quality and suggested the induction of Artificial Intelligence (A.I) for the purpose of estimation. Along with the suggestion they had also pointed out the advantages and disadvantages of A.I being used, and they had discussed quality attributes for a software product [4].

After investigating number of authenticated journals and 300 articles from 1991-2006 Martin Shepperd identified the areas of software cost estimation on which research could be done mostly and interesting facts were noticed and author had raised few questions, like what data is to be considered for empirical investigation, evaluate the understanding of the comparison and combination,

which type of project population might be interesting, why companies are using different SCEMs, how we predict that a particular system be deployed and how formal method can be helpful. In this study they had classified the estimation techniques in three groups, one is the algorithmic approach, this class of estimation techniques include COCOMO, SLIM, Function Point etc, second is the prediction system which contains ANNS (Artificial Neural Networks) and CBR (Case Based Reasoning) and third is the human centric judgment which is also known as expert judgment. The study is also inclined towards the fusion of estimation techniques to predict correctly and avoid over run [8].

Another similar study by Magne Jorgensen et. al. reviewed 304 research papers and came out with the fact that most of the research had done on technical point of view and a mixture of planning and estimating techniques has been deployed. It was also noticed that the researchers are targeting analogy and expert based judgments for cost estimation. Another fact which was missing in Barry Boehm et. al study is raised i.e. the use of SCEMs in real life, how a SCEM is used in real life is pointed out in this study [9].

2.1. Factors of Software Cost Estimation

The cost factors play important role in software cost estimation. Cost factor which were there and cannot be avoided in the nature of software as it was intangible. Project cost estimating was usually performed by summing estimates for individual project elements into a project total. Cost was supposed to be an "*Independent Variable*" and can be method of choice for planning projects. It begins with a "*fixed budget*" and as the project progresses the budgets reduces from the initial, it happens through a "*representative process*" of prioritizing and selecting requirements that arrive at a project scope attainable within budget limitations. Cost estimates were prepared due to various reasons, and the *rationale* of the estimate usually tells a bias to the numbers. "*Marketing estimates*" are usually to be low but good and budget estimates are often high. When reviewing the accuracy of an estimate, one must need to know the source of the estimate and the reason for which it was derived. If the estimate was initiated by a project advocate, one may want to use caution before putting those numbers in the initiated budget.

There are two main types of software cost estimation.

1. Non Algorithmic Model
2. Algorithmic Model

2.2 Non-Algorithmic Model

2.2.1. Expert Judgment

Expert judgement was one of the important methods in non algorithmic method. Expert judgement does the cost estimation of any project on the basis of expert opinion. As the expert experience of doing project in the software industry was difficult to quantify.

The factors which are included for cost estimation are.

1. The expert makes their decision on the basis of previous estimated projects.
2. All the experts of the organization do meeting and pass their ideas, how to do this projects
3. At the end of the meeting they make the summery how to estimate this project cost.
4. On the basis of summery the expert agree on the given and they do cost estimation.

2.2.2. Estimation by Analogy

Analogy costing means that compare the old project data of similar nature with the current project (had to do estimation). This type of cost estimation was difficult because the similar project data must have to be saved otherwise it will not produce accurate results. This cost estimation method was used at the component level estimation.

The factors which were included for cost estimation are.

1. Previous completed project record available
2. Compare the previous project data with ongoing or proposed project

2.2.3. Parkinson

In the Parkinson principle, work expands to fill the available volume. This principle was often used to compare the cost estimate to the available resources. This method was harmful for use as it had the potential to provide unrealistic estimates. So it had not been promoted in practice by software engineers.

The factors which were included for cost estimation are.

1. Months required to complete the project
2. Number of people required to complete the project

Effort (E) = Months * Person

2.2.4. Price to Win

In this method, cost estimation was equated to the price that was believed necessary to win the job or to be first in the market with a new product. Estimation was based on the customer's budget instead of the software functionality.

The factors which were included for cost estimation are.

1. Months required to complete the project
2. Number of people required to complete the project

Effort (E) = Months * Person

Suppose there was project to develop website for the customer and after doing estimation it calculate 200 effort and the customer was not agreeing in 200 but instead he was willing to give the effort of 150. So in this method the estimator would modify the effort to 150. So now company were able to win the project.

2.3 Algorithmic Model

2.3.1. Function Points

This methodology quantifies the amount of functionality provided by an application and expresses it in a metric called Function Point, such size measurements were needed to quantify development, maintenance, productivity and estimate development work effort [10]. It was normally seen that the system normally communicate with other system. It is necessary to make a boundary around the system and to measure the priority wise component according to the user's point. That boundary specifies the border between the project or application being measured and the applications which are external or user domain. Now components can be classified, ranked and tallied. An application's functionality was determined by its data boundary [11]. Function point can be utilized in the software application in term of size. Sizing was one

of the most important factors in making the product or project productive in term of quality. This type of estimation was being performed by different people. That's the final estimation should produce accurate results. Function point can also do analysis of tool or situation was productive in comparison to others [11, 12].

2.3.2. ESTIMACS Model

ESTIMACS Model was one of the models which use the micro estimation model with the help of function point estimation. ESTIMACS Model had set of factors which were being used in software cost estimation for any project and that were:

1. Total cost required
2. Total staff required
3. Total effort required
4. Hardware
5. Portfolio of development

The height of risk concurrent with the successful implementation of the proposed system was determined that based on responses to a questionnaire. The questionnaire examines the project factors like size, structure and technology.

2.3.3. Linear Models

There was another cost estimation model that Linear models and it had the equation such as $a_0 + \sum_{i=1}^{n} a_i x_i$, [13]. It was useless to say that software cost estimation model or technique had the importance in regards of software development. This model had their importance but in term of cost estimation it was not as compared to other models.

2.3.4. Multiplicative Models

There was another cost estimation model that was Multiplicative models and it had the equation such as Effort=$a_0 \prod_{i=1}^{n} a_i^{x_i}$ [9]. These models were always generating three values such as -1, 0, and +1. These models confirmed to be limiting to add in lots of cost factor values.

2.3.5. COCOMO (Constructive Cost Model)

This family of models was proposed by Boehm [14] and has been widely accepted in practice. In these models, code-size S is given in thousands LOC (KLOC) and effort is in person-months. The most important incentive for COCOMO model was to help people to understand the cost consequences of the decisions they had made at the time of cost estimation of the project or product. COCOMO was based on the three models which starts from the single macro based estimation model to micro based estimation model. This type of cost estimation was further divided into sub category and they are listed below:

1. Organic project: It had the small team to do the cost estimation but there results were more accurate results in term of accuracy. They had a good working experience and it only deal small projects.
2. Semi-detached projects: They had the medium team. They made the team comprising of experienced and fresh people. They only deal with the medium projects.
3. Embedded project: In this type of projects were developed within a set of tight limitations for software, hardware and operational requirements.

The Cocomo II has three stage series models.

1. Application Development

   The application development model tackles the early design phases or spirals; it is also accommodating for the project which are build using the modern GUI builder tools.

2. Early design

   This is the next step after Application Development which addresses the next cycle or spiral; it investigates alternative architecture and development approach. Requirements of this stage are consistent details with accessible information and estimation precision.

3. Post Architecture

When the system is ready to develop and it has life cycle architecture which provides detail information on cost driver and allow accurate cost estimations

2.3.6. Putnam's Model and SLIM

Putnam model was the software cost estimation model which was used for the cost estimation. This was a software tool which does the estimation automatically [15]. The formula for this software cost estimation model was following $S = E\ X(Effort)^{1/3}\ t_d^{4/3}$, in this formula one can see the E is being considered as the environment factor which bases on the historic data. One can see the S is the size of the project and size can be calculated by Line of Code and Effort will be calculated in terms of staff and time required. There is other model called SLIM. This was software tool based on *"cost estimation and manpower scheduling"*.

2.3.7. Other Models

2.3.7.1. Linear Regression

This type of model or technique does not take local conditions into thought. One can use these cost factors by applying on the *"local data and linear regression"*. So the cost estimation would be as:

$Effort = a \times S^b$.

Taking the logarithm of both sides and transforming the result into a linear equation, one gets:

$Y = A + bX$

Where Y = log (Effort), A = log (a) and X = log (S).

By applying the least square method to a set of previous project data $y_i, x_i : i = 1, \ldots . k)$ one obtains parameters b and A for the power function.

2.3.7.2. Discrete Models

Discrete models were being represented in the form of tabular which will represent the factors that are such as effort required completing the project,

duration needed for completing the project and other cost factors [15, 16 & 12] .The models was very simple as compared with other models and that's why it gains popularity.

2.3.7.3. Price-S Model

The Price-S was a proprietary software cost estimation model developed and maintained by RCA [17]. It was a macro cost-estimation model developed for embedded system applications which formulation has evolved from subjective complexity factors to equations based on the number of computers/servers, personnel, and project attributes that modulate complexity. The program provides a wide range of useful outputs such as activity distribution analysis and cost-schedule-expected progress forecasts.

2.3.7.4. Doty Model

This model was the result of extensive data analysis collected by the Air Force in the 1960's and 1970's. A number of models of similar form were developed for different application areas.

For general applications.

$MM = 5.288\ (KDSI)^{1.047}$, for $KDSI \geq 10$,

$MM = 2.060\ (KDSI)^{1.047} (\prod_{j=1}^{14} f_j)$, for $KDSI < 10$,

This model had numerical stability issues because it exhibits a discontinuity at KDSI = 10, and produces widely varying estimates via the f factors. For instance, answering "yes" to "first software developed on CPU" adds 92% to the estimated cost.

2.4. Cost Factors

2.4.1. Prioritized List of Cost Factors

S.No	Name of Cost Factor	Priority
1	Total Cost	25 %
2	Total Effort	20 %
3	Total Time	17 %
4	Total Staff Required	15 %

5	Personal Difficulty	8 %
6	Platform Difficulty	8 %
7	Product Reliability	4 %
8	Product Complexity	3 %

2.4.2. Software Cost Estimation Frequency

S.No	Software Cost Estimation Model Frequently used
1	COCOMO Model
2	Analogy Costing
3	Function Point
4	Expert Judgment
5	Putnam's Model and SLIM
6	Estimacs Model
7	Linear Model
8	Price to Win
9	Multiplicative Model
10	Parkinson Law

2.4.3. Top 20 Cost Factors

S.No	Name of Cost Factor
1	Total Cost
2	Total Effort
3	Productivity
4	Total Staff required
5	Total Time
6	Product Reliability and Complexity
7	Personal Capability
8	Platform Difficulty
9	Data Communication
10	Distributed data Processing
11	End user efficiency
12	Complex Processing
13	Multiple Sites Development
14	Software Tool
15	Application Experience
16	Main Storage Constraints
17	Required Software Reliability
18	Reusability
19	Required Development Schedule
20	Risks

CHAPTER 3
PROBLEM AREA

Chapter 3: Problem Area

3.1. Introduction

The software cost estimation was the most important area which was being neglected from many years in Pakistan software industry. Estimation plays a vital role in the success of the project. Cost estimating was a well-formulated prediction of the cost of a specific project. A cost estimate could be an important management tool of a project providing information about the project budget. All projects begin with an idea and end by filling a need.

There were such studies conducted in this area of cost estimation which have been performed in western world and there results are valid for western world only because they presented only the western view on SCEM which are have been used in their software houses. We did not find any study having association with SCEM in Pakistani Industry before. So our main target of software cost estimation is to see either cost estimation is being done in the Pakistani software industry or not. On the result of cost estimation was being done in the Pakistani software industry we will propose a framework for the betterment of cost estimation.

Following were the list of Cost Factors of Non-Algorithmic Models and Algorithmic Models.

3.2. Non-Algorithmic Model

3.2.1. Expert Judgment

Below was the cost factors which play important role at the time of cost estimation and on these factors expert judgment were being performed on any project or product [18].

1. Total Cost
2. Total Effort
3. Productivity
4. Total Staff Required
5. Total Time
6. Product reliability and complexity

3.2.2. Estimation by Analogy

Below were the cost factors which play important role at the time of cost estimation and on these factors analogy was being performed on any project or product. For performing this estimation technique the previous project data was also required [18].

1. Total Cost
2. Total Effort
3. Productivity
4. Total Staff Required
5. Total Time
6. Product reliability and complexity

3.2.3. Parkinson's Law

Below were the cost factors which play important role at the time of cost estimation and on these factors Parkinson's Law is being performed on any project or product. For performing this estimation technique the previous project data was also required [19].

1. Total Effort
2. Total Time
3. Total Staff Required
4. Procedural changes

3.2.4. Price to Win

Below were the cost factors which play important role at the time of cost estimation and on these price to win factors are being performed on any project or product and the main focus was to win the project at any cost, this deals with only customer satisfaction [19].

1. Customer Budget
2. Total Effort
3. Total Time
4. Total Staff Required
5. Management want to win Project

3.3. Algorithmic Model

3.3.1. Function Point

Below was the cost factor which plays important role at the time of cost estimation and on these factors function point was being performed on any project or product and for performing this estimation technique the previous project data was also required [20].

1. Data Communications
2. Distributed Data Processing
3. Performance
4. Heavily Used Configuration
5. Transaction Rate
6. On-line Data Entry
7. End-User Efficiency
8. On-line Update
9. Complex Processing
10. Reusability
11. Installation Ease
12. Operational Ease
13. Multiple Sites
14. Facilitate Change

3.3.2. COCOMO Model

Below are the cost factors which play important role at the time of cost estimation and on these factors COCOMO was being performed on any project or product and for performing this estimation technique the previous project data was also required [21].

1. Required Software Reliability (RELY)
2. Data Base Size
3. Product Complexity (CPLX)
4. Execution Time Constraint (TIME)
5. Main Storage Constraint (STOR)
6. Platform Volatility (PVOL)

7. Analyst Capability (ACAP)
8. Programmer Capability (PCAP)
9. Applications Experience (AEXP)
10. Platform Experience (PEXP)
11. Language and Tool Experience (LTEX)
12. Personnel Continuity (PCON)
13. Use of Software Tools (TOOL)
14. Multisite Development (SITE)
15. Required Development Schedule (SCED)

3.3.3. Estimacs Model

Below was the cost factor which plays important role at the time of cost estimation and on these factors Estimacs is being performed on any project or product and for performing this estimation technique the previous project data was also required [22].

1. Effort Hours
2. Staff Count and Cost
3. Hardware
4. Risk
5. Portfolio

3.3.4. Linear Model

Below was the cost factors which play important role at the time of cost estimation and on these factors linear model were being performed on any project or product. For performing this estimation technique the previous project data was also required [19].

1. Total Effort
2. Total Cost
3. Product reliability and complexity
4. Personnel capability
5. Platform difficulty

3.3.5. Multiplicative Model

Below are the cost factors which play important role at the time of cost estimation and on these factors multiplicative was being performed on any project or product and for performing this estimation technique, the previous project data was also required [23].

1. Effort
2. Total Cost
3. Product reliability and complexity
4. Platform difficulty
5. Personnel capability
6. Facilities

3.3.6. Putnam's Model and SLIM

Below were the cost factors which play important role at the time of cost estimation and on these factors Putnam's and SLIM is being performed on any project or product and for performing this estimation technique the previous project data was also required [24].

1. Effort
2. Size
3. Productivity
4. Scaling Factor
5. Product Delivery Time

CHAPTER 4
PROPOSED SOLUTION

Chapter4: Proposed Solution

4.1. Introduction

In order to perform industry survey for said study initially a questionnaire had been designed. Keeping in view all the requirements for software cost estimation, some questions were asked related to the personal information of the workers while nineteen questions were related to their job characteristics which were often highlighted as motivators/de-motivators by literature. The questionnaire was filled by 50 employees of different companies both male and female subjects. In this survey it was observed that mostly the males are working in this area as the survey forms were filled by 88% male and 12% were female of different working experiences. Their experience ranges from 3 years, 5 years and 8 years and among them four were having experience of more than ten years. Moreover survey forms were filled form different job levels in order to obtain the validation of results. The company's chosen for the survey was of different nature and of different sectors. The survey had been conducted mainly for the cost estimation method/technique used by those companies and to get the tenure from which they were using these techniques. So to validate the study results through finding the accuracy rate with respect to their cost estimation technique/ method used. In this survey it was also taken into account that the accuracy of cost estimation technique and its accuracy with respect to the projects. This survey had also included the priority list for cost estimation of on different factors. This study survey also broaden, focusing not only on cost and effort but on time, number of staff, personal difficulty, platform difficulty, product reliability and product complexity comparison as well as phases in which cost estimation was usually done. Another area on which this study was focussing and taken in their survey was that whether the industry personals were contented with their software cost estimation methods and whether they had compared their technique with other technique. This survey also includes the question that if IT personals had compared their technique with other technique then what was the result of comparison. Are they looking at new method, so that can replace old method with new one?

