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Cost Analysis in Context of Change Management in Software Development

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ABSTRACT: Software development is considered to be the most important field in software engineering. As many researches focused on the issues related to accurate and efficient software cost and effort estimation in software development project. Software development projects have a high dynamic nature so accurate software cost estimation in context of change management is a highly difficult task. Also because of accurate software cost estimation is the project manager's responsibility so estimating cost at early stages of software development life cycle is considered to be most challenging task. Hence this paper address the issues related to consistent cost estimation in context of change management in software development. This research conducted survey and structured interview to collect the data from different software industries of Pakistan. Based on descriptive analysis of data, collected from different software industries of Pakistan this research proposed a solution for estimating cost in context of change management.

Keywords— cost estimation model, change management, software project, software cost estimation, software effort estimation

1. INTRODUCTION

Software cost estimation (SCE) is a method of estimating software's cost being developed. Tracing and planning of software projects involves in Software cost estimation [6]. In software engineering, accurate software cost estimation is most highly concerned topic. In order to successively complete a project scheduling and applied effort refers as software development cost [10]. Hence Software cost estimation and the software effort estimation is very difficult job for large scale projects [1].

In order to maintain the cost and budget many techniques are available such as Computational Intelligence techniques [11]. From past four eras many cost estimation models have been developed. Function point analysis and constructive cost model (COCOMO) are mostly used models for software development efforts [12].

The process of measuring the scope and intricacy of software system based on the function that the system offers to the end-user is known as Function point analysis [13].

COCOMO model was developed by berry bohem[14].COCOMO model is algorithmic models and other algorithmic models are "SDC model (Nelson, 1966), Boeing model (Black et al., 1977), GRC model (carriere and Thinodeau, 1979), Meta model (bailey and Basili, 1981), TRW Wolverton model (Wolverton, 1974), Putnam SLIM (Software Lifecycle Management) model (Putnam, 1978), Doty model (Herd et al.,1977) , RCA PRICE S model (Freiman and Park, 1979), IBM-FSD model (Walston and Felix, 1977)"[15].

Changing needs of customers and computer technology are the dynamic factors that affect the development of software [16]. Many requirement are changed within the software development life cycle, and it's necessary to maintain the

changing requirement so that software successfully lead to its required results [17].

Software maintenance refer to the software that can be configured once it is launched in the actual environment in order to correct the faults and error, and another attributes so that product can be adopted in changing environment [18].

The purpose of this paper is to provide correct estimation for change management. This research provide information of recent work that is mentioned in section 2. Section 3 describes methodology as well as analysis of result and proposed solution. At the end section 4 conclude this paper and future work indicated in section 5.

2. LITERATURE REVIEW

Software cost estimation methods [1] are writing algorithms, judgment of the expertise and machine learning. Cost estimation techniques are organized into two central groups one is parametric models and 2nd is Non-parametric models. Many algorithmic model under parametric models and machine learning under non-parametric models are established. COCOMO model consist of Intermediate COCOMO, Basic COCOMO and Detailed COCOMO. Basic COCOMO is mostly used model for software cost estimation. Expert Judgment based Methods is also used to study the past progress of the project and this technique is better than the Algorithmic approach (Poonam Pandey, 2013). In 2012, Anupama Kaushik et al use the back propagation neural networks for software cost estimation. This research used "Feed Forward Back Propagation model of neural network" to maps the COCOMO model. This model used identity function at the input layer and sigmoidal function at the hidden and output layer [4]. In 2010, Iman Attarzadeh et al proposed a "novel constructive cost model (COCOMO)" based on "soft computing approach" and include some structure of neural networks. As accurately evaluating the cost of software development require a premeditated planning so, Experiment result of neural network on algorithmic and non-algorithmic software cost estimation model showed that proposed neural network based software cost estimation model produced better and more accurate cost estimation "in view of MMRE, Pred(0.25) evaluation criteria" than COCOMO model[6].

