Exploring the Human and Organizational Aspects of Software Cost Estimation

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ABSTRACT

Cost estimation is important for planning, scheduling, budgeting and pricing of software development. Previous research has mainly focused on improving estimates and the associated processes. However, there is still a lack of research on human and organizational aspects of cost estimation and informal uses of cost estimates. This paper presents initial findings from a qualitative study addressing these questions. Based on four semi-structured interviews with experienced managers from different software developing organizations we have identified a number of aspects not commonly discussed in the cost estimation literature. The analysis indicates that cost estimates are used not only for prediction and planning, but also play a role in power plays within the organizations based on the stakeholders' differing interests. There are also human and organizational factors that are likely to influence the quality of estimates.

We also suggest a basic taxonomy of attributes that could be used to structure the many issues involved in and affecting software cost estimation. We conclude that there are many factors that affect software cost estimation and need to be considered in future research. Longer-term this is important not only for cost estimation but can also be useful to understand how human and organizational factors affect software development processes in general.

Categories and Subject Descriptors

D.2.9 [**Software Engineering**]: Management – *Cost estimation, Time estimation*

General Terms

Management, Measurement, Economics, Human Factors

Keywords

Human Aspects, Cost Estimation, Qualitative Study

1. INTRODUCTION AND RELATED WORK

During the last three decades a large part of research in software cost estimation has been devoted to developing and evaluating estimation models [1]. During the same period of time the amount of projects with cost overruns has been reported to be between 41% [2] and 80% (budget and duration overruns) [3] with no apparent tendency to decrease.

The reasons for inaccurate cost estimates have been investigated in a number of studies [2, 4-12] where the findings can be categorized as either *technical* or *human*. The former are concerned with models and methods for estimation and the latter focus more on individuals, groups and organizations.

In the *human* category of studies, self-reports [2, 3, 5-11] (studies investigating what human subjects can and are willing to tell us about the topic) and cognitive experiments [4, 12] (studies investigating the unconscious reasons for cost estimation inaccuracy, such as optimism and wishful thinking) are most commonly used research methods. Most of the human studies have focused on cognitive estimation biases in estimation situations. This area has grown during the last decade resulting in new knowledge about practitioners optimism [12] and unrealistic self-confidence [4].

Lederer and Prasad conducted a quantitative self-report study [13, 14] recognizing the inadequacy of a rational perspective when it comes to understanding and predicting human behavior. Instead, the authors take support in the political perspective that "recognizes that conflicts of interest are common and expected". The results show differences between the six interest groups (IS management, user representatives, estimators etc.) in padding and shrinking behaviors, objectives and also evidence of a link between the objectives and shrinking/padding behaviors.

Hidden agendas are discussed in a paper by Jorgensen et al [4] where the authors, based on the results of observations and three experiments suggest that practitioners might have other goals a high correspondence between confidence level and hit rate. The desire to be perceived as a skilled developer is mentioned as one of the possible agendas that would lead to narrow effort prediction intervals.

This study differs from other similar studies as we use the explorative approach [15] in data collection and analysis. We collect not only the data on previously known behaviors, but we also encourage the subjects of the study to add observations they find interesting and important. This makes it more likely for

previously unknown data to emerge. This study is in progress and it is designed to answer the following research questions:

RQ 1: What are the informal roles of estimates in large traditional organizations?

RQ 2: What human aspects affect software cost estimates and how can we categorize them?

2. METHODOLOGY

This paper is based on the findings from four initial interviews in an ongoing exploratory study with experienced project managers from three different organizations. Three of the interviewees reside in large, traditional organizations. One subject represents a young, large organization. Data was also added from one of our previous studies [11]. The interviews are explorative and use an open format with interview questions on stakeholders and their interests, conflicts of interest, use of estimates (formal and informal), influence, power and perception of organizational politics. Interviewees are asked open-end questions and encouraged to talk freely about what happens with the estimates in their organization, from the start until the end of a project. If an interviewee fails to cover some of the topics of interest further questions are posed. This way interviewees are not restricted only to our topics but can expand into relate or new but relevant ones. Conversations are recorded and then transcribed. Transcripts are sent to the interviewees for proofreading and validation. Aspects and supporting examples were extracted by one of the authors. After initial interpretation the analysis was done in parallel and then merged.

3. RESULTS

Our initial analysis shows that cost estimation plays a number of informal roles in organizations. Below we summarize the identified aspects in four main categories. We give summary names (within parentheses) for types of identified issues.

3.1 Differing interests

The interviewees from the large traditional companies (embedded software) described three main stakeholders when it comes to resource distribution – product planning organization (PPO), line or functional organization (LO) and project organization (PRO). The PPO is responsible for understanding current trends in different user categories and transferring these needs to technical requirements together with the involved software developers. The LO is responsible for staffing projects and PRO is responsible for delivering the products.