This survey can also include that cost factors which were being considered at real time cost estimation whether they can saved the cost estimation data for future in comparison of accuracy rate. This survey also represents the thinking of different people about project size, estimation accuracy and also importance of cost estimation with other aspect of cost estimation. Moreover it also reflects the different views of size of project in cost estimation and how cost estimation had been done and as well as on the size of the project.

4.2. Industry Survey

4.2.1. Total years of working experience in capacity of an estimation?

Survey forms were filled form different employee having different estimation experiences. 20% of the survey was filled by the employee having 1–3 years of experience. 44% of the survey was filled by the employee having 2–5 years of experience. 14% of the survey was filled by the employee having 5–8 years of experience. And 22% of the survey was filled by the employee having 8 and more years of experience.

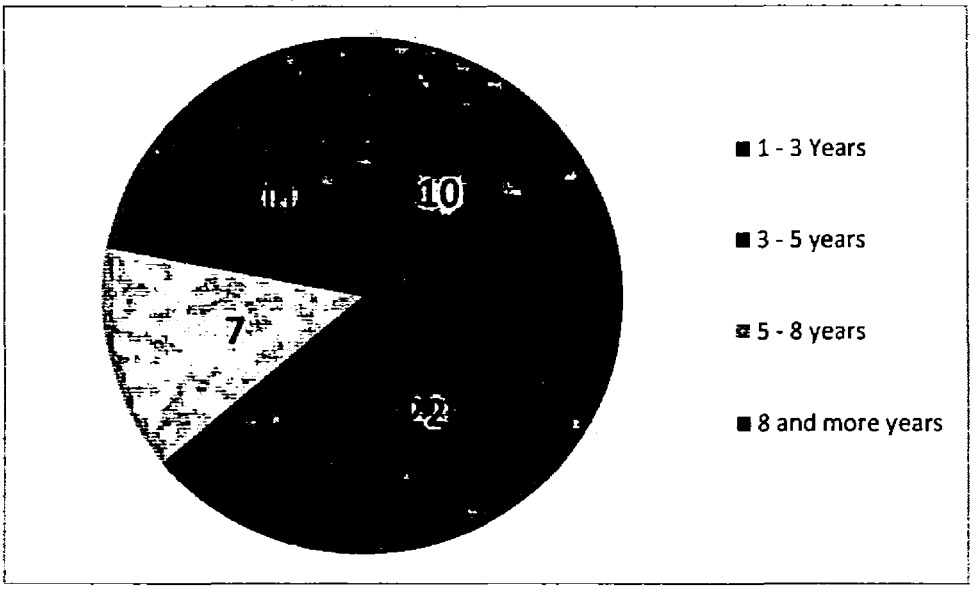

Fig1. Work Experience

4.2.2. What is your job role at your organization?

Survey forms were filled form different job levels for the validity of results. The job level ranges from Requirement Engineer, Developer, Quality Assurance Personnel, Team Lead, Project Manager and Development Manager. 60% of the survey was filled by the Project Manager, 12% of the survey was filled by the Quality Assurance Personnel, 10% of the survey was filled by the Team Lead and 6% of the survey was filled by the Developer, Requirement Engineer and Development Managers.

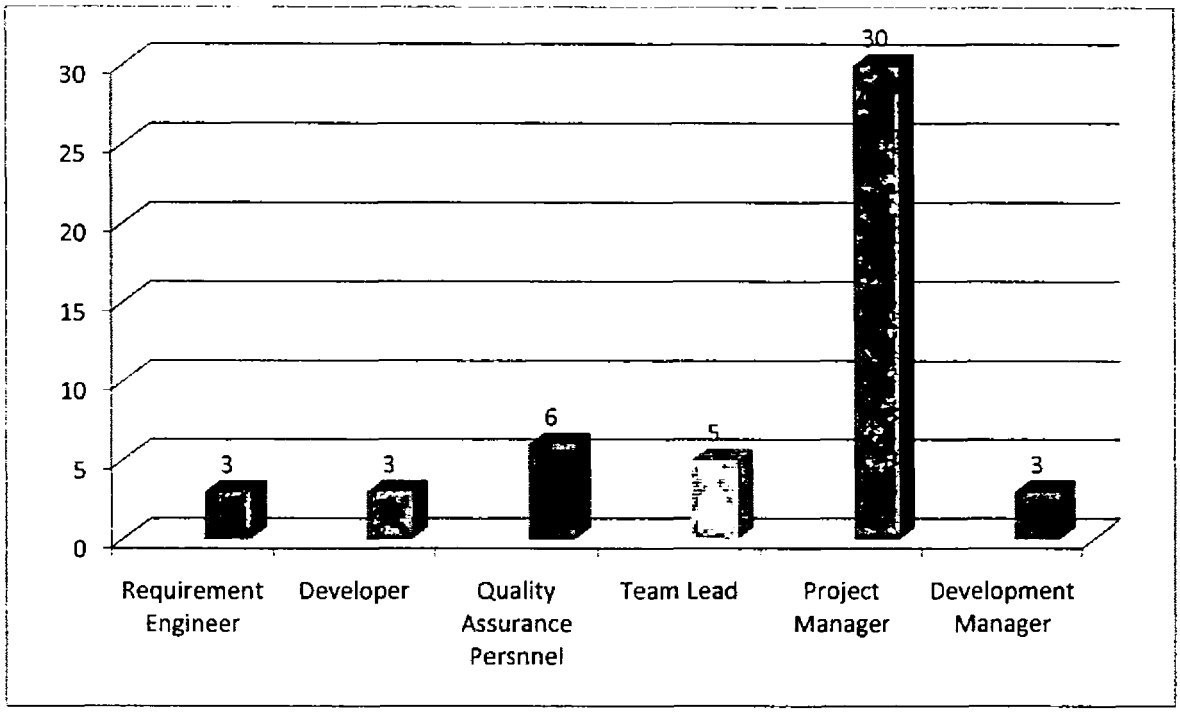

Fig2. Role at your Organization

4.2.3. Which Sector does your company belong to?

The survey was conducted on different companies. The survey was filled by three sector of Pakistan software industry and that are private, semi government and Public or government sector. The survey being filled by the private sector were having maximum participation of 64%, while the participation from government that was public and semi government sectors were 26% and 10% respectively. On considering both public and semi government sector it became obvious that the participation on cost estimation was lacking. So it was observed that in public and semi government sector all

the decisions were suppose to carry out with the team consultation and they don't have direct input for the cost estimation.

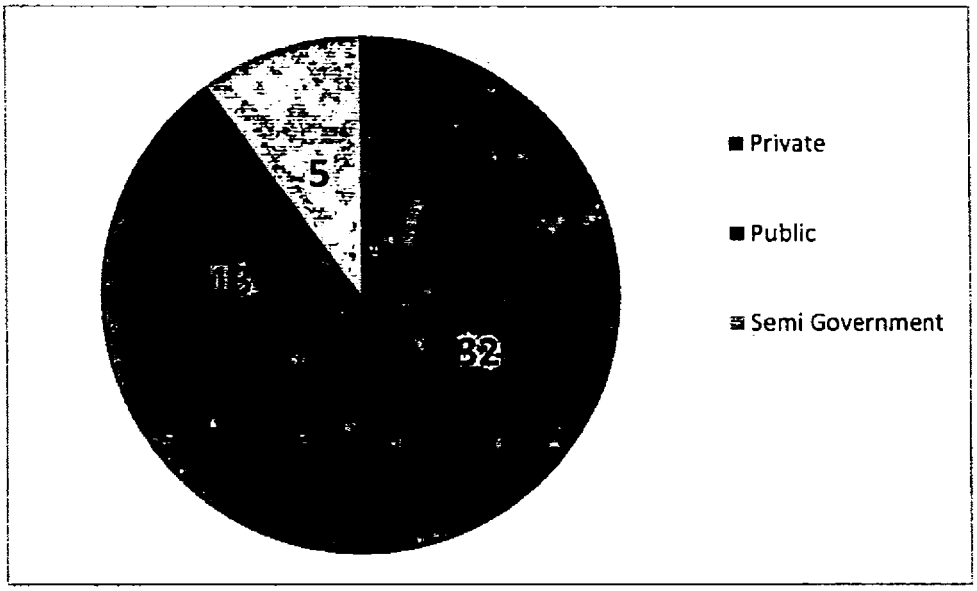

Fig3. Your company belong to

4.2.4. Which software cost estimation method your company is using?

The survey was also conducted on the use of cost estimation method by those companies. In the said survey it was observed that 44% of the respondent chooses the "Industry Benchmarks" and normally termed as Expert Judgment technique for cost estimation. Out of total 56% of the respondent chooses the "Methods of estimation" for cost estimation. In this technique the COCOMO model was the most popular model among the model based cost estimation technique were such as function point analysis, line of code, analysis effort method and so on.

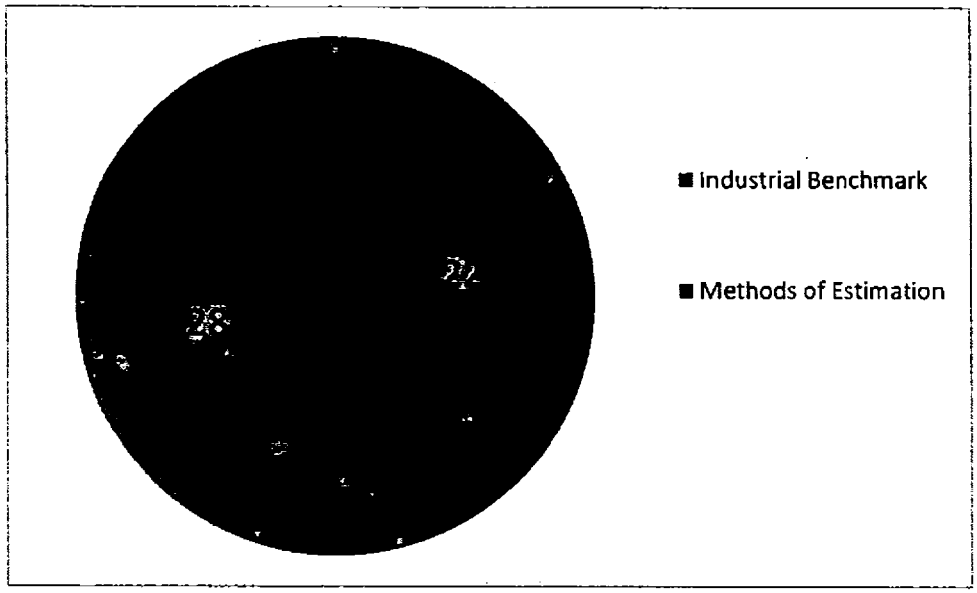

Fig4. Cost Estimation Technique

4.2.5. From how long your company has been using mentioned software cost estimation methods?

The survey was conducted from different companies for the use of cost estimation method and tenure from which they were using these methods. The survey reports that these companies were using cost estimation ranges from 1 to 2 years, 3 to 5 years and 6 and above years. 40% of the respondent belonging to those companies which have the experience of cost estimation methods for the last 3 to 5 years, 38% of the respondent belonging to those companies which have the experience of cost estimation methods for the last 6 or above years. 22% of the respondent belonging to those companies which had the experience of cost estimation methods for the last 1 to 2 years.

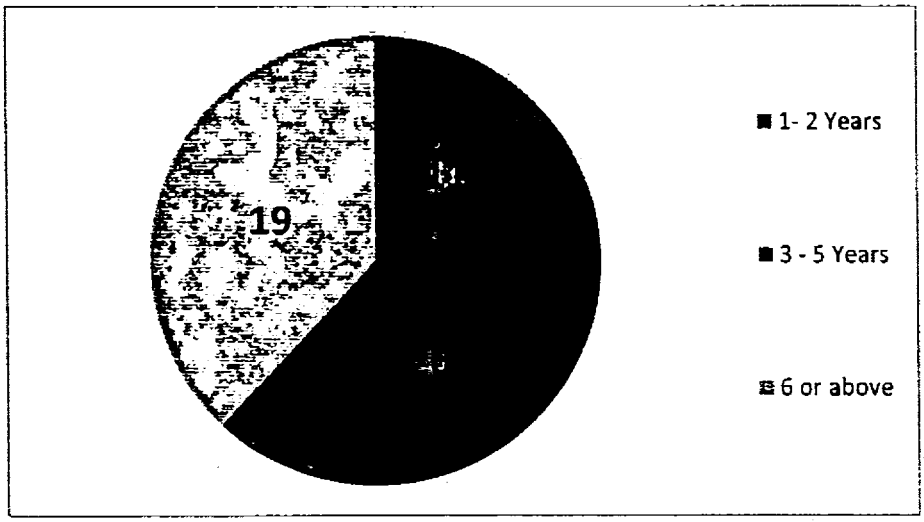

Fig5. Use of cost estimation

4.2.6. How do you measure the size of the project?

Survey was conducted from different companies in order to inquire about the effort required for cost estimation. Most of the respondents replied that Effort will be required to measure the size of the project that was 62%. The respondent replied that Time will be required to measure the size of the project that is 26% and some respondent replied that line of code will be required to measure the size of the project that is 12%.

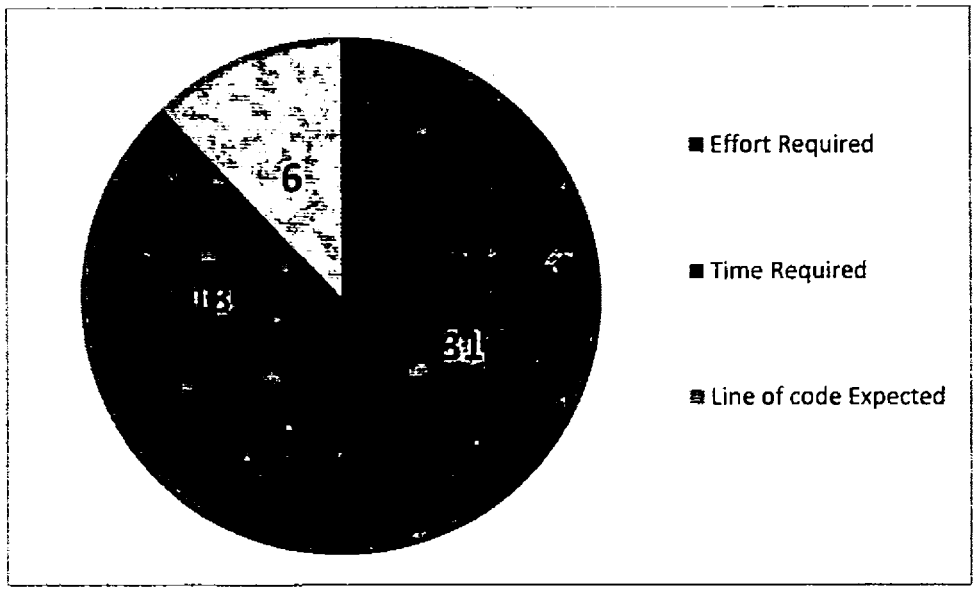

Fig6. Size of Project

4.2.7. What is the accuracy rate of estimation methods you are using?

Form our survey, which was conducted in the software industry, we had categorized the 60-80% accuracy to "challenged", 80-100% accuracy to

"success" and 40-60% accuracy to "other" . We came to know from the results that most of the respondent answered the accuracy between 60 to 80 percent, it can be termed as "challenged". 21 company's respondent between the 80 to 100 percent accuracy and it is termed as "success". Most of the respondent opted for model based estimation followed by expert judgment and others in the "success" category. Those companies who are using expert judgment and other techniques should consider model based estimation as well because the accuracy rate was on the higher side in model based estimation.

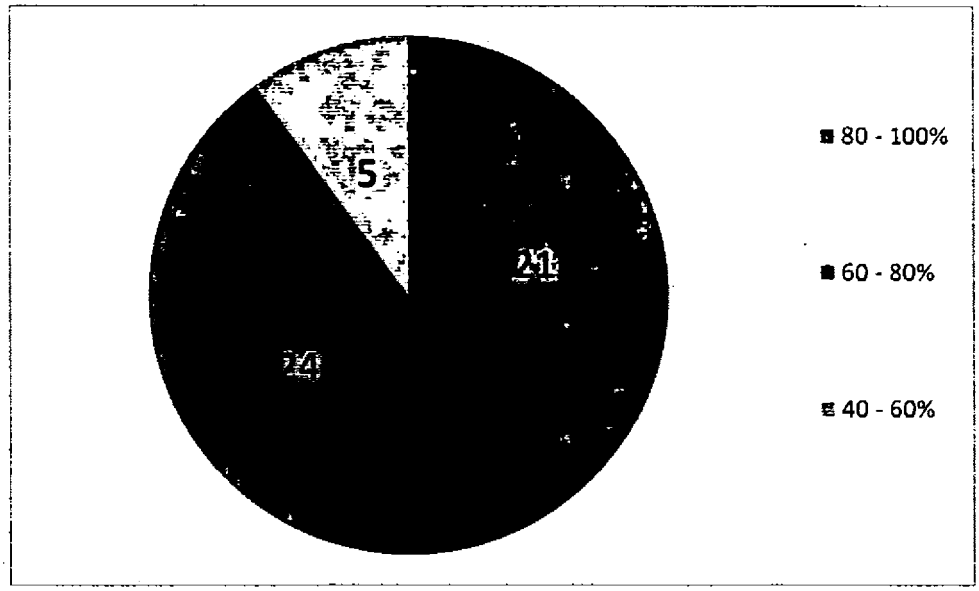

Fig7. Accuracy of cost estimation

4.2.8. Accuracy of Cost estimation methods is varying?

The survey also focused on the accuracy of cost estimation methods with respect to the projects. The accuracy level of cost estimation methods was varying during the project. From different companies the form survey had been filled and most of them replied that accuracy level changes during the project. The 86% respondent replied that the accuracy level of cost estimation methods changes and only 14% of the respondent replied that accuracy level of cost estimation methods does not change. Accuracy of cost estimation varies from low level to medium level projects and medium level to large level projects. As the project size grows it was more likely became the victim of under cost estimation.

