

AN INVESTIGATION OF EFFECTIVE FACTORS ON EFFORT ESTIMATION
OF SOFTWARE PROJECTS INSIDE THE ORGANIZATION

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“Dedicated to my beloved husband and daughter”

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ABSTRACT

Management of software projects has become a challenging issue during the last decade. The latest published statistics related to the status of software projects shows a substantial rate of fail, which has raised a critical challenge for project managers. In prior studies, inaccurate effort estimation has been mentioned as the most important reason behind the fail of software projects. The latest published papers in this area reported that the accuracy of existing estimation models are not convincing and the flexibility of models is not enough to be utilized for different types of project. Considering an estimation process (estimation model, materials, techniques and so on) to be used in a wide range of organizations regardless of the capabilities and specifications of organization is the main problem leads the current estimation models towards inaccurate and unreliable estimates. As a solution, each organization must know its strengths, weaknesses, opportunities, threats, capabilities and all aspects related to effort estimation. In other words, the real status of organization in terms of effort estimation must be clarified so that the reasonable decisions can be made to reach an efficient process of effort estimation. This research conducts a survey in which the important aspects of effort estimation including estimation process, limitations, management issues and project attributes are evaluated. Unlike prior survey-based studies conducted in the past, this research focuses on importance of project attributes and management issues. In addition, this research tries to integrate the concepts considered by prior studies separately. Moreover the relationships between the key concepts related to effort estimation are evaluated and discussed. Finally, a form is designed in which the results are efficiently summarized, which clearly depicts the real status of organization if field of effort estimation. This survey is conducted on a sample of 135 developers working in a large software company.

ABSTRAK

Pengurusan projek perisian semakin menjadi isu yang mencabar semasa dekad yang lepas. Statik terkini yang disiarkan berkaitan dengan status projek perisian menunjukkan kadar kegagalan yang besar, di mana ia telah meningkatkan cabaran kritikal kepada pengurus projek. Berdasarkan kajian yang lepas, kadar usaha yang tidak tepat menunjukkan sebab utama di sebalik projek perisian gagal. Menurut kajian terkini, ketepatan dalam model anggaran yang sedia ada tidak meyakinkan dan fleksibiliti model tidak cukup untuk digunakan bagi jenis projek yang berbeza. Dalam mempertimbangkan proses anggaran (model anggaran, bahan, teknik dan sebagainya) untuk digunakan dalam pelbagai organisasi tanpa mengira keupayaan dan spesifikasi organisasi adalah masalah utama menjurus kepada model anggaran kini yang tidak tepat dan anggaran yang tidak boleh percaya. Sebagai penyelesaian, setiap organisasi perlu mengetahui kekuatan, kelemahan, peluang, ancaman, keupayaan organisasi dan semua aspek berkaitan anggaran usaha. Dengan kata lain, status sebenar organisasi dari segi anggaran usaha perlu dijelaskan, oleh itu keputusan yang munasabah dapat diperolehi untuk mencapai proses yang efisien dalam anggaran usaha. Penyelidikan ini menjalankan kaji selidik tentang aspek penting dalam anggaran usaha termasuk proses anggaran, had, isu pengurusan dan ciri projek disiasat. Tidak seperti beberapa kaji selidik yang dijalankan sebelum ini, penyelidikan ini memfokuskan kepada kepentingan ciri projek dan isu pengurusan. Di samping itu, penyelidikan ini cuba untuk mengintegrasikan konsep yang berbeza yang dipertimbangkan dalam kajian yang lepas. Tambahan lagi, hubungan antara konsep utama berkaitan anggaran usaha telah dinilai dan dibincangkan. Akhir sekali, borang direka di mana keputusan disimpulkan secara efisien, yang jelas menunjukkan status sebenar organisasi dalam bidang anggaran usaha. Kaji selidik ini dijalankan pada sampel 135 pembangun yang bekerja di syarikat perisian yang besar.