In 2013, D.Manikavelan et al used Differential evolutionary Algorithm for proper estimation of cost as Software cost estimation Categorized in two types one is Algorithmic cost estimation and second is Non- Algorithmic cost estimation. The example of Algorithmic cost estimation method and non-Algorithmic cost estimation method are functional point model & COCOMO model [19]. Cost of the software [2] can be calculated through Regression Equation. Regression Equation perform Regression and Correlation investigation. The requirements of the user are varied at every phase of SDLC and change in requirement disturbed Schedule, Quality and Cost of the software project. The change in requirements effected the whole phases of SDLC. The authors explain experimental study of changing requirement and also explain its effect on the cost of the software project they also suggested intangible frame work and systematic analyze of change and its effect on cost estimation according to generic regression equation and phase of SDLC (Bushra Sharif et al, 2012). In 2011 Hemanta Kumar Doloi find out the issues related to the observations of board stakeholders .This study organize structured interview to collect data from different organizations and to form a big picture on each stage of project development. This big picture is then converted into concept model using soft system methodology approach. However factors effecting cost estimation are "political, economic, financial, technical and attitudinal concerns". However conceptual model in this study is not validated with international practices and mentioned factors need to be tested and hypothesized on interactive and basic links [7].

In 2015 Manal El et al perform systematic mapping study (SMS) to sum the software cost estimation in the environment of Global software development. This study perform the systematic review of considered software development and maintenance cost and effort estimation. The techniques which are used for the software cost estimation are non-machine learning models, Expert judgment and machine learning model. Infect they discuss different software estimation activities, technique and cost

drivers for GSD projects. Future research would explore how these challenges and factors affect cost estimation techniques [3]. In 2012, Narayan Ramasubbu et al inspect the challenges by firstly examine the core cause of cost estimation error from the perspective of worldwide distributed software projects. The observation showed the problems related to standard matrix-based estimation tools that managers use(a) did not integrate varied project characteristics and configurations, (b) inclusive data required at early phase that are not available at the start of projects, and (c) and important field experience required to make estimates. To these problems authors suggested the "semi-automated solution" in term of "case-based reasoning". The overall result of six-month field-study for three large ISO-9001 proficient companies at CMMI-level 5 showed that learning-based cost estimation approaches reduce estimation errors up to 60% and increase the economic benefit of 20% per project on average. To address various software environment this research yet working on expanding the method [8]. "Integrity of maintenance, Adaptability maintenance, and correction of maintenance" [18] are the fundamentals types of software maintenance. Moreover "application experience, staff stability, application time, the external environment, support environment, and user requirements" are non-technical factors and density of software, human ability development, efficiency of documentation and conditions of modern programming are technical factors that influence the software maintenance cost. This study also improving the cost estimation model for software maintenance (Yongchang Ren et al, 2011).

In 2010, Violeta Bozhikova et al classify the method of software cost estimation in term of basic functionality and important features. The authors presented a cost estimation model that combine basic, intermediate COCOMO model and COCOMO II with function point estimation features. This proposed model estimate cost by identifying the aims and requirements, by estimating the size of product and complexity and by estimating the schedule, resources and applied efforts. Correctly estimating large and typical software projects yet not present this research [9]. In 2006, Stein Grimstad et al explain that how poor cost estimation analysis technique central to incorrect. The cost of the project is estimated through two ways first through "self-developed estimation model" and second by "expert estimation". According to these consequences they suggest a framework for correct cost estimation. Through this framework the cost of the software project can easily be measured. [5].

Table 2.1: Results of literature review

Year	Methodology, Design and statistical analysis	Result, proposed solution	Limitations of study
2010	Experiments at original COCOMO dataset and artificial dataset.	Proposed a "new novel (COCOMO) based on soft computing approach" include some features of neural network approach	
2011	Structured interviews in construction industries of Australia.	developed a concept model on cost overrun	Conceptual model was not validated with international practices
2012	observations of three software development companies six-months field-study of three large firms to test the proposed solution baseline comparison variation reduction	Development of a new "learning-oriented and semi-automated early-stage cost estimation solution" learning-based cost estimation approaches reduce estimation inaccuracies up to 60% and increase the financial benefit of 20% per project on average	Developed framework was not applied for other type of software projects like product development, reengineering and maintenance

	sensitivity analysis		
2011	Descriptive Analysis forms to list the cost factors.	Improving the cost estimation model for software maintenance. Proposed the formula for improving the cost estimation model for software maintenance as cost of basic maintenance factor multiplied by each of mass.	Proposed method was not applied to secondary development of cost estimation.
2010		presented a cost estimation model that combine basic, intermediate COCOMO model and COCOMO II with function point analysis proposed model estimate cost by identifying the aims and requirements, by estimating the size of product and complexity and by estimating the schedule, resources and applied efforts	Module's operations were only verified for a limited number of small-size students Projects. Correctly estimating large and typical software projects not presented this research.
2013	1)Expert Judgment based Methods 2) Algorithmic models	Cost estimates can be explain through algorithmic models	The models are formed by historical data and it will not be capable to reflect current hardware, programming languages and software engineering.
2012	Regression Equation	Authors proposed intangible frame work. Systematically analyzed the change and also its effect on cost through generic regression equation.	
2015	Systematic mapping study (SMS). non-machine learning models Expert judgment. Machine learning model.	Systematically examined software development and effort estimation.	SMS having deficiency of primary studies.
2012	"Feed Forward Back Propagation model" of neural network which can be maps the COCOMO model	Due to COCOMO model and neural network approach enhance the cost estimation.	
2006	Self-developed estimation model	Unfortunate cost estimation will fundamental to improper	Purpose a framework through this framework the