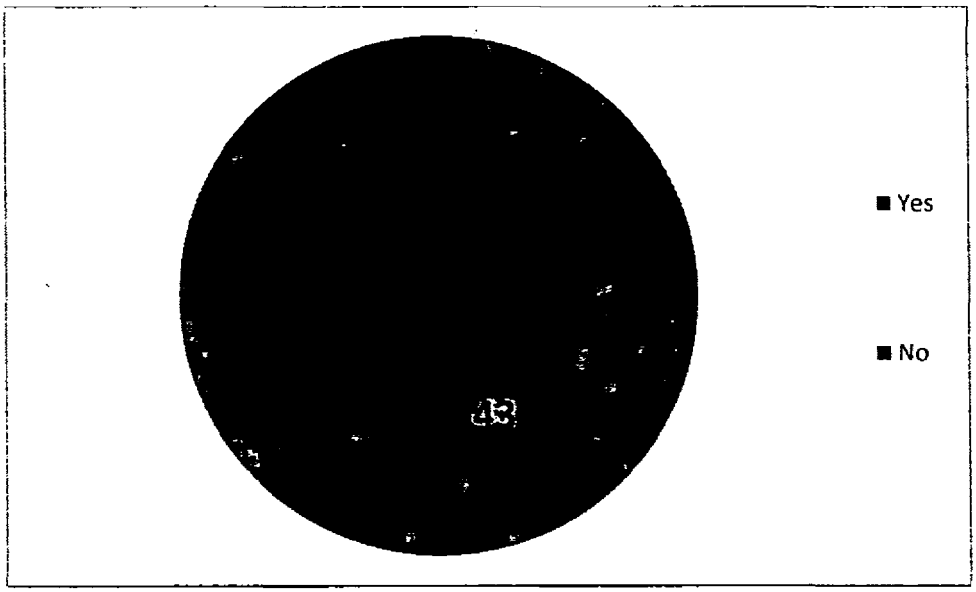

Fig8. Variance in cost estimation accuracy

4.2.9. In software cost estimation methods which cost factor are on your priority (Please Prioritize from 1 to 8)? Please list it down in ascending order

This survey included different factors at least different companies and their priority list for cost estimation. It also concluded that cost, effort, time, and number of staff, personal difficulty, platform difficulty, product reliability and product complexity were areas to be addressed. The priority ranged from 1 to 8, 1 indicates to very high priority of the cost factor whereas 2 mean less priority and so on. Total cost had very high priority and most of the people rated it as a very important factor and given it a priority of 21%. Whereas Total Effort and Total Time has less priority from Total Cost and people has rated this factor a priority of 20%. Total Staff required had priority of 14%. Product Complexity had priority of 8%. Platform Difficulty and Product Reliability had 6% and the Personal Difficulty had least priority from all others priorities and people had rated this factor priority of 5% only.

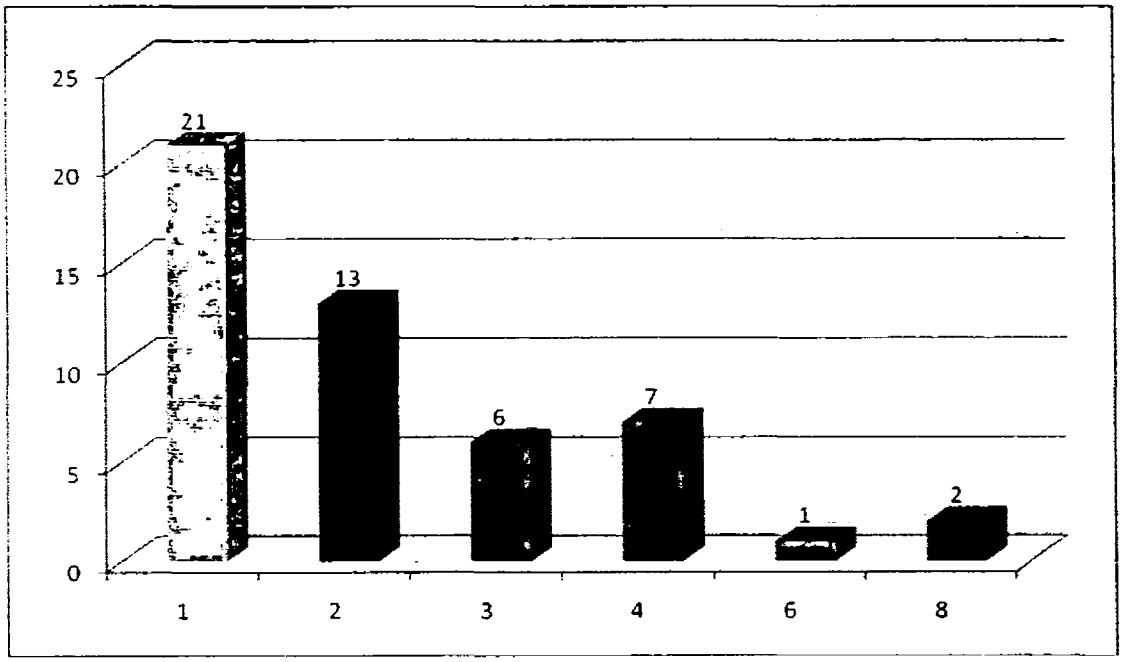

Fig9. Perception of the practitioners regarding the importance of cost estimation

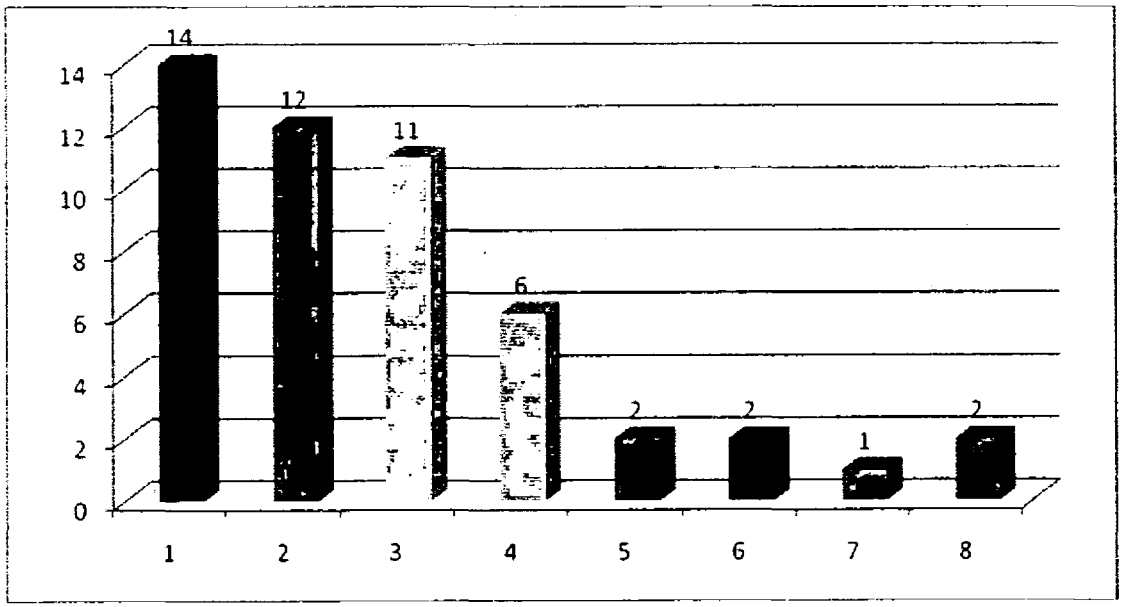

Fig10. Perception of the practitioners regarding Effort required for cost estimation

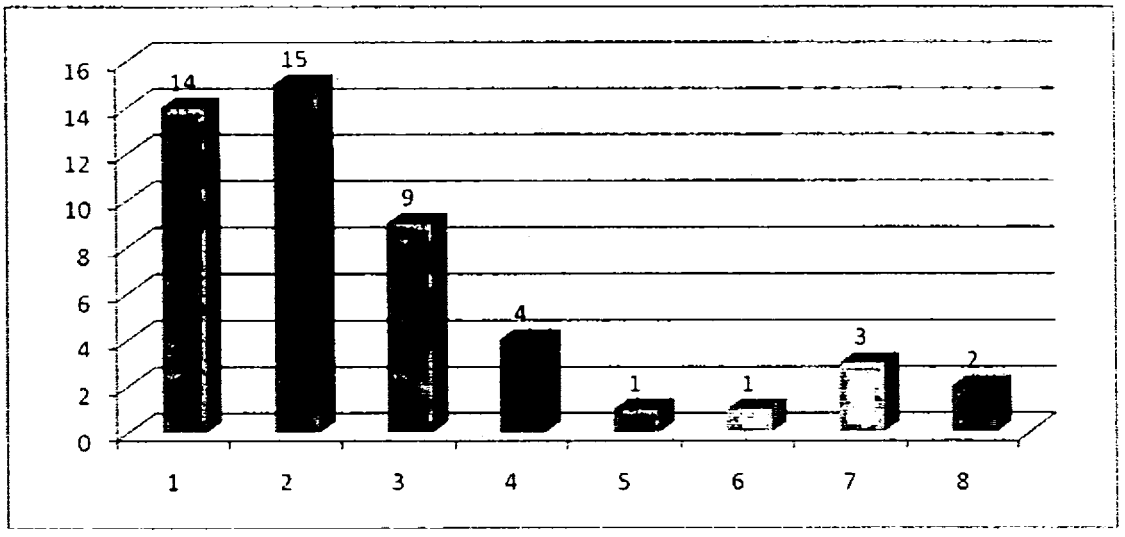

Fig11. Perception of the practitioners regarding the Total Time for cost estimation

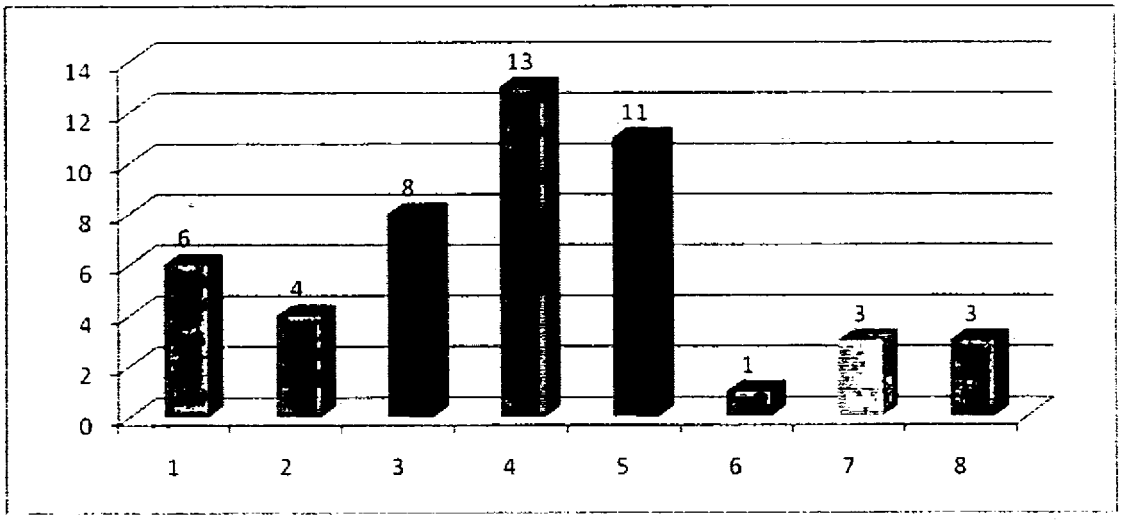

Fig12. Perception of the practitioners regarding the Total Staff Required for cost estimation

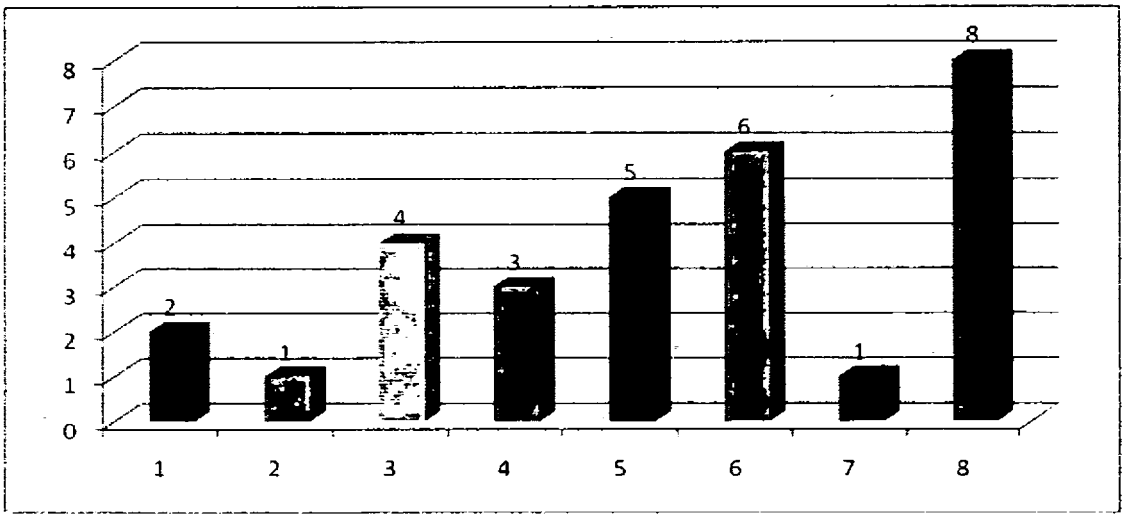

Fig13. Perception of the practitioners regarding the Personal Difficulty in cost estimation

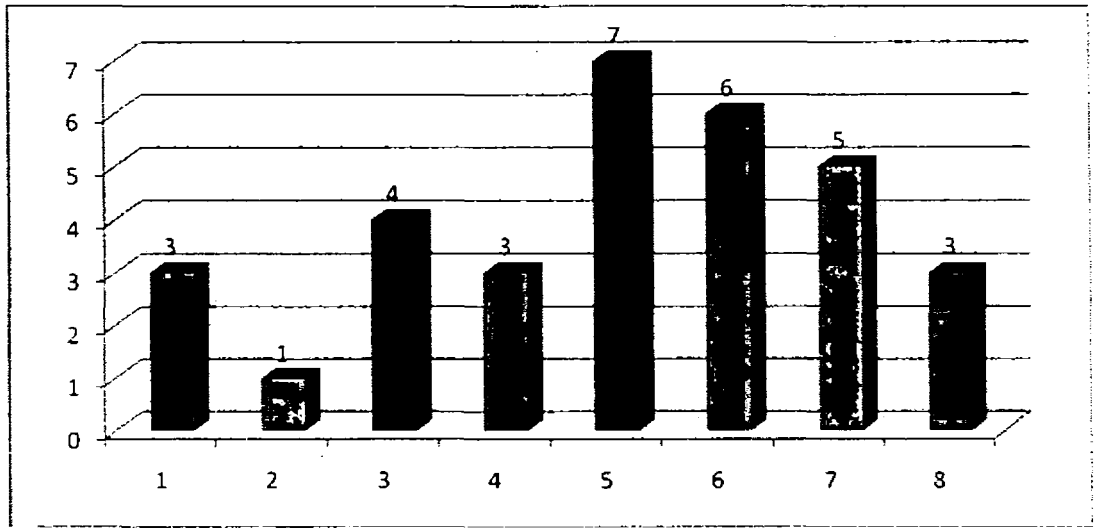

Fig14. Perception of the practitioners regarding the Platform Difficulty in cost estimation