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CHAPTER 1

INTRODUCTION

1.1 Overview

Project management is one of the most important activities performed throughout the software projects. Main phases of project including analysis, design, implementation and test are entirely dependent on project management process. All policies, milestones and responsibilities are organized in project management plan. It is undeniable that planning and scheduling of project are the critical parts of project management regardless of project type. In first steps of project, project management team should decide on several important questions related to project planning such as how to arrange development team, how to distribute the responsibilities, how to determine the deadline for artifacts, how to determine the duration of project and so on. Appropriate response to these questions can ensure the success of software project. On the other hands, careless answering and lack of attention to planning aspects of project may lead to project fault. Knowledge of project management team regarding the project attributes has a considerable effect on dealing with the mentioned questions.

Development effort is a key attribute of project that influences on most of planning and managing aspects in software projects (Jones, 2007; Li, et al., 2009). This attribute refers to amount of effort required for project development. It comprises of all activities done within different phases of project. Development effort is the basis of decision making on management issues at first steps of project.

Accurate estimating the amount of effort required for performing the project will make the development process so smooth and convenient. This is why so many Researchers have tried to increase the accuracy of software development effort estimation using various techniques and models.

Software projects are strongly different than other projects because the purpose of software projects is producing an intangible and logical product (Stepanek, 2005). This fact makes the production cycle to be so complicated and difficult in software projects. Therefore, complexity level of software project management is more than other projects. Software project managers are confronted with uncertain and unstable production which is hard to be controlled and managed. Moreover, customer requirements, development technologies and tools are changing rapidly in this field. All of these make the estimation of development effort to be difficult in software projects.

The latest researches in field of software development effort estimation show that it is impossible to suggest an estimation model to be used in all types of software projects (Bettenburg, et al., 2012b; Menzies, et al., 2011). Indeed, the problem of effort estimation for software projects cannot be solved in global space including all the related organizations. As a solution, each organization needs to arrange its own rules, techniques, models and procedures to estimate the development effort. In other words, each organization must exactly know its capabilities, limitations, viewpoints and knowledge of developers as well as management issues to determine an efficient trend for estimation of development effort in software projects.

Despite invention of numerous estimation models, the accuracy of estimation and the adaptability of models are not enough to support different types of organization. In the literature, there are a few studies focused on analysis of the current situation of an organization in field of effort estimation. The existing works are relatively old and mostly focus on accuracy of estimates achieved by organization or the estimation models used by developers.

In this study, an investigation is performed to determine the influence of effective factors on management of effort estimation in software projects. A questionnaire is designed to collect the opinions of developers about the different aspects of software development effort estimation inside the organization. The questionnaire is designed so that it includes the most important parts of prior survey-based studies as well as the latest issues related to effort estimation in software projects. The survey conducted in this research makes a connection between analytical studies and survey-based studies to clarify the current status of organization for management of effort estimation. Respondents comprise of project developers in a large software company. This research tries to suggest a systematic and structured method in which the aspects of effort estimation are cleared for an organization. Finally, it is expected that the results achieved by this survey to be useful for project managers in field of project planning and scheduling.

1.2 Research background

In 1973, Interactive productivity and Quality (IPQ)(Jones, 2007) was proposed by IBM group as the first automated tool for software development effort estimation. Afterward, Constructive COst Model (COCOMO) was invented by Barry Boehm (Boehm, 1981). COCOMO utilizes some effort drivers to forecast the amount of development effort. It offers several equations based on complexity level of project. “Software Engineering Economics” (Boehm, 1981) is a famous book in this area that still numerous researchers employ proposed models in which for effort estimation. Putnam Lifecycle Management (SLIM) (Putnam, 1978) and Software Evaluation and Estimation of Resources – Software Estimating Model (SEER-SEM) (Galorath Inc.,1980) have used similar principals to COCOMO (Boehm and Valerdi, 2008).

In all the mentioned models, Lines of Code (LOC) has been utilized for designing the estimation model. In fact, the development effort has been estimated using LOC as size of project.

Function Point (FP) is so important sizing parameter proposed by Albrecht (Albrecht and Gaffney, 1983). It was the first idea for measuring the size of software project by using a functional method. Using of FP showed that it can be placed in effort estimation models instead of LOC because computing process of FP is more reliable and accurate than LOC. Advantages of FP motivated researchers to invent new estimation models based on function point such as Albrecht-Gaffney (Albrecht and Gaffney, 1983), Kemerer (Kemerer, 1987) and Matson, Barrett and Mellichamp (Matson, et al., 1994). Introducing of the new version of COCOMO namely COCOMO II in 2000 (Boehm, 2000) is a significant event in this field. COCOMO II considers more details of software project for effort estimation. Estimation equations in this method were improved by applying several scale factors.