	Expert estimation.	decisions.	cost of the software project can easily be measured.

Analysis of existing literature indicate that in many countries researchers have conducted surveys, interviews[1,2,3,4,5,6,7,8,9,18,19] in which researchers have identified some software development cost estimation model and many technical and non-technical factors that influence accurate software cost estimation. But no one discuss any cost estimation method for change management. Hence need of software cost estimation model for change management become essential. Therefore, this research result in software cost estimation model for change management

One and half month. This research also mentioned some factors that are the main cause of change management. We also conducted the structured interviews from different software industries to collect data.

Questionnaire was designed to know what problem software industries face because of change management on software

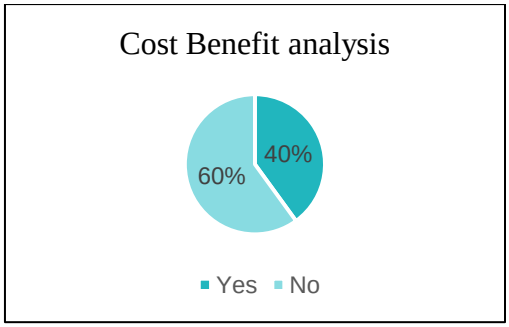
3.1 Analysis of data and Results

Statistical approach is use to analyze and evaluate results.

Table 3.4.1: Questionnaire Response

Question Criteria	Yes	No	Other
Cost Benefit analysis	40 %	60%	0

Statistics of Table 3.4.1 shows that 40% software industries conduct cost benefit analysis using different tools and techniques such that Traceability Matrix, ROI, BCR, NPV, COCOMO model, Functional point analysis. 60% of industries does not conduct cost benefit analysis. (Fig: 3.4.1)



3. RESEARCH METHODOLOGY

This research apply "mix-method" research approach. This research review the literature to identify some software cost estimation model [1, 19, 9] and many technical and non-technical factors [18] that influence accurate software cost estimation. In second stage of research we conducted the survey and interviews to understand how software industries face the problem of change management on Software cost estimation. The survey process take place in the duration o

cost estimation. The questionnaires were disturbed among 100 software industries of Pakistan to collect data based on software industry's needs. Only 12% software industries of Pakistan result in respond to questionnaire and interview. Questionnaire consist of both open ended and close ended questions so that software industries can easily mentioned the challenges that they encountered.

Fig 3.4.1: cost benefit analysis conducted by industries

Table 3.4.2: Questionnaire Response

Question criteria	Capacity-related, price-to-win	Expert judgments	Analogy	Model based methods	Depends on scenario to scenario
Estimation Methods	16.7%	27.3%	1%	33.3%	8.3%

Statistics of Table 3.4.2 shows that 16.7% estimation methods used in the industry for Capacity-related price-to-win,27.3% for Expert judgments,1% for Analogy base , 33.3% for Model based methods, three estimation methods are being used, top-down estimation, bottom-up estimation, Parametric model, 8.3% estimating Depends on scenario to scenario. (Fig: 3.4.2)

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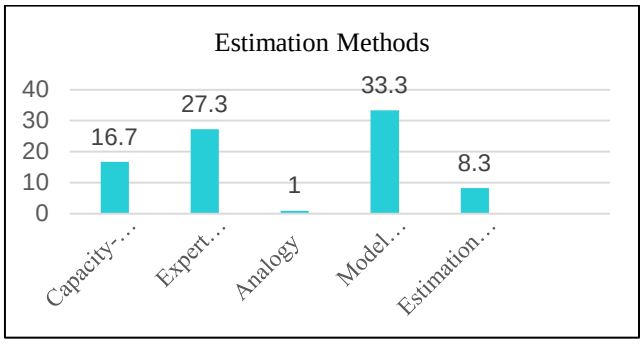

Figure 3.4.2: cost estimation methods used in industries

Table 3.4.3: Questionnaire Response

Question criteria	yes	No
Project Size effect Effort and schedule estimation accuracy	83.3	8.3

Statistics of Table 3.4.3 shows that 83.3% of software industries responses that project size effect schedule and effort estimation accuracy. 8.3% of industries responses were in No. (Fig: 3.4.3).