These three parts of organizations are driven by different goals: the PPO is driven by the customer needs, the LO by the need to distribute resources between (many) different projects and the PRO is supposed to deliver the right product within the planned time and price. Numerous examples of conflicts were given by the interviewees based on differing goals. Following was said about the conflicts between the stakeholders: *"It happens a lot. The balancing [of requirements and costs] is often a difficult task."*

In more software-focused organizations the developers sometime get too involved in their work: *"If you are a developer within a certain area, it is likely that you will find that area and your work very important. As a manager, I see the bigger picture and know that your area might not be so important, and I might chose not to reward it with a lot or resources. It is likely we'll have different opinions on this."* said one of the interviewees.

In the case of the younger, more software oriented company, the developers seem to have a lot of influence on both the product and the way work is done at the company: *"The management has little influence in our company [...]. In principal, they have to convince us [technical staff] to do the right thing. They cannot control us. As soon as they try controlling us, we will avoid it by switching the project we work on [...] so if your managing skills are not good, everyone will leave the project."*

We can see that even though the actual goals and reasons for conflicts differ conflicts arise since the humans involved have different agendas (Balancing Agendas) which in turn is affected by their views of themselves and their role as well (Self Support) and emotional attachment (Emotional Attachment).

3.2 Lobbying

Whether it is because of personal interests or organizational affiliation, lobbying to get support seems to be a common behavior in relation to cost estimation. One interviewee said that certain individuals would try to get support for their personal interests by building pacts: *"If they have pacts? Yes, that can happen, because product planners and developers are involved in common projects."* And these pacts sometimes have the intended effect: *"When humans are involved of course some things slip through".* Another interviewee supports this: *"Yes, absolutely! Everybody does it [Lobbying]. You have an emotional band to your project."* When asked about influence the interviewees told us that experienced individuals get their projects approved easier as they *"gain approval for their projects through their informal networks".*

One of the interviewees also told us about some kind of distributional justice, where all technical divisions are supposed to get a piece of the cake: *"whether it is good or bad for the company. Sometimes it would be better to concentrate on less projects, but this way you see to that nobody misuses their power and takes the whole cake."*

Concluding, there are indications that lobbying is common (Pact Building, Misusing Contacts) in organizations of all kinds. It is exercised both in formal (meetings) and informal (personal contacts) forums. It also seems to be working, whether it is for the company's best or not.

3.3 Intentional padding/shrinking of estimates

The interviewees mention that there are cases of both intentionally optimistic and intentionally pessimistic estimates. These two serve different purposes. One of the interviewee shares his experience of wishing to see to that a project is chosen for the implementation: *"...often a person is managing a project and is really enthusiastic about it. Then this person might ask himself – How optimistic should I be [In giving estimates]?"* But the interviewee also reflects on an opposite influencing factor: *"How much should I add to really be sure this is an estimate I can follow?"*

So, optimistic estimates are not always the case of cognitive biases (Intentional Misestimating), but can also be rather consciously engineered to "sell" a project or to stay on the safe side in being able to deliver on the estimates.

3.4 Other "political" behaviors

The interviewees were first asked if they see the signs of organizational politics in their organizations. All said yes, but

when asked how they interpret the concept of organizational politics the answers differed. One of the interviewees said that politics often meant that people go through their informal networks (Misusing Contacts) and try to get support for their ideas (Self Support) before the official discussions, or try to make others look bad (Misinterpreting Others). He also added that although this happens it is not the most common kind of behavior, something that is supported by the literature on organizational misbehavior [16].

Another interviewee interprets the concept of organizational politics as something managers do in order to increase the bureaucracy in the company and if the developers perceive the meetings to be of the bureaucratic nature instead of technical they are likely to respond with what best is described as civil disobedience – skipping the meetings (Civil Disobedience).

Yet another interviewee interprets the concept of organizational politics as the struggle between the different parts of organizations (Balancing Agendas), but states that also individuals can affect the whole organization (negatively), especially if their position is that of an expert (Self Support).

One of the interviewees even says he has been forced to *"estimate a certain amount",* saying that he has been ordered by his superior to report a certain, optimistic, number when discussing estimates (Intentional Misestimating).

It is difficult to know whether the perceived organizational politics (OP) indeed are politics or not, as the definition of OP is a debated one [17]. However, it is still interesting to understand both what the interviewees perceive as politics and why. No matter what we call these behaviors, they seem to be affecting the estimation and estimates.

4. ANALYSIS AND DISCUSSION

Below we discuss our results by giving analytical frameworks for aspects that affect cost estimation and the roles that estimates play in organizations. We then discuss our results in the light of these frameworks and the methodology to use for this type of research.