In contrary to static methods, there are several dynamic models which rely on using past projects information. Classification And Regression Tree (CART) (Breiman, et al., 1984) is one of the dynamic methods in this area. It makes a regression tree according to the available information of completed projects and uses the tree to estimate the effort of new project. Analogy Based Estimation (ABE) is the other dynamic method proposed in 1997 (Shepperd and Schofield, 1997). ABE method works based on comparing the attributes of new project and past projects to estimate the development effort. It is still so popular because it follows simple and straightforward methods for estimation. ABE have been used widely in recent years (Azzeh, et al., 2010; Chao-Jung, et al., 2007; Chiu and Huang, 2007; Hsu and Huang, 2011; Huang, et al., 2008; Li, et al., 2009a; Song and Shepperd, 2011).

Latest advancements in estimation of development effort are related to using of soft computing techniques. Neural networks (Attarzadeh and Hock, 2010; Bhatnagar, et al., 2010; Kalichanin-Balich and Lopez-Martin, 2010; Kaur, et al., 2010; Li, et al., 2009a; Reddy and Raju, 2009) and fuzzy techniques (Ahmed, et al., 2005; Azzeh, et al., 2010; Ch. Satyananda Reddy, 2009; Prasad Reddy, et al., 2010; Sharma and Verma, 2010) are most important soft computing methods employed in this field.

There are a few analytical studies that focus on finding the relationship between project attributes and development effort using statistical techniques (Bajwa, 2009; Lafferty, 2010). Survey-based studies are restricted to investigation of accuracy of estimates (McAulay, 1987; Trendowicz, et al., 2011) time of estimation (Lederer and Prasad, 1992; Yang, et al., 2008), limitations (Briand, et al., 1998), estimation models (Mansor, et al., 2012), goal of estimation (Yang, et al., 2008) and importance of effort estimation (Trendowicz, et al., 2011).

This study aims to fill the gaps that exist in prior survey-based studies through proposing a structured and comprehensive investigation method in which the critical aspects of effort estimation are assessed and analyzed.

1.3 Problem statement

The problems in the field of software development effort estimation can be categorized into domain and technical problems as explained in the following sections.

1.3.1 Domain problems

Inconsistency and complexity of software projects are the main problems that impede the accurate estimation of development effort in software projects. Analysis of prior completed projects that are similar to new project is the idea frequently utilized by researchers to estimate the development effort in software projects. Inconsistency and complexity as two natural features of software projects make the existing estimation methods to be confronted by serious drawbacks. Actually, computing-based estimation methods are unable to overcome the particular characteristics of software projects.

1.3.2 Technical problems

Prior studies have tried to propose the estimation models to be used in different organizations. In other words, they have considered the data collected from different organizations to build the estimation model regardless of the fact that software projects are entirely uncertain and dynamic as compared to other types of project. Gathering data from different organizations has led the estimation models to be confronted by a high level of non-normality in related datasets.

The idea of global effort estimation (the same estimation process for different organizations) has been seriously criticized by researchers during the recent years (Bettenburg, et al., 2012a; Menzies, et al., 2011; Minku and Yao, 2012; Posnett, et al., 2011). The researchers believe that estimation must be localized according to the type of software projects.

From the localization perspective, the process of effort estimation can be localized inside the organizations meaning that each organization has its own issues in terms of effort estimation. Although investigation the status of organization in field of effort estimation is an important step towards the localization of effort estimation, a few prior studies took this issue into account in a particular domain.

1.4 Research questions

The research question in this study is determined as follows:

“How to realize the status of software development effort estimation inside the organization?”

In order to answer the main issue raised above, the following issues need to be addressed as a prerequisite:

- RQ1: To what extent the key project attributes affect the development effort in software projects conducted by organization, from developers' perspective?
- RQ2: What are the most important obstacles and limitations against the accurate effort estimation in software projects conducted by organization, from developers' perspective?
- RQ3: To what extent the management issues are considered in process of effort estimation inside the organization, from developers' perspective?
- RQ4: How the overall status of effort estimation (inside the organization) can be summarized and depicted in a form?