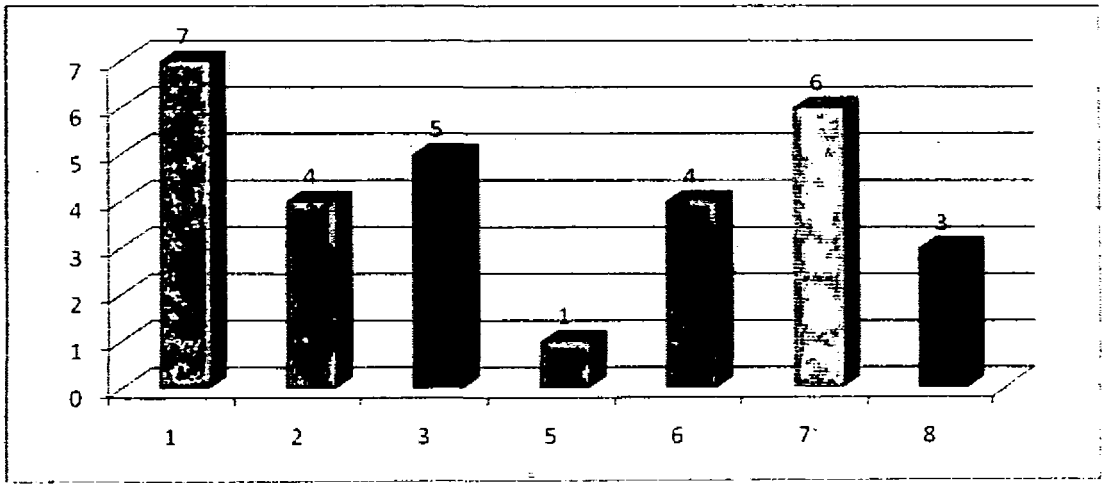

Fig15. Perception of the practitioners regarding the Product Reliability in cost estimation

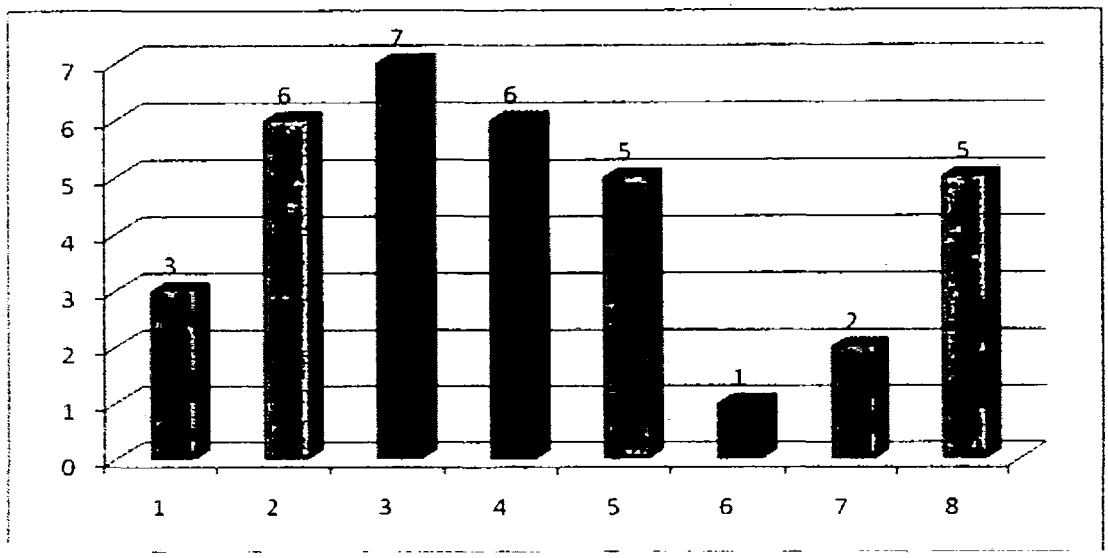

Fig16. Perception of the practitioners regarding the Product Complexity in cost estimation

4.2.10. Are you contented with existing software cost estimation methods you are using?

Survey was conducted on different companies in order to see whether the organizations were satisfied with their software cost estimation method or not. The survey depicted that 78% people having different work experience were satisfied with their cost estimation methods which they were using. 22% people having different work experience were not been satisfied with their cost estimation methods.

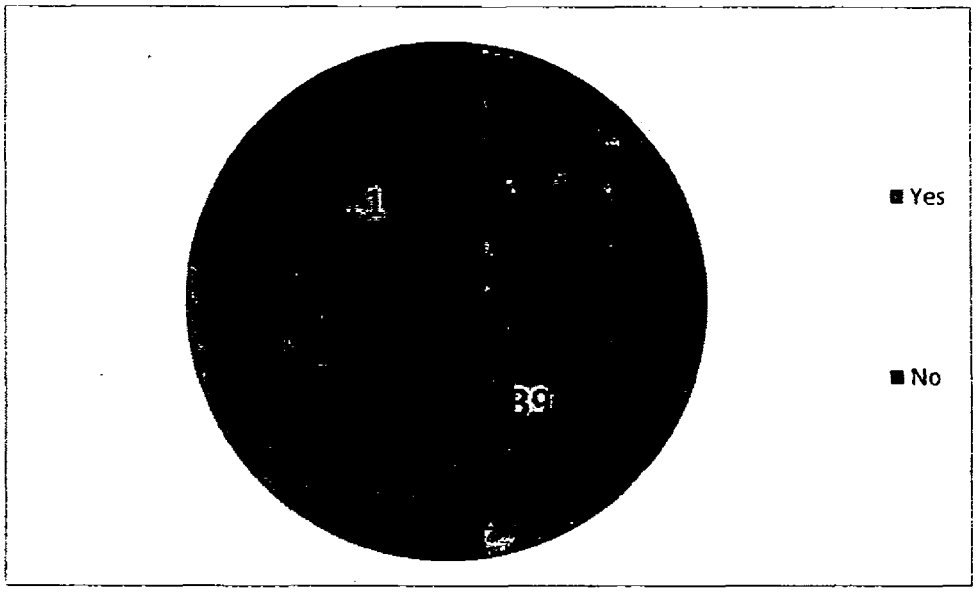

Fig17. Contented with cost estimation Technique

4.2.11. Did you perform any comparison with other software cost estimation methods?

The survey was done from different companies in order to assess whether the companies had compared their cost estimation methods with other methods. Only 14% respondent replied that they had compared their technique with other cost estimation methods. 86% respondent replied that even did not need to compare their method with other cost estimation methods as they suppose that their cost estimation method was producing good results.

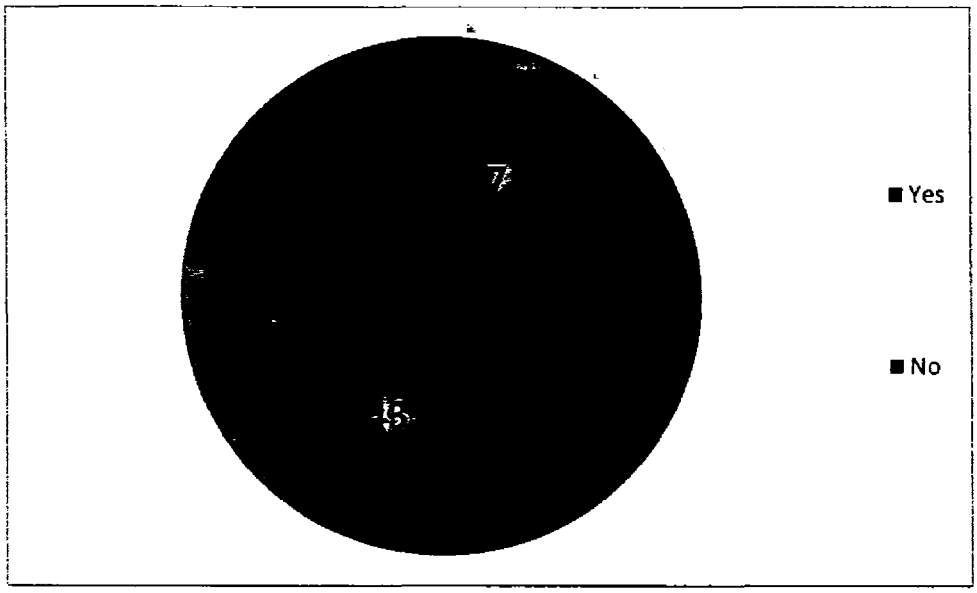

Fig18. Cost Estimation Comparison

4.2.12. What was the result of comparison?

The result of comparison was done because as told above most of the companies not perform comparison and they supposed that their cost estimation method was producing good results. 90% had not compared with other method. 2% people had compared and found some results that are with 40% variation, 5 % error because they are working in an international market and have to estimate quickly for BIDs. In this regard COCOMO was good for quick estimations, Cross model comparison and existing actual from similar projects and it depends on the nature of project and ones priorities. Results may be different sometimes but none of them was efficient in absolute way.

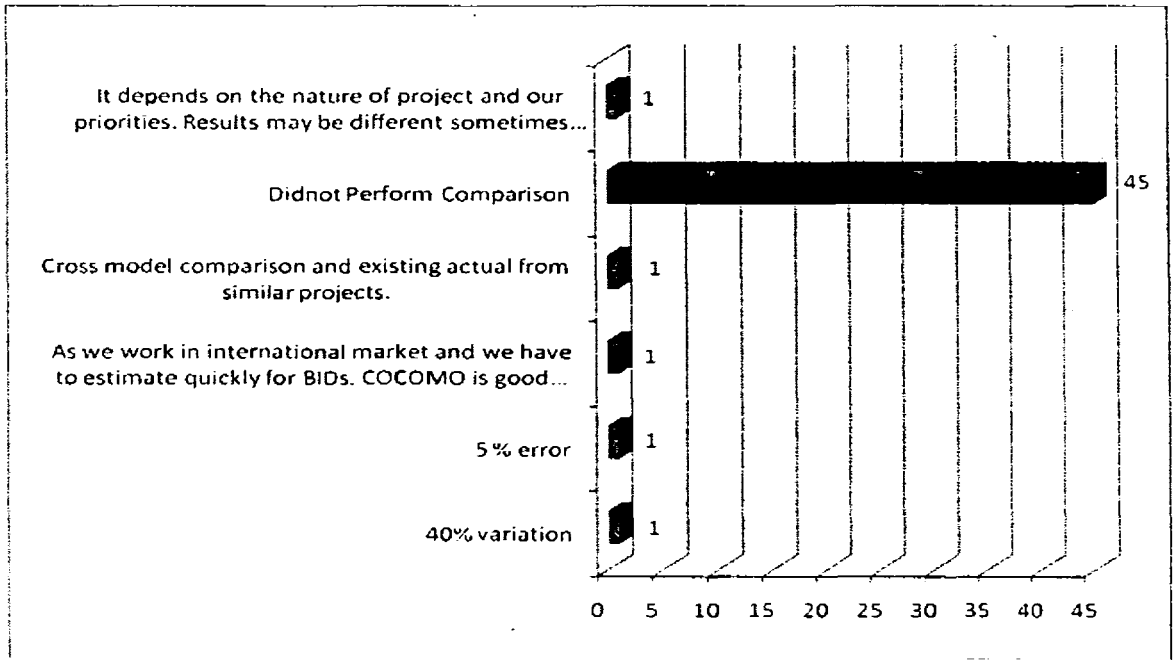

Fig19. Comparison Result

4.2.13. If we provide you with a method of cost estimation, will you be interested in using the method instead of your existing estimation method?

The survey was done from different companies and they were looking at new method. So want to replace old cost estimation method with new cost estimation method. 72 % respondent replied that were looking to use the new method and 28 % people were not interested in using the new method of cost estimation.

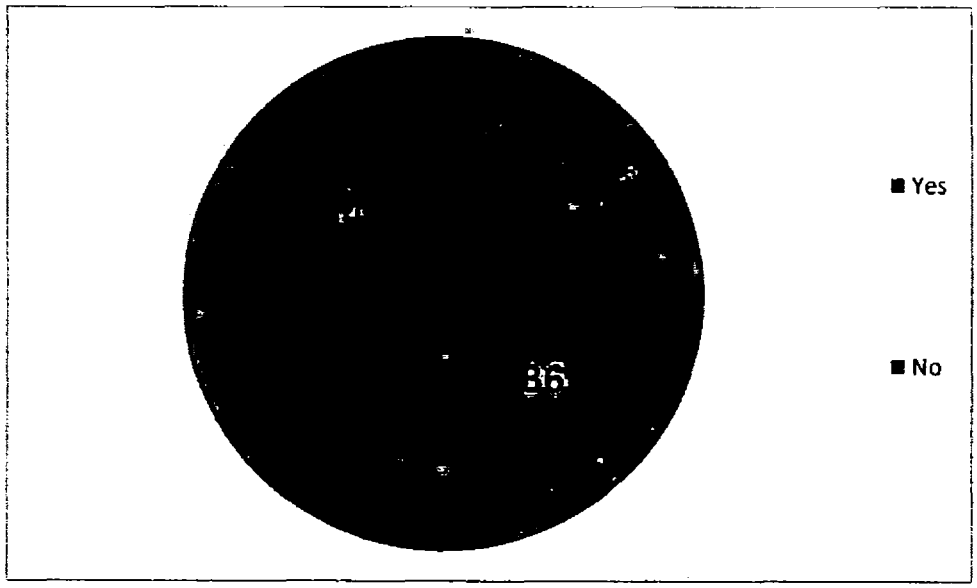

Fig20. New Method for Cost Estimation

4.2.14. Which factors should be considered at the time of software cost estimation method?

The survey was done from different companies. The survey also concluded that cost factors can be considered at real time cost estimation. Total effort was being considered at the time of software cost estimation. It had very high priority as compared to others and was approximately 36%. Total cost and its priority was 34%. Total Time and its priority was 20%. Total staff required and it had the priority of 10%.

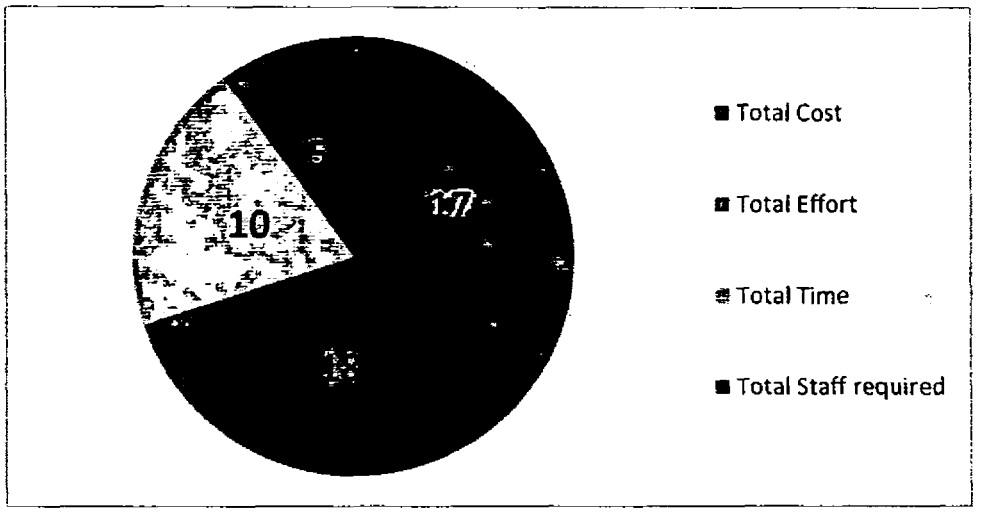

Fig21. Factors at Cost Estimation

4.2.15. Have you preserved the cost estimation data of recent projects?

The survey was done from different companies and whether they had preserved for the analysis of cost estimation data. The result came that form our observation just 62 percent of the companies had preserved the past data regarding their completed or aborted projects whereas 38 % people have not preserved the cost estimation data for future comparison.

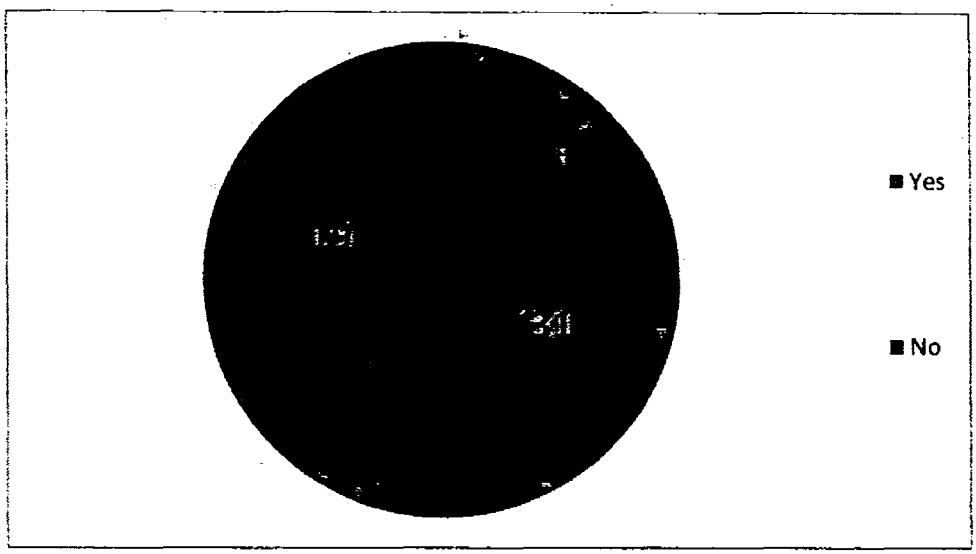

Fig22. Cost Estimation Data

4.2.16. Does project size affects effort and schedule estimation accuracy?

The survey was done from different companies and 94% people replied that size will affect the effort and schedule of cost estimation and 6% people replied that size will not affect the effort and schedule of cost estimation.