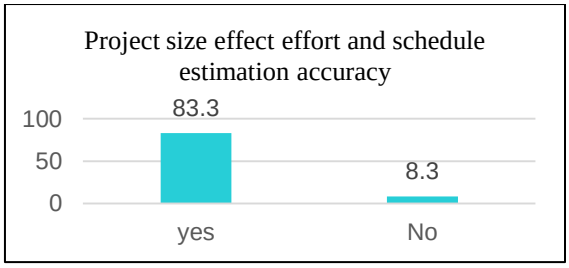

Figure 3.4.3: Project size effect effort and schedule estimation accuracy

Table 3.4.4: Questionnaire Response

Question Criteria	Requirement are volatile	Requirement are unclear	Changing in technology
Causes of inaccurate estimation	27.3	18.2	2
	Resources are unavailable	**Absence of applicable cost estimation methods and process**	**Use rolling wave planning instead of planning at once.**
	9.1	27.3	27.3

Statistics of Table 3.4.4 shows causes of inaccurate estimation as 27.3 % of Requirement are volatile, 18.2% of Requirement are unclear, 2% Changing in technology, 9.1% Resources are unavailable, 27.3% absence of applicable cost estimation methods and process 27.3 % industries use rolling wave planning instead of planning at once for large projects(Fig: 3.4.4).

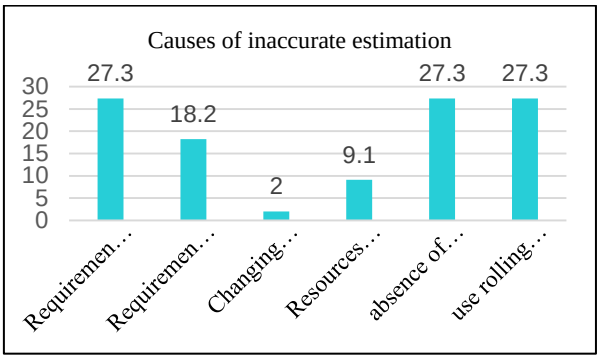

Figure 3.4.4: Causes of inaccurate estimation

Table 3.4.5: Questionnaires Response

Question Criteria	A great deal of effort to collect data and configuration require in Software cost estimation models	The software cost estimation models results in insignificant advantage
Obstacles and problems in the application of software cost estimation models	41.7	2
Unclear Agenda	**Organization usually have insufficient assets in order to improve software cost estimation**	**Software cost estimation models are difficult to study and use**
8.3	33.3	8.3

Statistics of Table 3.4.5 shows Obstacles and problems in the application of software cost estimation models result in 41.7% great deal of effort to collect data and configuration require in Software cost estimation models, 2% software cost estimation models results in insignificant advantage, 8.3% Software cost estimation models are difficult to study and use, 8.3% Unclear Agenda, 33.3% Organization usually have insufficient assets in order to improve software cost estimation (Fig: 3.4.5).

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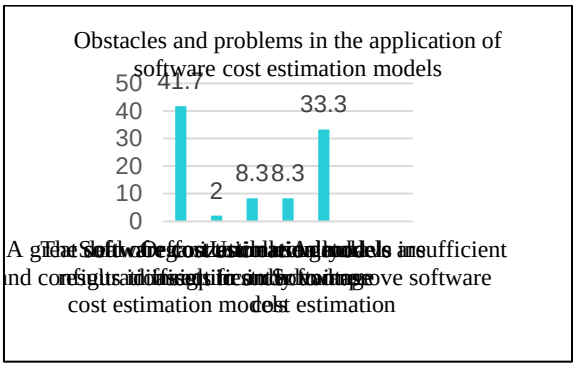

Figure 3.4.5: Obstacles and problems in the application of software cost estimation models

Table 3.4.6: Questionnaires Response

Question Criteria	By using appropriate cost estimation models	On Experience base	innovative projects requires detailed study scope baseline, mostly scope is poorly defined	Time and Man Power
Handle change in software project cost	33.3	50	8.3	8.3

Table 3.4.6 indicate how industries Handle change in software project cost 33.3% By using appropriate cost estimation models ,50% On Experience base,8.3% innovative projects requires detailed study scope baseline, mostly scope is poorly defined,8.3% Time and Man Power(Fig: 3.4.6).