1.5 Research hypotheses

The research hypotheses are determined as follows:

- **Hypothesis 1.** There is a significant relationship between the experience of developers and the importance level of effort estimation mentioned by developers.
- **Hypothesis 2.** There is a significant relationship between the experience of developers and the satisfaction level of effort estimation.
- **Hypothesis 3.** There is a significant relationship between the satisfaction of effort estimation and the rate of fails in projects.
- **Hypothesis 4.** There is a significant relationship between the rate of fails in projects and the importance level of effort estimation mentioned by developers.
- **Hypothesis 5.** There is a significant relationship between the time of effort estimation and the rate of fails in projects.

- **Hypothesis 6.** There is a significant relationship between the goal of effort estimation and the rate of fails in projects.
- **Hypothesis 7.** There is a significant relationship between the selected effort estimation method and the rate of project fail.
- **Hypothesis 8.** There is a significant relationship between the goal of effort estimation and the satisfaction of effort estimation.
- **Hypothesis 9.** There is a significant relationship between the selected effort estimation method and the satisfaction of effort estimation.

1.6 Research goal

The main aim of this research is to propose a structured approach for evaluating the status of effort estimation inside the organization. Indeed, this research aims at conducting a comprehensive survey in which the most important issues regarding the effort estimation process performed inside the organization are assessed and analyzed. Moreover, this research tries to summarize the results of survey in a status form so that they can be simply interpreted by organization managers for future decision making and planning in field of effort estimation.

1.7 Research objectives

In order to achieve the aforementioned goal, the objectives of this study are listed as below:

- (i) To determine the importance level of project attributes in field of effort estimation inside the organization.
- (ii) To investigate the status of obstacles, limitations and management issues related to effort estimation inside the organization.

- (iii) To investigate the relationship among the factors related to effort estimation (experience of developers, goal of estimation, time of estimation, importance of estimation, method of estimation, satisfaction of estimation and the rate of project fails) inside the organization.
- (iv) To design a form in which the overall status of effort estimation in organization is efficiently shown.

1.8 Scope of research

This research more focuses on:

- (i) Software projects - The projects defined to produce software based on software engineering principles.
- (ii) Project attributes - Dependent attribute in this study is development effort and other ones such as team size, development type, programming language, development style, development technique, CASE tools and organization type are considered as independent attributes.
- (iii) Project developers and managers - Those who have experience in field of developing and managing the software projects.

1.9 Research justification

1.9.1 Importance of software development effort estimation

According to the latest report released by Standish group in 2011, only 37% of software projects have been successful, 42% have been in challenged and 21% have failed (Standish.Group, 2011). This high rate of fail causes concerns to the future of software projects. The researchers have tried to find the reasons behind the

substantial fails in software projects (Galorath and Evans, 2006; Jones, 2007; Jorgensen, 2005; Jorgensen and Grimstad, 2012; Kemerer, 1987; Molokken and Jorgensen, 2003). However suddenly decisions, insufficient requirements engineering, poor planning and inaccurate estimations have been reported as the reasons of fail in software projects, majority of prior studies agree that the key factor is inaccurate estimation.

Planning and scheduling of software projects are considerably dependent on accurate estimation of development effort (Jones, 2007; Jørgensen and Grimstad, 2010; Rao, et al., 2012) and consequently inaccurate estimation of development effort can cause unpredictable results and ultimately project fail. Although numerous estimation models have been invented in this area, the accuracy of estimates is not still convincing and the adaptability of models are not enough to coverage an extensive domain of projects. Therefore, this area needs to be seriously taken into account by researchers.

1.9.2 Localization of estimation process inside the organization

As reported by the latest published papers in field of software development effort estimation, the problem of effort estimation cannot be solved by an unique solution considered for all types of project (Bettenburg, et al., 2012a; Menzies, et al., 2011; Minku and Yao, 2012). In other words, the complexity and inconsistency of software projects restrict the use of existing models so that a single estimation model cannot be used in different types of organization. Therefore, the idea of localization must be implemented in the organizations plan to conduct the software projects. In order to manage the process of effort estimation efficiently, each organization needs to recognize the capabilities, limitations, interests, threats, opportunities and all the issues related to effort estimation through a structured method. This is what has not been considered by prior studies.

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