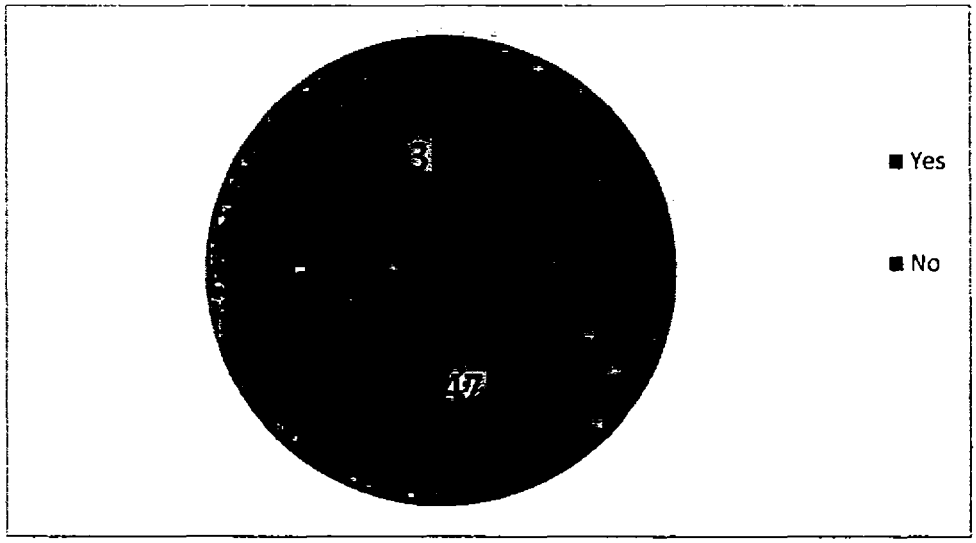

Fig23. Size affects effort and schedule

4.2.17. What are the causes of inaccurate software cost estimation methods?

When the survey was conducted from different companies and respondent has answered that the inaccuracy in estimation modeling

were due to volatile, vague, incomplete requirements and unskilled resources different people from different companies have different opinions for the causes of inaccurate cost estimation method. Out of total surveyors 34% respondents replied that Product Complexity was the one of the main causes of inaccurate cost estimation. 22% people think that Total Cost was the one of the main causes of inaccurate cost estimation. 12% people replied that Total Effort was the one of the main causes of in accurate cost estimation. 8% people replied that Personal Difficulty was the one of the main causes of in accurate cost estimation whereas 6% people replied that Total Time, Total Staff Required, Platform Difficulty and Product Reliability were the causes of inaccurate cost estimation.

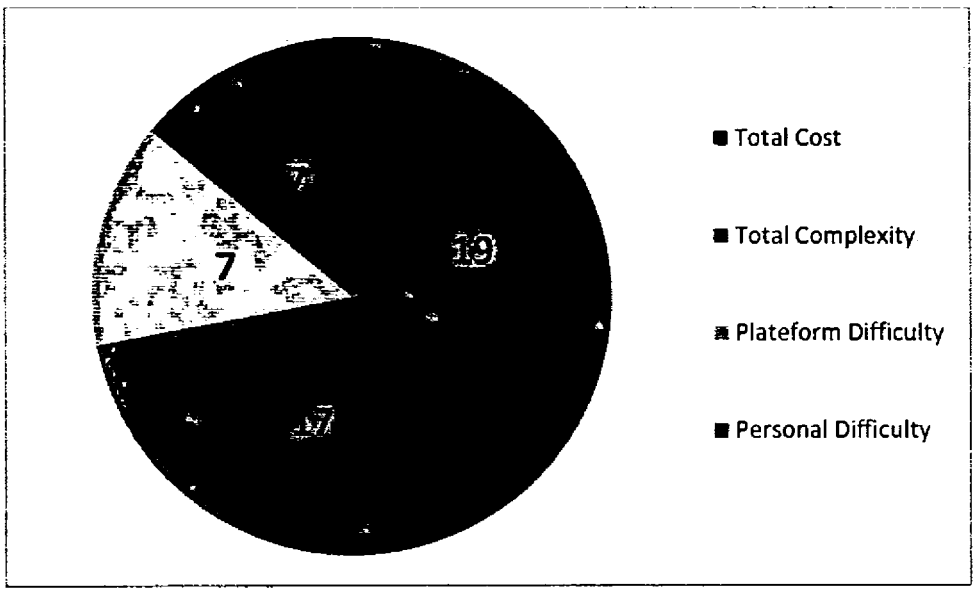

Fig24. Causes of Cost Estimation

4.2.18. What are the barriers and difficulties in the application of software cost estimation?

When the survey was conducted on different company's people from different companies replied differently for the barriers and difficulty faced when applying cost estimation method. 44% people replied that they usually faced the problem of Personal Difficulty and skilled staff, when they applied cost estimation method. 24% people replied that they faced the problem when data was incomplete requirement at the time of

applying cost estimation method. 20% people replied that they faced the problem of lack of information at the time of applying cost estimation method. 12% people replied that they faced problem due to Company's Policy.

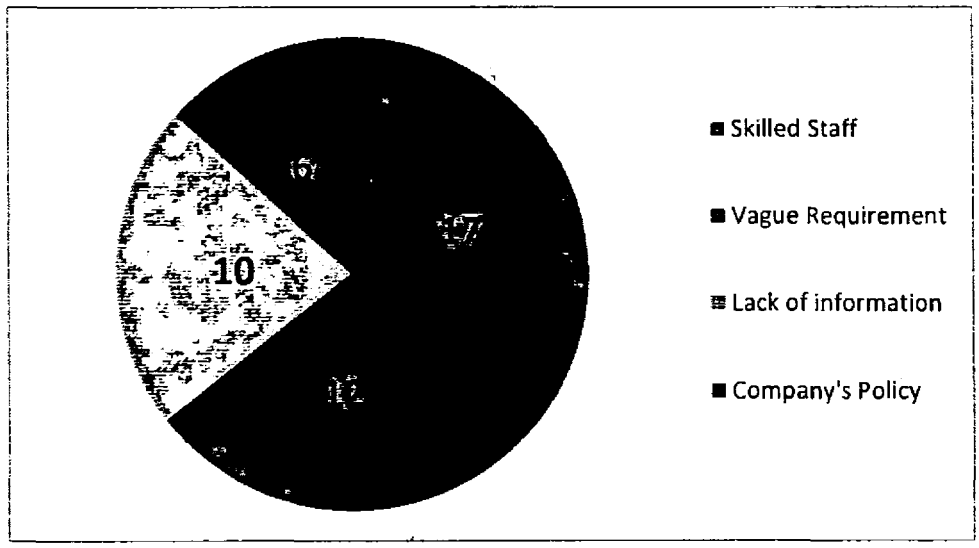

Fig25. Barriers of Cost Estimation

4.2.19. Are you using any software for cost estimation?

When the survey was conducted on different companies for the answer whether they were using software for cost estimation most of them replied that they were not using any software for cost estimation method 66% companies were not using where 44% were using software for cost estimation method.

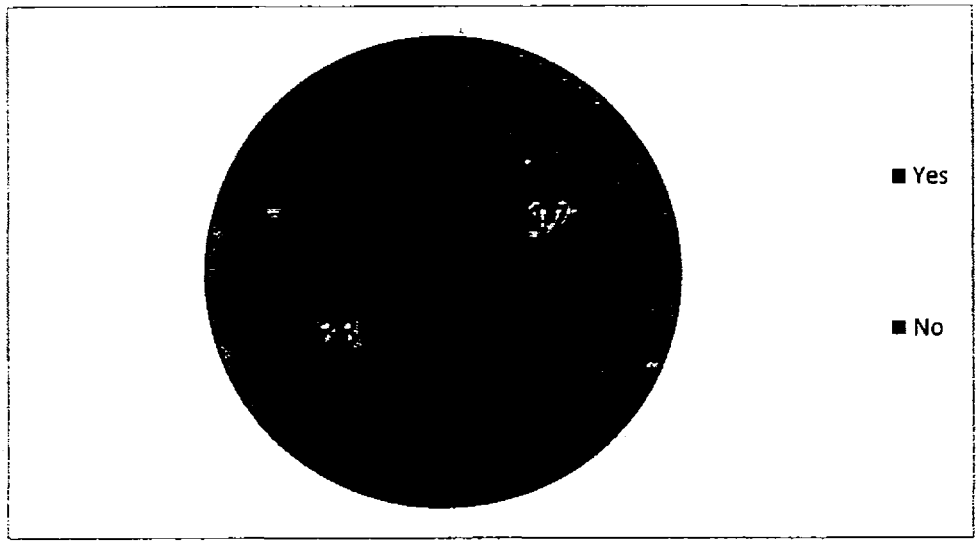

Fig26. Software for Cost Estimation

4.2.20. Does the size of the project play a vital role in cost estimation?

The survey was done on different companies and most of the respondent replied that the 88% from those companies replied that size of the project play vital role in cost estimation whereas few replied that size of the project did not play any vital role in cost estimation and those were 12% of the total.

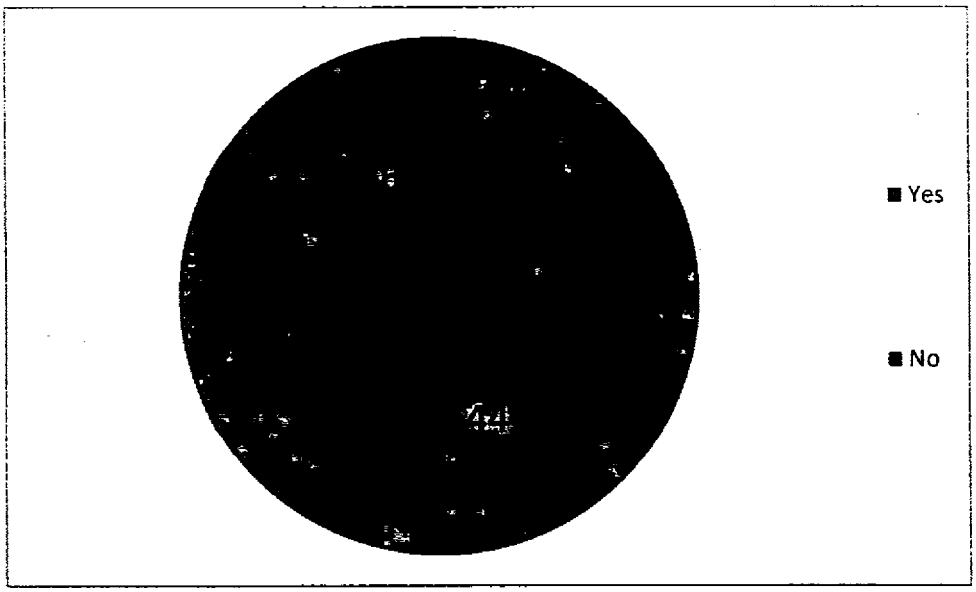

Fig27. Vital Role

4.2.21. If answer of question 20 is YES, What is the reason? If answer of question 20 is NO, which factors are important and why?

When the survey was conducted on different companies 32% of the respondent replied that there was "resources availability" problem. 26% of the respondent replied that if the project was big than "more time" will be required to complete the project. 22% of the respondent replied that there was "budget availability" problem. 20% of the respondent replied that problem only arise when the "final goal was unknown".

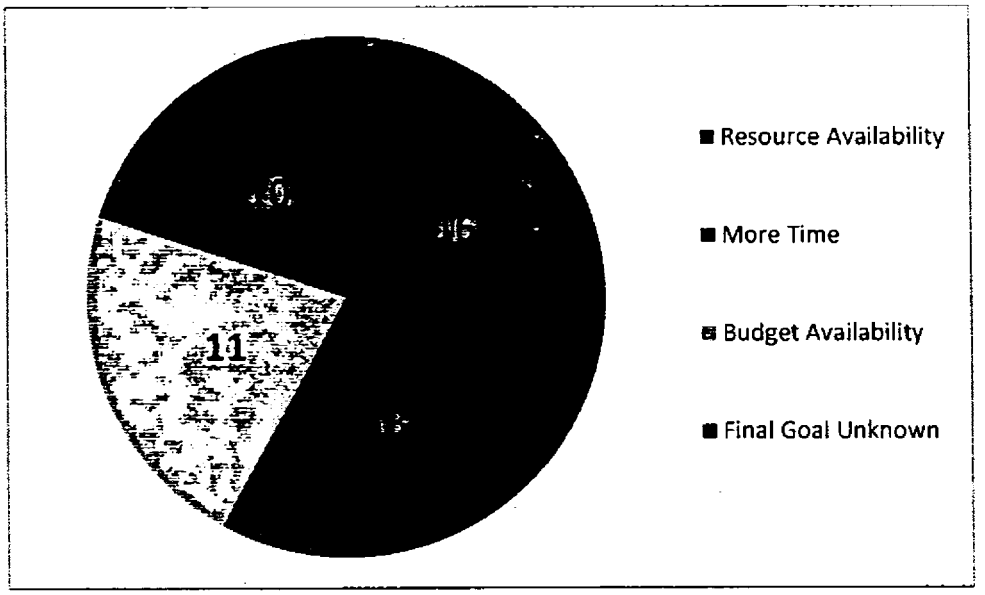

Fig28. Size Importance

CHAPTER 5
RESULTS & DISCUSSION

Chapter 5: Results and Discussion

5.1. Introduction

The intent of this research was to assess which software cost estimation models (SCEMs) were used in the Pakistani software industry. It is found that most software companies neglect this crucial step and enhance detriment software quality. Due to the intricate process of cost estimation modelling unskilled practitioners prey victim to the inherited complexities of the process.

We have followed the steps of software engineering institute guidelines for making the design of the survey [19].

The steps which were being followed were given below.

1) Identify the research objectives

In this guideline, we had to find which software cost estimation model was being followed in the Pakistani software industry and does this area have improvement capabilities of software cost estimation methods.

2) Design and write the questionnaire

In this guideline, we had made the survey questions close ended. It was because that the respondent feels at ease in replying efficiently and quickly.

3) Analyze the results and write a report

In this guideline, we had surveyed from different companies and gathered the sample of 50 at that time.

5.2. Results and Discussion

Software cost estimation methods in practice

Our study was consisted with harmony to Malaysian studies [24], Chinese studies [25] and Norwegian studies [26] where the use of Expert Judgment was on the higher side. Model based methods were much popular and COCOMO received the highest ratings. This result was consisted with harmony to Malaysian studies [24] as well in terms of accuracy. From the above mentioned stats, we analyzed that the Expert Judgment was most popular method used in the software industry. It justifies that the project manager had a huge theoretical and practical knowledge

of expert Judgment in relation to the other cost estimation methods used in the industry.

Accuracy rate of software cost estimation Methods being used

Form our survey, which was conducted in the software industry. We came to know from the results that most of the respondents answered the accuracy between 60 to 80 percent and it can be termed as "challenged". Study was consistent with the Norwegian studies [26], 21 companies' respondent between 80 to 100 percent accuracy and it was termed as "success". Most of the respondents opted for model based estimation followed by expert judgment. Rest was "success" category. Those companies who were using expert judgment and other techniques should consider model based estimation as well because the accuracy rate was on the higher side in model based estimation.

Form our survey, which was conducted in the software industry, we came to know from our results that are consistent with the Chinese studies [25] where the cost estimation is being used early in the project or product. It is also consistent with the general practice when the project feasibility, analysis, budgeting, project planning and control all the requirements which are necessary are being done early in the cost estimation.

Causes of inaccurate software cost estimation methods

Form our survey, which was conducted in the software industry, we came to know from our results that were consistent with the Chinese studies [25]. We endorse this proposal that more research should be done regarding Lederer proposal that had satisfaction which will suggest that correspondence from the managers and professionals may have accepted the inaccurate cost estimation as factors. Most of the respondents who have "unsatisfactory" response were using Expert Judgment and it was also consistent with our own results where we had observed that model based cost estimation yields higher cost estimation accuracy than the expert judgment.

Practitioner's perception about cost estimation methods.

Our survey which was conducted in the software industry, we came to know from our results, shows that people in the industry recognize it due to its importance of cost estimation modeling. Our survey results were being consistent with the

Chinese studies [25] and Norwegian studies [26] where a distinct majority had recognized the importance of this activity. Majority of the respondents 41 termed it "important", 4 respondents termed as "neutral" and 5 respondents termed as "un important". The respondents who termed cost estimation modeling "neutral" and "un important" also scaled low at their satisfaction level.