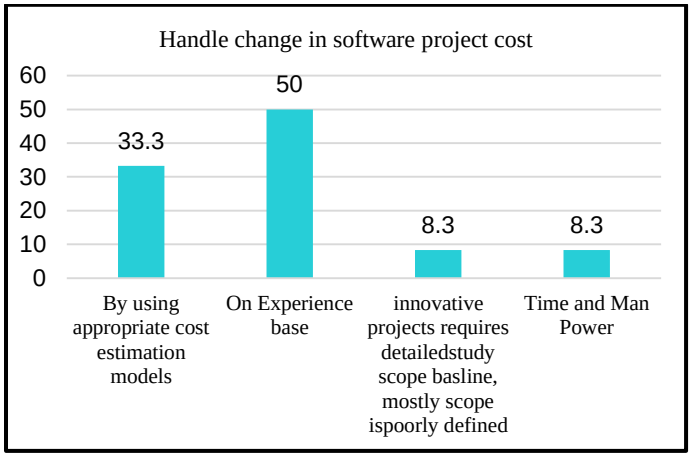

Figure 3.4.6: Handle change in software project cost

Table 3.4.7: Questionnaire Response

Question Criteria	Increase delivery time	Increase human effort	Already keep margin in time and cost
Approach to risk management	1	16.7	66.78
	Integrated Change control process		Change Control Management
	83.3		8.3

Statistics of Table 3.4.7 indicate industry's approaches to risk management that are result in 1% Increase delivery time,16.7% Increase human effort,66.78% Already keep margin in time and cost,83.3% Integrated Change control process,8.3% Change Control Management(Fig: 3.4.7).

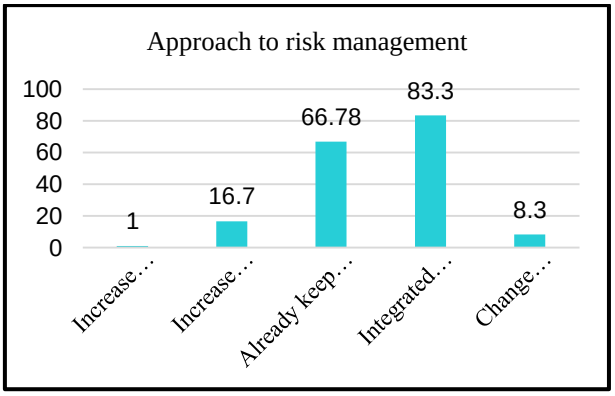

Figure 3.4.7: Approach to risk management

Table 3.4.8: Questionnaire Response

Question Criteria	Deliver project within time	project complete within estimated cost	both :Deliver project within time, project complete within estimated cost
Critical success factors	8.3	8.3	66.7
	integrated change control process		None
	8.5		8.6

Statistics of Table 3.4.8 indicate Critical success factors of industries as 8.3% industries indicate that project deliver within time is critical success factor as well as 8.3% project complete within estimated cost, 66.7% both: Deliver project within time, project complete within estimated cost, 8.5 % integrated change control process all are critical success factors for industries. 8.6% responses were in none. (Fig: 3.4.8).

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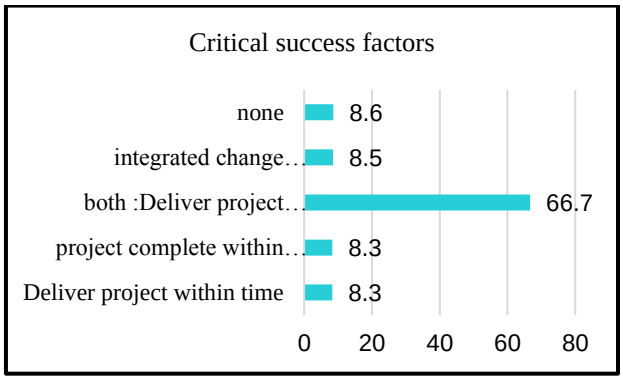

Figure 3.4.8: critical success factor for industries

Table 3.4.9: Questionnaire Response

Question Criteria	RAD model	Scrum model	Water Fall
model used in industry for software development	32.3	66.7	1

Statistics of Table 3.4.9 indicate that 32.3% of industries used RAD model for software development, 66.7% industries used Scrum model and 1% Water Fall model for software development. (Fig: 3.4.9).