4.1 Aspects affecting cost estimation

We divide the aspects affecting cost estimation into *human* and *technical*. Examples of technical aspects are quality of estimation models and methods and suitability of those methods to different kinds of development processes [18]. The technical aspects are by far the most explored ones within the area of cost estimation [1].

Human aspects are concerned with effects of human behavior on cost estimates, and humans can either be *aware* or *unaware* of these behaviors. Optimism, anchoring and over confidence are all examples of behaviors that humans are unaware of [4, 12]. As for the aware behavior, we propose a continuous scale with behaviors the subjects are willing to talk about (*reportable*) as one extreme and behaviors they are not willing to disclose (*hidden*) on the other. Problems with management and changes in projects are often encountered examples of aware aspects [2, 3, 5-7, 11] while lying about resource needs or project status [11] could be a hidden one.

4.2 The role of cost estimates in organizations

When it comes to the use or role of cost estimates in organizations we propose classification into *formal* and *informal* ones. Formal uses of cost estimates are usually explained in software engineering literature and are easy to discuss with practitioners. For example, estimates can be used as a forecasting tool for resource consumption, a tool for project control or as input for budgets. As for the informal role or use of estimates, not much is yet known. However, it is clear from our interviews that estimates are used for a number of things that are external to (or have other goals) the estimation process itself.

4.3 Discussion of the results

A few studies have been carried out with the goal of better understanding the aspects that affect cost estimates where practitioners are aware of and willing to report their observations (*reportable* aspects in 4.1) [2, 3, 5-11]. This work has mostly been quantitative, an approach that is unlikely to help uncover insights previously unknown to the researchers as questions are formal and based on previous knowledge [15]. This study, however, offers an insight into reportable human aspects from a qualitative perspective, which allows collection of preciously unknown data [15]. The aspects found in this study (aspect 1-8) are together with the aspects reported in our previous work (aspects 9-12) [11] displayed in table 1. We also added information on whether similar aspects have been reported in papers by other authors (see table for references).

Out of twelve aspects in table 1 five have already been mentioned as the results of other studies. However, these aspects are often just reported and not explored further. Therefore a further exploration of the reportable aspects is necessary, as well as understanding of the effects these aspects can have on software projects. This will likely improve the ability of practitioners to control and monitor their projects and produce more useful estimates.

Aspect	Addressed in other studies
1. Intentional Misestimating	[2, 4, 7]
2. Emotional Attachment	No
3. Pact Building	No
4. Civil Disobedience	No
5. Misusing Contacts	No
6. Self Support	No
7. Misinterpreting others	No
8. Balancing Agendas	[7]
9. Bureaucracy (from [11])	[2, 7]
10. Negotiations (from [11])	[7]
11. Not relating requirement uncertainty to estimate uncertainty (from [11])	[2, 5-7, 9]
12. Sharing resources with other projects (from [11])	No

Table1. Overlaps of the issues found in this study with issues found in other studies

As for the role and use of estimates in organization, we have in this paper presented some initial evidence of cost estimation being

a power play (informal use) rather than a rational calculation (formal use).

4.4 Methodological considerations

The initial results of this study indicate that the rational perspective on cost estimates might be too simple if we are to understand the behaviors that affect cost estimation and estimates as these behaviors do not come from extensive planning, but rather from negotiations and mutual agreements and adjustments.

Also, there is no clear line between the hidden and reportable aspects. For example, one early observation from this study is that the interviewees are more likely to talk about a sensitive question if it is not asked up front, but rather if they bring up the subject them selves or if the question is brought up as a follow-up question. It is important to form a *trusting* relationship with the *suitable* subjects and *adapt* the interview situation to each interviewee.

Accuracy, otherwise often used as a measure in estimation studies, was not addressed in this study. It is a difficult concept to explore as software projects often change during execution [2, 3, 5-8, 11]. This makes it difficult to compare initial estimates with actual results [19].

5. CONCLUSIONS AND FUTURE WORK

In this paper we have presented two analytical frameworks, one for analysis of aspects that affect cost estimation and the second one for defining the role of cost estimates in organizations. We have also presented a collection of reportable human factors that affect cost estimation as well as some early evidence of estimates not only being tools for forecasts, but also tools in an organizational power plays.

Based on the results from this study, we plan for a quantitative study in order to better understand different stakeholders and their interests, as well as the effects of these interests on software cost estimation and steering of software projects in general. We can never be sure that the interviewees will disclose all information on these topics. It is likely that some information will be forgotten and even more likely that other would be consciously hidden. Therefore, categories from literature on organizational misbehavior [16] will be added to the later quantitative study. We will also study the research approaches from this discipline in order to improve our own work.

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