Hurdles in the application of software cost estimation

Our study, we observe that major barrier in Pakistani industry was the requirements engineering phase and unskilled technical worker, whereas in Chinese studies [25] they do have problem with requirements engineering but they don't have problems with unskilled worker. There was lack of specialized and skill resources which were lacking in Pakistani industry. Whereas in Chinese studies [25] there was lack of skilled resources were scaled at the bottom where as 22 percent of the respondents faced this problem. Hence more effort will be required to train the technical personnel in order to employ cost estimation models. Whereas general response of respondent from Pakistani industry was same as that of Chinese studies and some common responses include skill that staff required and need of resources. Vague or incomplete requirement at that time of gathering information, lack of data for performing cost estimation, company's policy as some of the companies were against the wall of these cost estimation techniques and so on.

Fully automated software cost estimation software's

Our results, 17 respondents using software tools for cost estimation and out of 16 are satisfied with the estimation modeling techniques. Whereas out of 33 respondents not using any software. 18 were satisfied with whatever technique they were using and 15 were unsatisfied. In this observation, we can conclude that an automated cost estimation model yields the higher satisfaction with the model is 94.11 percent. Whereas those who are not using any software their satisfaction level is at 45.45 percent. This was a huge difference, so we propose an efficient software cost estimation model in this regard.

As we have done the survey in Pakistani software industry and our results are similar to the results which are being reported by the Chinese studies [18] and the main causes of inaccuracy in estimation modeling are due to volatile, vague,

incomplete requirements and unskilled resources. And whereas the in which the unskilled resources problem is not that sever as that in the case of Pakistani software industry.

From the result of survey, our survey was consistent with the Norwegian study [19] that reveals that as project size grows it was more prone to under estimation. And this fact is acknowledged by 47 respondents out of 50 and from this analysis we can say that size was the main important feature in any good doing cost estimation.

Accuracy of Cost estimation method varies

We conducted the survey in the Pakistani software industry and the result came that most of the respondents acknowledged that accuracy of cost estimation varies from low level to medium level projects. And as the project size grows, it had more likely become the victim of under cost estimation.

The other barrier which came across in advancing the research in cost estimation was non cooperation in Pakistani software industry and only 16 percent of the companies show their willingness to share their data for research purposes. We propose research in this direction regarding some confidence building measure between the academia and industry people.

Factors considered at the time of software cost estimation methods

This survey also included different factors which were being considered in different companies have on their priority list for cost estimation. It was also concluded that cost, effort, time, and number of staff, personal difficulty, platform difficulty, product reliability and product complexity were areas to be addressed. The priority ranges from 1 to 8, 1 indicates to very high priority of the cost factor, 2 means less priority and so on. Total cost had very high priority and most of the people have rated it as a very important factor and given it a priority of 21%. Total Effort and Total Time has less priority from Total Cost and people have rated this factor a priority of 20%. Total Staff required had priority of 14%. Product Complexity had priority of 8%, Platform Difficulty and Product Reliability had of 6%. Personal Difficulty had least priority from all others priorities and people have rated this factor priority of 5% only.

CHAPTER 6
VALIDATION

Chapter 6: Validation

6.1. Introduction

We have done the survey of different companies which were facing some problems in applying software cost estimation method in this regard. There was the list of problems which are being highlighted and they were given below.

1. As we see the companies which were using model based cost estimation, their accuracy level was high as compared to those companies which were using expert judgment but expert judgment was most popular method used.
2. The companies faced the problem due to incomplete or volatile requirement at the time of applying software cost estimation.
3. The companies which were doing cost estimation with the help of software is 44%, had the higher accuracy but companies which were doing cost estimation without the help of software is 66%, had the lower accuracy.
4. There was also the problem of unsaved data, as we seen from the survey that most of the companies were not saving the data and most of the companies are using expert judgment. If the people leave the company then there was no data available for comparison with old projects.
5. In our survey, we also came to know there was a problem of skilled worker in case of cost estimation

On the above mentioned problem we have came with the guidelines followed by framework. By using them there will be more accuracy in coming projects and these guidelines are given in the next section.

6.2. Guidelines for SCEMs

There was a lack of proper cost estimation use which can cause severe consequences. This indicates that the companies are frequently using cost estimation models lack of understanding. So, there is a need for clarification of the goal of the estimation on the impact of the factors on cost estimation models. From the above mentioned problem, we have proposed the guidelines for the improvement of cost estimation accuracy.

1. Two stage process using expert judgement for initial activities for example biding and using model based cost estimation for more elaborate activities such as planning, resource allocation.
2. Incremental cost estimation for noncritical requirements and accumulation into model based cost estimation.
3. Automate the cost estimation models.
4. Periodic training of the personnel on the emerging issues of cost estimation.
5. Maintain a complete repository of completed and aborted projects.

Now these proposed guidelines are explained in detail as under.

6.2.1. Two stage process using expert judgement for initial activities and model based cost estimation for more elaborate activities

As we have done the national wide survey and according to the result we come to know that companies were using either expert judgement or Model based cost estimation. So that was one of the reasons of having low accuracy of cost estimation of the projects at the time of using expert judgement. We observed that Expert Judgment was most popular method among the software cost estimation practitioners whereas Model Based Cost Estimation yields higher accuracy result which was consistent with the Malaysian studies [26]. Therefore, we propose Expert Judgment for approximate estimation early in the project and more detailed and precise estimation later on using any of the available Model Based Cost Estimation method.

6.2.2. Incremental cost estimation for noncritical requirements and accumulation into model based cost estimation.

We have observed during the course of the survey analysis that requirement's creeping was a vital issue faced virtually by all the

organizations. We propose that newly popped-up requirements should be addressed using fast methods e.g. Expert Judgment and results can be accumulated with the model based cost estimation.

6.2.3. Automate the cost estimation models.

We have observed that inclusion of automated tools increases satisfaction level of cost estimation practitioners. The need of automation was required because as we have seen in the industry the companies are doing cost estimation either by expert judgement or by model based estimation. They were doing manually there was no automated tool used. Therefore, we propose that cost estimation models used in industry should be properly automated. This was because those companies which want manual cost estimation they do estimation with expert judgement. Those companies which want to use model based cost estimation there was automated tool available and this tool will be built by integrating different model based estimation techniques such as COCOMO, Agile estimation, Prototyping model, V model and so on.

6.2.4. Periodic training of the personnel on the emerging issues of cost estimation.

We observed that there was a problem of unskilled staff and this result was consistent with Chinese studies [25]. People do not give importance to cost estimation, so they simply skip cost estimation by giving the excuse of unskilled staff. So by giving training to the specified people who were being involved at the time of cost estimation of the project or product. In order to address the problem of unskilled workers we have to motivate the staff at the end of the training by giving different incentives.

6.2.5. Maintain a complete repository of completed and aborted projects.

We had observed that a number of software companies are not recording data of their completed or aborted projects. This data was of vital importance since it reflects the current position of the organization and its culture towards cost estimation practices. Since a larger number of organizations rely only on Expert Judgment, therefore organizations were dependent heavily on these experts and in case of job migration precious data is also lost and there will be nothing available for comparison held when new projects are estimated. Moreover, without proper historical data some cost estimation method can't be used e.g. analogy based cost estimation, case based reasoning, etc. For this above mentioned problem we need to take confidence building measure in the industry people.

6.3. Comprehensive Framework for SCEMs

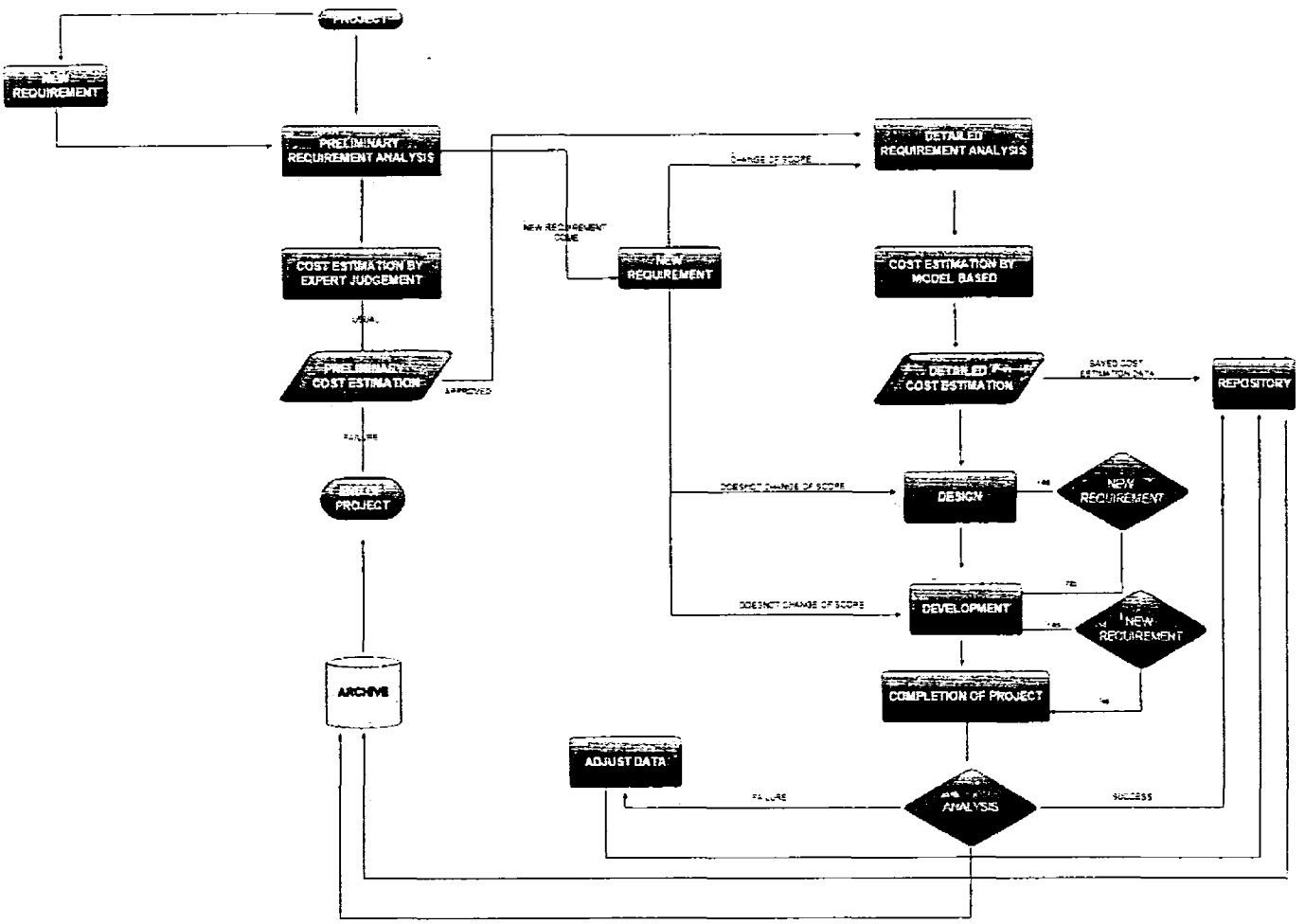

Fig29. Proposed framework for Cost Estimation

The above figure shows the proposed framework for SCEMs. Whenever the project came we had to do preliminary requirement analysis. After requirement analysis the cost estimation of the project was calculated by the expert judgement and if cost of the project was approved by the customer in the bidding then we will proceed further on otherwise it will be terminated. If it was approved by the customer then we will do detailed requirement analysis. After analysis cost estimation was done by model based estimation. Data was saved in the temporary database. If some new requirement came by the customer, then the expert will see this requirement was changing all scope of the project. If it was changing all scope of the project then all the cost estimation was done from start. If it was not changing scope of the project then only that requirement cost estimation and carry out the project. When the project complete then we will do analysis and see whether our estimation of the cost was correct or not. If the estimated data was correct then the data was saved in the temporary database. From temporary database it was saved to achieve database. If the cost estimation was not according to estimation then we had to adjust the cost estimation data and then it was being updated in temporary database. From temporary database it was saved to achieve database.

6.4. Validation of Framework for SCEMs

As we surveyed for the validation of the proposed framework guidelines, most of the respondents appreciated the effort we made in improving the accuracy of the software cost estimation model.

1) Kindly select one or more issues related to cost estimation faced by your company.

Below figure would explain the companies which are facing the problems. The 64 % of the respondents are facing the problem of "Due to incomplete or volatile requirement at the time of applying software cost estimation". The 46 % of the respondents are facing the problem of "use of model based cost estimation; their accuracy level was high as compared to those which are using expert judgment" and "Cost estimation with the help of software has higher accuracy but those who are not using software has lower accuracy". The 42% of the respondents were facing the problem of "Unsaved old project data and

find problem in doing cost estimation for new projects as estimation was done through expert judgment". The 36 % of the respondents were facing the problem of "Problem of skilled worker in case of cost estimation".

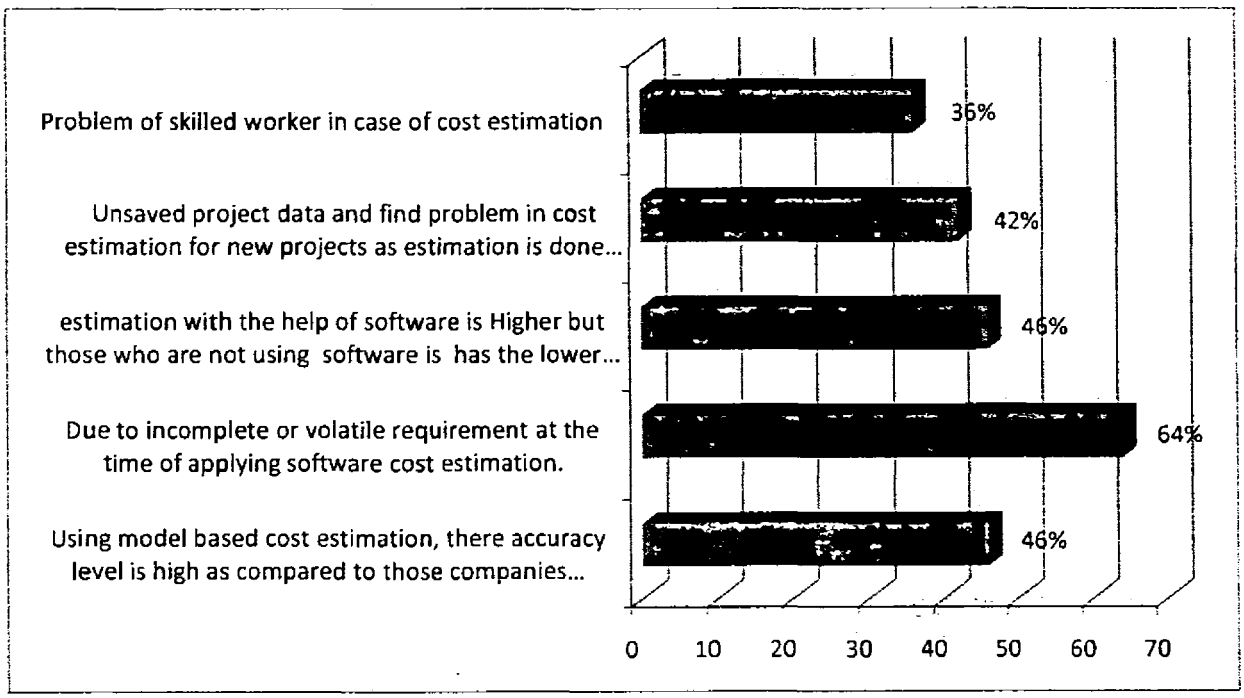

Fig30. Issues related to Cost Estimation

2) We have proposed comprehensive framework in order to address aforementioned issues. In your expert opinion our framework is good enough to address these issues?

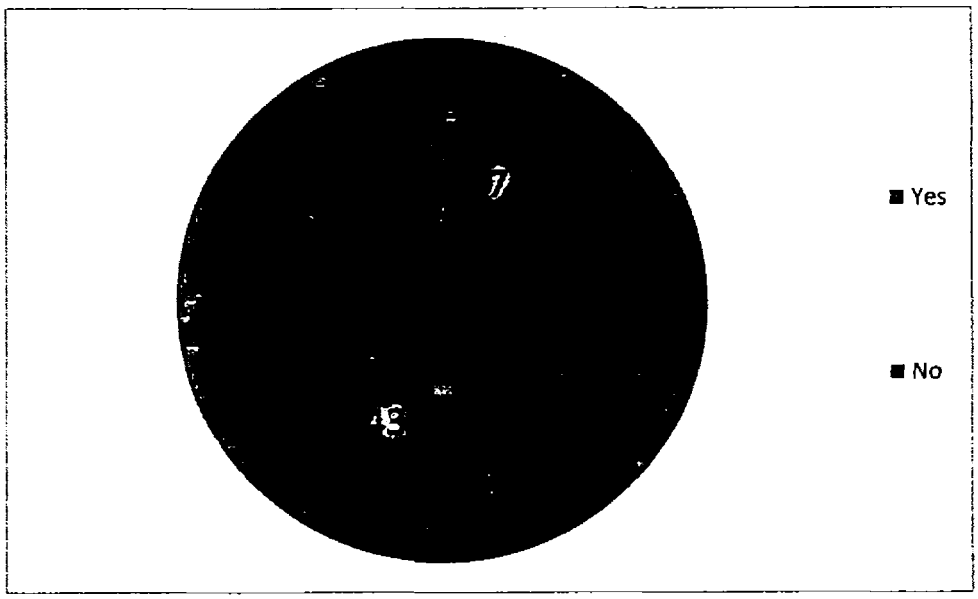

Fig31. Comprehensive Framework

Below figure explain that most of the companies have appreciated our framework and our framework will help in improving the software cost estimation. Most of the respondents have appreciated the framework, 86% of respondent replied "yes". They want to use the framework and 14% of respondent replied "No". They do not want to use the framework. The remarks came from the respondents are the "volatile requirement" factor was very good highlighted factor, the idea of incremental estimation was wonderful, good work of combining expert judgment and model based techniques, and cost required evaluation, current trend, future technology and lot more".