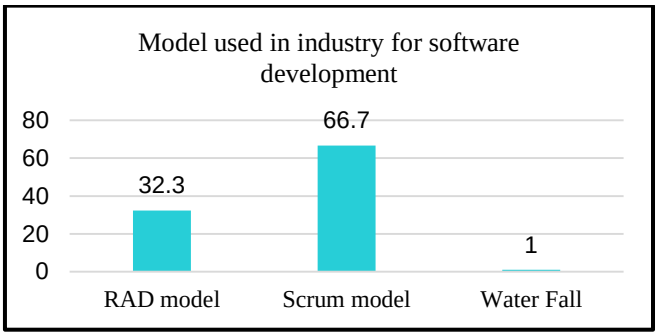

Figure 3.4.9: Model used in industry for software development

Table 3.4.10: Questionnaire Response

Question Criteria	business values	Budgeting	Risk analysis
purpose to use cost estimations	8.3	58.3	1
	Project planning and control		**To create project cost baseline and project budget**
	24		10

Statistics of Table 3.4.10 indicate the purpose to use cost estimations 8.3% used cost estimation for business values,58.3% for Budgeting, 1% for Risk analysis, 24% for Project planning and control and 10% to create project cost baseline and project budget (Fig:3.4.10).

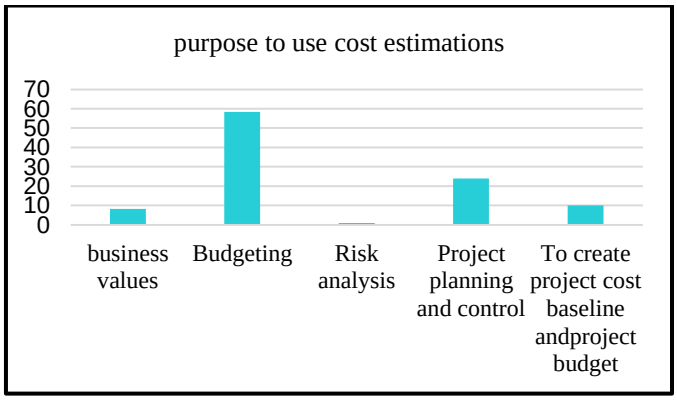

Figure 3.4.10: purpose to use cost estimations

Table 3.4.11: Questionnaire Response

Question criteria	Initial project proposal stage	Feasibility study	Requirement gathering	Design
Organizations usually make cost estimations	45.5	27.3	9.1	9.1
	Implementation	**Integration & testing**	**planning process group**	
	2	0.5	9.1	

Statistics of Table 3.4.11 indicate 45.5% Organizations usually make cost estimations during initial project proposal stage, 27.5% use during feasibility study.

3.2 Proposed Solution

3.2.1 Q1. Overcome change in management

By using same techniques like Pessimistic Estimates, Work breakdown structure, decomposition, estimate resource requirements, estimates duration and then estimate cost one can overcome change in management. Moreover one can impose restriction in change requests by limiting the number of revisions a client can ask. Additional revisions are analyzed and quoted separately.

Finalize requirements before starting project and by mentioning timelines one can easily overcome change in management.

3.2.2 Q2. Estimate cost in context of change management

Risk management is input to every estimating process. Plan risk management by creating risk management plan, then identify risk to build risk register, then perform qualitative & quantitative risk analysis and then advise risk strategies for positive (Enhance, Exploit, Accept, Share) and negative (Mitigate, Transfer, Avoid, Accept) risks. Moreover if change occur within milestone then it can be overcome according to intended requirements within each milestone.

However, PMI PMBOK5, Managing Change in Organizations: A PMI Practice guide, Change Management Control and Scrum model are best practices or methodologies for change management.

4. CONCLUSION

This research investigated the effect of change management on software cost estimation. As accurate software cost estimation is project manager's responsibility so estimating cost at initial phase of software development life cycle is a challenging task. So, this research conducted a survey and Structured interview from different software industries of Pakistan. From the analysis of data collected from different software industries, this research proposed a solution to minimize the impact of change management on software cost estimation. This research also indicate factors that are main reason for change management. By applying the best practices the impact of these factors can be minimized as well as accurate software cost estimation can be made possible.

5. FUTURE WORK

As Changes during software development are obvious, so accurate software cost estimation in context of change management is considered to be difficult task. As many cost estimation models used now a day, but there is no model available to accurately estimate cost in context of change management. Hence future work involve proposed a new model based on change management.

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