CHAPTER 7

CONCLUSION & FUTURE WORK

Chapter 7: Conclusion and Future work

7.1. Conclusion

Companies in Pakistan are working from a long time. Bulk of companies were in private sector, further expansion in them results in Public, and semi government sector needs to cover more area. So the public sector can be self sufficient in producing its own software but the process or method being followed was mostly ad-hoc. Another encouraging factor was the following of the standards and getting certified. Most of the companies were certified and were following a standard. This was the basic information regarding various companies.

Coming to the software cost estimation, the goal of our survey was to investigate used software cost estimation methods in Pakistani software industry. Find the area which needs improvement and try to give the suggestion how to improve the software cost estimation in terms of accuracy.

In this thesis, we have performed the survey from different companies, we found that most of the companies are using Expert Judgement and Model based methods in cost estimation. We also find that if the companies use the above mentioned cost estimation together then they will produce the better cost estimation results in terms of accuracy as compared to the today's accuracy. The integration of both model based and expert judgement are very important to get the accurate results.

Continuing the context of SCEM, the models are being used but the number of companies that are using any SCEM is not encouraging. Most of the companies are using the expert judgment and few are using Model Based for cost estimation and in terms of SCEM their participation is very low. The reasons can be of un-availability of skill set and tool set, this means that it is a one person company which is being out sourced. The practise of switching different of any SCEM is not seen as it is low in frequency and not a common practice, and the reasons to shift were again internal to the organisation and mostly affected by the choice of the software product they were building. The time spent in using SCEM was from one day to three days, the factor which was encouraging here was the SCEM was used iteratively in a software product which shows the flexibility and level of expertise of the company.

Keeping in view the Pakistani industry, it was suggested that the P.S.E.B and P.A.S.H.A need to be involved with the companies which were starting their business in the software industry and arrange training sessions and encourage them to move forward. These sessions will not only encourage the other people to come in the software industry but it will also help them to start interface between the companies which were working in the software industry. Sessions not only regarding training but there was a need of interaction and sharing of experiences of various companies.

Regarding any new SCEM development, the factors that were needed to be taken into account are definitely the current trends in technology and foreseeing what can be there (in terms of technology), team structure, definitely a study which was consisted of the past data i.e. there was a SCEM in the past and how it was used then, what were the predicaments that were seen and what were the reasons that were involved in the development of the new SCEM, and then keeping these factors and other factors which can be there, a new SCEM can be developed.

7.2. Recommendations for Future Work

In our finding, we have seen that most of the companies are using expert judgement but their accuracy level was not high but those companies which were using model based estimation method, their accuracy level was high as compared to the expert judgement. So the future work will be a

1. Tool by using the Model based estimation method and expert judgement; the tool should be fully automated because people feel the ease of using automated tool. Tool should incorporate the existing features of all existing and state of the art cost estimation methods. Tool should provide flexibility to the practitioners in order to incorporate new knowledge. By the use of that tool there will be more accuracy of the project or product. In our research this was only limited to Pakistani software industry, now it can be used in other environments too.
2. As our research is mainly targeted to "industry point of view" but the other future work will be targeting the cost estimation to project or product oriented research.

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APPENDIX -I

APPENDIX – I Questionnaire

Questionnaire

Dear respondent,

- As a part of my MS (SE) research work at International Islamic University Islamabad, I am conducting a survey on my thesis topic "Integrated Framework for Software Cost Estimation Models" [A Pakistani Case].
- Please answer all questions carefully and correctly. The information you provide is strictly confidential and will solely be used for research purpose only. I will be appreciating if you could complete the following questionnaire.

If you have any question about the research, please contact Ali Arshad

Mobile 0300-5135683

Email: alli.arshad@gmail.com

Software Engineering Research

There are 20 questions in this survey.

INTRODUCTION

The items in this section concern your demographic profile/Organizational profile. Please choose the correct option from the given options.

1. **Total years of working experience in capacity of an estimation?**
   - ☐ 1 - 3 years
   - ☐ 3 - 5 Years
   - ☐ 5 - 8 Years
   - ☐ 8 and more Years
2. **What is your job role at your organization?**
   - ☐ Requirements Engineer
   - ☐ Developer
   - ☐ Quality Assurance Personnel
   - ☐ Team Lead
   - ☐ Project Manager
   - ☐ Development Manager
3. **Which Sector does your company belong to?**
   - ☐ Private
   - ☐ Semi Government
   - ☐ Public

SECTION I

The items in this section concern the job characteristics which are often highlighted as motivators/de-motivators by literature. Using the scale below, please tick your answer in given options to what extent these aspects motivate you at your workplace.

4. **Which software cost estimation methods your company is using?**

   _____

   _____

5. **From how long your company has been using mentioned software cost estimation methods?**
   - ☐ 1 to 2 Years
   - ☐ 3 to 5 Years
   - ☐ 6 or above

6. **How you measure the size of the project?**
   - ☐ Effort Required
   - ☐ Time Required
   - ☐ Line of Codes Expected
7. **What is the accuracy rate of software cost estimation methods you are using?**
   - ☐ 100 %
   - ☐ 80 – 100 %
   - ☐ 60 – 80 %
   - ☐ 40 – 60 %
   - ☐ Less than 40 %
8. **Accuracy of Cost estimation method is varying (changes from project to project)?**
   - ☐ Yes
   - ☐ No
9. **In software cost estimation methods which cost factor are on your priority (Please Prioritize from 1 to 8)? Please list it down in ascending order**
   - ☐ Total Cost ☐
   - ☐ Total Effort ☐
   - ☐ Total Time ☐
   - ☐ Total Staff Required ☐
   - ☐ Personal Difficulty ☐
   - ☐ Platform Difficulty ☐
   - ☐ Product Reliability ☐
   - ☐ Product Complexity ☐
10. **Are you contented with existing software cost estimation method you are using?**
    - ☐ Yes
    - ☐ No
11. **Did you perform any evaluation with other software cost estimation method?**
    - ☐ Yes
    - ☐ No
12. **What was the result of comparison?**

    _____

    _____

13. **If we provide you with a method for cost estimation, will you be interested in using instead of your existing software cost estimation method?**
    - ☐ Yes
    - ☐ No
14. **Which factors should be considered at the time of software cost estimation method?**
    - ☐ Total Cost
    - ☐ Total Effort
    - ☐ Total Time
    - ☐ Total Staff required
15. **Have you saved the cost estimation data of recent projects?**
    - ☐ Yes
    - ☐ No
16. **Does project size affect effort and schedule estimation accuracy?**
    - ☐ Yes
    - ☐ No
17. **What are the causes of inaccurate software cost estimation method?**
    - ☐ Total Cost
    - ☐ Total Effort
    - ☐ Total Time
    - ☐ Total Staff Required
    - ☐ Personal Difficulty
    - ☐ Platform Difficulty
    - ☐ Product Reliability
    - ☐ Product Complexity
18. **What are the barriers and difficulties in the application of software cost estimation?**

    _____

    _____
19. **Are you using any software for cost estimation?**
    - ☐ Yes
    - ☐ No
20. **Does the size of the project play a vital role in cost estimation?**
    - ☐ Yes
    - ☐ No

21. **If answer of question 20 is YES, what is the reason? If answer of question 20 is NO, which factors are important and why?**

_____

_____

APPENDIX -II

APPENDIX – II Validation of the Framework

Validation of the Framework

We have conducted the nationwide survey on the issues of software cost estimation. We have identified the following major issues.

1) Kindly select one or more issues related to cost estimation faced by your company.

☐ Use of model based cost estimation; there accuracy level is high as compared to those which are using expert judgment

☐ Due to incomplete or volatile requirement at the time of applying software cost estimation

☐ Cost estimation with the help of software has higher accuracy but those who are not software has lower accuracy

☐ Unsaved old project data and find problem in doing cost estimation for new projects as estimation is done through expert judgment

☐ Problem of skilled worker in case of cost estimation

From the above mentioned problem(s) we have proposed the guidelines for the improvement of software cost estimation accuracy.

1. Two stages process using Expert Judgment for initial activities and Model Based cost estimation for more elaborate activities?

   ☐ Agree

   ☐ Disagree

2. Incremental cost estimation for non-critical requirements and accumulation into model based cost estimation?

   ☐ Yes

   ☐ No

3. Automate the cost estimation models?

   ☐ Yes

   ☐ No

4. Periodic training of the personnel on the emerging issues of cost estimation?

   ☐ Yes

   ☐ No

5. Maintain a complete repository of completed and aborted projects?

   ☐ Yes

   ☐ No

2) We have proposed comprehensive framework in order to address aforementioned issues. In your expert opinion our framework is good enough to address these issues.

☐ Yes

☐ No

☐ Remarks

APPENDIX -III

APPENDIX – III Table of Industry Survey

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	44	88.0	88.0	88.0
	Female	6	12.0	12.0	100.0
	Total	50	100.0	100.0	

Total years of working experience?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 - 3 years	10	20.0	20.0	20.0
	3 - 5 Years	22	44.0	44.0	64.0
	5 - 8 Years	7	14.0	14.0	78.0
	8 and more Years	11	22.0	22.0	100.0
	Total	50	100.0	100.0	

What is your job role at your organization?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Requirements Engineer	3	6.0	6.0	6.0
	Developer	18	36.0	36.0	42.0
	Quality Assurance Personnel	6	12.0	12.0	54.0
	Team Lead	5	10.0	10.0	64.0
	Project Manager	9	18.0	18.0	82.0
	Development Manager	3	6.0	6.0	88.0
	Other	6	12.0	12.0	100.0
	Total	50	100.0	100.0	

Your company is a?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Local Company	20	40.0	40.0	40.0
	Multinational Company	29	58.0	58.0	98.0
	Other	1	2.0	2.0	100.0
	Total	50	100.0	100.0	

Which Sector does your company belong to?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Private	32	64.0	64.0	64.0
	Semi Government	5	10.0	10.0	74.0
	Public	13	26.0	26.0	100.0
	Total	50	100.0	100.0	

Which software cost estimation method you are using?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agile Estimation	1	2.0	2.0	2.0
	Analysis effort method	2	4.0	4.0	6.0
	Best Practises	1	2.0	2.0	8.0
	COCOMO	10	20.0	20.0	28.0
	Effort based costing	1	2.0	2.0	30.0
	Effort Estimation	3	6.0	6.0	36.0
	Effort Estimation Model and Defect Estimation Model	1	2.0	2.0	38.0
	Expert Judgement	17	34.0	34.0	72.0
	Function Point Analysis	2	4.0	4.0	76.0
	Integrated deployment model	1	2.0	2.0	78.0
	Line of Code (LOC)	2	4.0	4.0	82.0
	Microsoft SharePoint 2010	1	2.0	2.0	84.0
	Scrum	1	2.0	2.0	86.0
	SEER	1	2.0	2.0	88.0
	Spiral	1	2.0	2.0	90.0
	Tecnotrade	1	2.0	2.0	92.0
	Time duration estimation. Agile	1	2.0	2.0	94.0
	V Model and Prototyping model	1	2.0	2.0	96.0
	Wideband Delphi	2	4.0	4.0	100.0
	Total	50	100.0	100.0	

From how long your company using above mentioned software cost estimation method?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 to 2 Years	11	22.0	22.0	22.0
	3 to 5 Years	20	40.0	40.0	62.0
	6 or above	19	38.0	38.0	100.0
	Total	50	100.0	100.0	

What is the accuracy rate of software cost estimation method you are using?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	100 %	4	8.0	8.0	8.0
	80 to 100 %	17	34.0	34.0	42.0
	60 to 80 %	24	48.0	48.0	90.0
	40 to 60 %	5	10.0	10.0	100.0
	Total	50	100.0	100.0	

Accuracy of Cost estimation method is varying (changes from project to project)?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	43	86.0	86.0	86.0
	No	7	14.0	14.0	100.0
	Total	50	100.0	100.0	

In software cost estimation method which cost factor are on your priority (Please Prioritize)? Total Cost

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	21	42.0	42.0	42.0
	2	13	26.0	26.0	68.0
	3	6	12.0	12.0	80.0
	4	7	14.0	14.0	94.0
	6	1	2.0	2.0	96.0
	8	2	4.0	4.0	100.0
	Total	50	100.0	100.0	

In software cost estimation method which cost factor are on your priority (Please Prioritize)? Total Effort

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	14	28.0	28.0	28.0
	2	12	24.0	24.0	52.0
	3	11	22.0	22.0	74.0
	4	6	12.0	12.0	86.0
	5	2	4.0	4.0	90.0
	6	2	4.0	4.0	94.0
	7	1	2.0	2.0	96.0
	8	2	4.0	4.0	100.0
	Total	50	100.0	100.0	

In software cost estimation method which cost factor are on your priority (Please Prioritize)? Total Time

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		1	2.0	2.0	2.0
	1	14	28.0	28.0	30.0
	2	15	30.0	30.0	60.0
	3	9	18.0	18.0	78.0
	4	4	8.0	8.0	86.0
	5	1	2.0	2.0	88.0
	6	1	2.0	2.0	90.0
	7	3	6.0	6.0	96.0
	8	2	4.0	4.0	100.0
	Total	50	100.0	100.0	

In software cost estimation method which cost factor are on your priority (Please Prioritize)? Total Staff Required

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		1	2.0	2.0	2.0
	1	6	12.0	12.0	14.0
	2	4	8.0	8.0	22.0
	3	8	16.0	16.0	38.0
	4	13	26.0	26.0	64.0
	5	11	22.0	22.0	86.0
	6	1	2.0	2.0	88.0
	7	3	6.0	6.0	94.0
	8	3	6.0	6.0	100.0
	Total	50	100.0	100.0	

In software cost estimation method which cost factor are on your priority (Please Prioritize)? Personal Difficulty

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		20	40.0	40.0	40.0
	1	2	4.0	4.0	44.0
	2	1	2.0	2.0	46.0
	3	4	8.0	8.0	54.0
	4	3	6.0	6.0	60.0
	5	5	10.0	10.0	70.0
	6	6	12.0	12.0	82.0
	7	1	2.0	2.0	84.0
	8	8	16.0	16.0	100.0
	Total	50	100.0	100.0	

In software cost estimation method which cost factor are on your priority (Please Prioritize)? Platform Difficulty

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18	36.0	36.0	36.0
1	3	6.0	6.0	42.0
2	1	2.0	2.0	44.0
3	4	8.0	8.0	52.0
4	3	6.0	6.0	58.0
5	7	14.0	14.0	72.0
6	6	12.0	12.0	84.0
7	5	10.0	10.0	94.0
8	3	6.0	6.0	100.0
Total	50	100.0	100.0	

In software cost estimation method which cost factor are on your priority (Please Prioritize)? Product Reliability

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20	40.0	40.0	40.0
1	7	14.0	14.0	54.0
2	4	8.0	8.0	62.0
3	5	10.0	10.0	72.0
5	1	2.0	2.0	74.0
6	4	8.0	8.0	82.0
7	6	12.0	12.0	94.0
8	3	6.0	6.0	100.0
Total	50	100.0	100.0	

In software cost estimation method which cost factor are on your priority (Please Prioritize)? Product Complexity

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	15	30.0	30.0	30.0
1	3	6.0	6.0	36.0
2	6	12.0	12.0	48.0
3	7	14.0	14.0	62.0
4	6	12.0	12.0	74.0
5	5	10.0	10.0	84.0
6	1	2.0	2.0	86.0
7	2	4.0	4.0	90.0
8	5	10.0	10.0	100.0
Total	50	100.0	100.0	

In how many phases cost estimation is being done?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	At Start	30	60.0	60.0	60.0
	Periodically (Tenure Wise)	20	40.0	40.0	100.0
	Total	50	100.0	100.0	

Are you satisfied with existing software cost estimation method you are using?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	39	78.0	78.0	78.0
	No	11	22.0	22.0	100.0
	Total	50	100.0	100.0	

Did you perform any comparison with other software cost estimation method?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	7	14.0	14.0	14.0
	No	43	86.0	86.0	100.0
	Total	50	100.0	100.0	

What was the result of comparison?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	40% variation	1	2.0	2.0	2.0
	5 % error	1	2.0	2.0	4.0
	As we work in international market and we have to estimate quickly for BIDs. COCOMO is good for quick estimations.	1	2.0	2.0	6.0
	Cross model comparison and existing actual from similar projects.	1	2.0	2.0	8.0
	did not perform comparison	45	90.0	90.0	98.0
	It depends on the nature of project and our priorities. Results may be different sometimes but none of them is efficient in absolute way	1	2.0	2.0	100.0
	Total	50	100.0	100.0	

If we provide you the algorithm, will you be interested in using instead of existing software cost estimation method?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	36	72.0	72.0	72.0
	No	14	28.0	28.0	100.0
	Total	50	100.0	100.0	

Which factors should be considered at the time of software cost estimation method?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Total Cost	17	34.0	34.0	34.0
	Total Effort	18	36.0	36.0	70.0
	Total Time	10	20.0	20.0	90.0
	Total Staff required	1	2.0	2.0	92.0
	Other	4	8.0	8.0	100.0
	Total	50	100.0	100.0	

Have you saved the cost estimation data of recent projects?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	31	62.0	62.0	62.0
	No	19	38.0	38.0	100.0
	Total	50	100.0	100.0	

Are you willing to provide previous project data for comparison of accuracy rate?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	8	16.0	16.0	16.0
	No	42	84.0	84.0	100.0
	Total	50	100.0	100.0	

Does project size affects effort and schedule estimation accuracy?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	47	94.0	94.0	94.0
	No	3	6.0	6.0	100.0
	Total	50	100.0	100.0	

How important do people think cost estimation is, in comparison with other aspects of development?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	At the upper management, especially in bidding new projects, extremely high.	1	2.0	2.0	2.0
	Average Significance	3	6.0	6.0	8.0
	Cost estimation is the primary factor in order to overall profitability of the projects and the success.	1	2.0	2.0	10.0
	Cost estimation is very important as far as the product liability is concerned.	1	2.0	2.0	12.0
	Cost gives quality	1	2.0	2.0	14.0
	Crucial	1	2.0	2.0	16.0
	Crucial factors for development	1	2.0	2.0	18.0
	crucial for small to medium sized projects	1	2.0	2.0	20.0
	Due to its importance	1	2.0	2.0	22.0
	Extremely important, as it may undermine the total benefits of the software development / deployment.	1	2.0	2.0	24.0
	Good	1	2.0	2.0	26.0
	It is a crucial factor in the overall development of software product/ project	1	2.0	2.0	28.0
	It's important because every manager have to plan accordingly.	1	2.0	2.0	30.0
	It's important. But it is the duty of manager or owner of the company to introduce such things	3	6.0	6.0	36.0
	It's important. But it is the duty of manager or owner of the company to introduce such things to developers.	1	2.0	2.0	38.0
	mandatory, because it make things cleared with agile processes.	1	2.0	2.0	40.0
	Many people donot give importance to the cost estimation	1	2.0	2.0	42.0
	May be important	1	2.0	2.0	44.0

People give due importance to cost estimation but normally they do not use defined cost estimation techniques, they perform these estimations by their own way.	1	2.0	2.0	46.0
Play very critical role in the project or product success or failure	1	2.0	2.0	48.0
Quality	2	4.0	4.0	52.0
They simply try to skip this part	1	2.0	2.0	54.0
Usually people do not give importance and they do their own.	1	2.0	2.0	56.0
Very High Importance, as the sole project/ product may fail with incorrect estimation.	1	2.0	2.0	58.0
Very Important	18	36.0	36.0	94.0
very important in term of cost, time and effort.	1	2.0	2.0	96.0
Without cost estimation no project will be successfull	1	2.0	2.0	98.0
yes cost estimation is very important	1	2.0	2.0	100.0
Total	50	100.0	100.0	

What are the causes of in accurate software cost estimation method?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Total Cost	11	22.0	22.0	22.0
	Total Effort	6	12.0	12.0	34.0
	Total Time	2	4.0	4.0	38.0
	Total Staff Required	3	6.0	6.0	44.0
	Personal Difficulty	4	8.0	8.0	52.0
	Platform Difficulty	1	2.0	2.0	54.0
	Product Reliability	3	6.0	6.0	60.0
	Product Complexity	17	34.0	34.0	94.0
	Other	3	6.0	6.0	100.0
	Total	50	100.0	100.0	

What are the barriers and difficulties in the application of software cost estimation?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1. Complexity 2. Personal Difficulty 3. Software Sizing	1	2.0	2.0	2.0
	1. Lack of experience 2. Lack of productivity figures for individuals and teams. 3. Lack of method to measure and translate complexity to effort. 4. Pressure due to unrealistic management or customer expectation.	1	2.0	2.0	4.0
	1. Technical Difficulties 2. Scope of the project not completely conquered 3. Changes	1	2.0	2.0	6.0
	At initial stage of the project all the requirements are not known.	1	2.0	2.0	8.0
	Change of requirement during development	1	2.0	2.0	10.0
	change of requirements	1	2.0	2.0	12.0
	Changes of Requirement	1	2.0	2.0	14.0
	Changes of requirement from customer point of view	1	2.0	2.0	16.0
	Company's policies	3	6.0	6.0	22.0
	Company Policies	1	2.0	2.0	24.0
	Due to its Complexity	1	2.0	2.0	26.0
	effort and time required	1	2.0	2.0	28.0
	Effort estimation is not correctly estimated	1	2.0	2.0	30.0
	environment and people	1	2.0	2.0	32.0
	Frequent user requirements, strict timelines without grace time.	1	2.0	2.0	34.0
	Inaccuracy. Not 100%.	2	4.0	4.0	38.0
	Lack of Data	2	4.0	4.0	42.0
	Lack of definite product requirements, uncertainty in customer funding, lack of software development team continuation, and schedule uncertainty.	1	2.0	2.0	44.0
	Lack of Interest	1	2.0	2.0	46.0
	Management	1	2.0	2.0	48.0
	Many	1	2.0	2.0	50.0
	Model	1	2.0	2.0	52.0
	no barriers	6	12.0	12.0	64.0

Normally our work is related to customization and changes to the existing product. Normally the scope of work is most important. For correct estimation, we need correct scope and clear requirements.	1	2.0	2.0	66.0
People are less concerned with conventional cost estimation techniques. Because, at initial stage of project, all requirements are not clearly known. Requirements of the users may change with the passage of time. Therefore, at the end it affects our early cost estimation value.	1	2.0	2.0	68.0
Personal Difficulty	1	2.0	2.0	70.0
Poor Requirement Analysis. Extensive Approach in Analysis. Unfortunate Infrastructure during development. Misconception of Analysis for Cost and Time.	1	2.0	2.0	72.0
requirement changes day by day	1	2.0	2.0	74.0
Software Sizing	1	2.0	2.0	76.0
Specialized skill required	1	2.0	2.0	78.0
specialized skills needed	1	2.0	2.0	80.0
specialized skills needed	1	2.0	2.0	82.0
Staff Motivation	1	2.0	2.0	84.0
Technical Difficulties	2	4.0	4.0	88.0
To cut short cost as per expectation of Customers	1	2.0	2.0	90.0
Too many unknowns	1	2.0	2.0	92.0
Un-defined or poorly defined scope	1	2.0	2.0	94.0
User Requirements Changing day by day	1	2.0	2.0	96.0
vague requirements	1	2.0	2.0	98.0
Work complexity cannot be perceived at the early stage.	1	2.0	2.0	100.0
Total	50	100.0	100.0	

Are you using any software for cost estimation?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	17	34.0	34.0	34.0
	No	33	66.0	66.0	100.0
	Total	50	100.0	100.0	

How you measure the size of the project?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Effort Required	31	62.0	62.0	62.0
	Time Required	13	26.0	26.0	88.0
	Line of Codes Expected	2	4.0	4.0	92.0
	Other	4	8.0	8.0	100.0
	Total	50	100.0	100.0	

Does the size of the project play a vital role in cost estimation?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	44	88.0	88.0	88.0
	No	6	12.0	12.0	100.0
	Total	50	100.0	100.0	

If answer of above question YES, why is it important? If answer of question NO, which factors are important and why?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	amount of work, module dependencies, integration etc	1	2.0	2.0	2.0
	as long as is the project, more effort, more resources are required	1	2.0	2.0	4.0
	Basically - the size is calculated after estimating the cost for individual items	1	2.0	2.0	6.0
	Because it gives idea about how much cost will the project have	1	2.0	2.0	8.0
	because bigger size take more time	1	2.0	2.0	10.0
	because it will tell us how much effort will be required and how much resources we had to gather	2	4.0	4.0	14.0

Because Project size should be estimated according to depending terms like requirements, resource, skills, platform, time and available cost.	1	2.0	2.0	16.0
Bigger size more maintenance is required and integration become complex	1	2.0	2.0	18.0
Bigger size need more Maintenance and it is important to know about the cost	1	2.0	2.0	20.0
Cost	1	2.0	2.0	22.0
Cost estimation helps keep the project under control. Spending on product development can be kept under watch	1	2.0	2.0	24.0
Cost estimation include effort, salaries of staff and expenses of company	1	2.0	2.0	26.0
Cost estimation will give idea, how much cost will be needed for that project	1	2.0	2.0	28.0
Dependencies which are out of scope	1	2.0	2.0	30.0
Effort	2	4.0	4.0	34.0
Effort	1	2.0	2.0	36.0
Effort and Time	1	2.0	2.0	38.0
Estimation effort, resources and cost can help in better resource utilization and also the projects do not take up additional resources in course of their development	1	2.0	2.0	40.0
Gives idea how much cost is required	1	2.0	2.0	42.0
Greater the size of the project, greater effort is needed and hence cost management increase	1	2.0	2.0	44.0
have to be clear what is going to be get at the end of project	1	2.0	2.0	46.0
If the size of the project is big then it will take more effort and time that results in increased cost...	1	2.0	2.0	48.0
Integration become complex when the size of the project is bigger	1	2.0	2.0	50.0
It gives the project cost.	1	2.0	2.0	52.0

it have dependencies which are out of the scope of project	1	2.0	2.0	54.0
It is important because larger the project, higher the cost.	1	2.0	2.0	56.0
it may have dependencies which usually are out of scope of the project	1	2.0	2.0	58.0
its important because: 1- a clear picture will be in mind that how much it will cost and whats the deadline. 2- Business development will check that when our team will be free from current projects, then they have to in take further projects.	1	2.0	2.0	60.0
Large projects need more revisions of cost estimations yearly.	1	2.0	2.0	62.0
Larger is the project then more effort will be required	1	2.0	2.0	64.0
No factors	4	8.0	8.0	72.0
one of the major factor in winning project from a competitive market	1	2.0	2.0	74.0
Project size defines size of development team and complexity of product. In other words, a smaller project can be handled by a smaller, single team while a larger project will have to be broken into multiple development teams with integration issues.	1	2.0	2.0	76.0
Running project always require time, efforts and resources. Therefore more uncertainty is involved in the success of project. Cost estimation includes efforts, salaries of staff and other expenses of the company. These all factors are reduced or expanded with size of project.	1	2.0	2.0	78.0

Significant travel costs can be incurred in case of a large - mulit location project which can change the whole cost estimations (in case of any issue / problems), Also, in our case the deployments have been more problematic than development, as we would often hit issues that take us back to development work, during the deployment creating significant hurdles and cost escalations.	1	2.0	2.0	80.0
Size can be measured either by complexity (features, functions and non-functional requirements) or SLOC or both. There is a non-linear relation between size and effort, which can only be approximately derived.	1	2.0	2.0	82.0
Size of the project has nothing to do with cost estimation.	1	2.0	2.0	84.0
Size of the project has nothing to do with cost estimation. Its the time and the efforts which determines the cost.	1	2.0	2.0	86.0
T bigger the project is, more important is to know how much it cost and how to price it.	1	2.0	2.0	88.0
This is base for any project	1	2.0	2.0	90.0
Time and the efforts will determine the cost.	1	2.0	2.0	92.0
time required and resources required depend on the size of project.	1	2.0	2.0	94.0
To make ourselves clear that what we are going to get in the end of this project.	1	2.0	2.0	96.0
To make ourselves clear that what we are going to get, when project is going to end.	1	2.0	2.0	98.0
We can analysis project life cycle easily.	1	2.0	2.0	100.0
Total	50	100.0	100.0	

APPENDIX -IV

APPENDIX – IV Companies Name

1. Fides Technologies
   http://www.fidesgrp.com/
2. Gladkovsoft Pakistan (Pvt) Ltd
   http://www.gladkovsoft.com
3. Goldbar-Tech (SMC-Pvt) Ltd
   http://goldbartech.com/
4. Ikonami (Pvt) Ltd
   http://www.ikonami.com/
5. Insignia Soft
   http://www.insigniasoftware.com
6. IT Link
   http://www.itlinksolutions.com/
7. TR&D Solutions
   www.tdsolutions.com/
8. Kallx (Ptv) Ltd.
   www.kallx.com/
9. Ko-Tech Computers
   Office #11 Rose plaza I-8
   Markaz Islamabad
10. Komatsu Pakistan Soft (Pvt) Ltd
    http://www.komatsu.com
11. Moftak Solutions
    http://www.moftak.com
12. MyPaperLess Office
    http://www.mypaperlessoffice.com
13. Nautica Group
    http://www.nauticagroup.com
14. Nethawk (Pvt) Ltd
    http://www.nethawk.com.pk
15. New Tech Enterprises
    Office # 10, Liberty Shopping
    Center, Abpara Islamabad
16. Norvida Pakistan
    http://www.norvida.com
17. Nvision Technologies
    http://www.nvision-tec.com
18. Omega Technologies
    http://www.omegatechs.com
19. One2one Solutionz (Pvt) Ltd
    http://www.121solutionz.com
20. Orazone Technologies (Pvt) Ltd
    http://www.orazonetech.com
21. Pakistan Resources Development
    Services (Pvt) Ltd
    http://www.prds.com.pk
22. Parity Systems Inc
    http://www.paritysystems.org
23. Pinpoint Communications (Pvt)
    Ltd
    http://www.pinpoint.com.pk
24. PMTAC (Pvt) Ltd
    1st Floor, Madni Plaza, Off
    Islamabad Highway, Behind
    Quaid-e-Azam Portrait
    Rawalpindi
25. Pyxis Technologies (Pvt) Ltd
    http://www.pyxis-intl.com
26. Renzym (Pvt) Ltd
    http://www.renzym.com
27. Ropstam
    http://www.ropstam.com
28. Saints IT (Pvt) Ltd
    http://www.thesaintsitgroup.com
29. Soft Tek Systems
    http://www.softteksystems.com
30. Streaming Networks (Pvt) Ltd
    http://www.streaming-
    networks.com

31. TEKenable (Pvt) Ltd
http://www.tekenable.com
32. Telebridge Communications
http://www.telebridgebpo.com
33. Triple I International
http://www.iiiint.com
34. Uffaq Technologies (Pvt) Ltd
http://www.iiiint.com
35. Ultimus Pakistan
http://www.ultimus.com
36. United Sol (Pvt) Ltd
http://www.uitedsol.net
37. Vizteck Solutions
http://www.vizteck.com
38. Xtranza
http://www.xtranza.com
39. Advanced Communications
http://www.advcomm.net
40. Altair Technologies (Pvt) Ltd
House # 1, Service Road North, Sector I-8/2 Islamabad
41. AnaDigi Systems
http://www.anadigisystems.com
42. Arkotech Corporation
http://www.arkotech.com.pk
43. Aspire Solutions
http://www.aspiresolution.com
44. Averox (Pvt) Ltd
http://www.averox.com
45. Binary Brainz (Pvt) Ltd
http://www.binarybrainz.com
46. BITSoft
http://www.bitqta.edu.pk
47. Brainspain BPO
Suite # 101, Golden Heights, F-11 Markaz Islamabad
48. Buraq Integrated Solutions
http://www.buraq.com
49. CreStar Data Services (Pvt) Ltd
http://www.crestardata.com
50. CRMXperts
http://www.crmxperts.com
51. DataFocal Systems (pvt) Ltd
http://www.dataflat.net
52. Datels International
http://www.datels.com
53. Diyatech Pakistan
http://www.diyatech.com
54. Electronic Solutions Pakistan (Pvt) Ltd (ESOLPK)
http://www.esolpk.com
55. ERDC Information Systems (Pvt) Ltd
http://www.informationsystems.com.pk
56. Evamp & Saanga
http://www.evampsaanga.com
57. Everlast Sols (Pvt) Ltd
http://www.everlastsols.com
58. EVS - eVision Software
http://www.evsoft.pk
59. LMKR
http://www.lmkr.com/
60. Cilkum
http://www.ciklum.com/
61. Ovex Technology
http://www.ovextech.com