Confirming Distortional Behaviors in Software Cost Estimation Practice

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***Abstract*—Cost estimation of software projects is an important management activity. Despite research efforts the accuracy of estimates does not seem to improve. In this paper we confirm intentional distortions of estimates reported in a previous study. This study is based on questionnaire responses from 48 software practitioners from eight different companies. The results of the questionnaire suggest that prevalence of intentional distortions is affected by the organizational type and the development process in use. Further, we extend the results with information about three companies' estimation practices and related distortions collected in interviews with three managers. Lastly, based on these results and additional organizational politics theory we describe organizational politics tactics that affect cost estimates.**

I. Introduction and Related Work

Cost and effort estimation of software projects is an important, yet difficult project management activity [1]. Projects are often finished later than scheduled deadlines and over budget [2]–[7]. One of the reasons so many projects are reported to be late could be additions to requirements driven by the changing market or misunderstandings of initial requirements [8].

Cognitive biases, such as optimism and over-confidence in project managers' forecasts, have been proven to affect the quality of estimates [9]. Also anchoring, i.e. adaption of a forecast to information that is clearly inaccurate or unimportant for the task, has been recognized as an estimation bias [10], [11].

Perceived estimation inhibitors have also been investigated by estimation researchers. The most commonly reported issues are unclear and changing requirements, user related problems, and technical issues [1]–[3], [12], [13]. Worth noting is that most of the reported inhibitors are of external nature, they are not caused nor can be controlled by the subjects.

If we define an estimate as the best forecast an estimator can achieve, e.i.:

> *'An honest forecast of the most likely effort needed to finish a development task using information available at the time of estimation.'*

we can argue that neither changing nor unclear requirements could cause distorted estimates. Rather, as suggested by Magazinius and Pernstål [13], the actual estimation distortion is caused by the organizational culture where the uncertainty of requirements is expected not to be reflected in the estimates. For example, point estimates and estimates with too narrow confidence intervals are awarded [9], and first estimates are often seen as promises rather than forecasts based on the available unclear and incomplete information [14]. This type of organizational culture might have contributed to the prevalence of *organizational politics* in information systems project cost estimation reported by Lederer and Prasad as intentional shrinking and padding behaviors caused by differing interests in project planning [1], [15], [16]. Magazinius et al [14] have further explored intentional distortions in estimates focusing on todays large, mature organizations concluding that intentional distorting of estimates exists. The authors also provided a description of preconditions and reasons for such behaviors.

In this paper we further investigate and explain prevalence of intentional estimate distortions. Since previous studies have shown the importance of the organizational context and the development processes in use we specifically want to study the effect of different types of development processes (plan driven and agile) or organizations (contractors and final product manufacturers). Since the estimation practices in agile processes, such as the planning game, often differ from traditional approaches it is likely this can have a large effect. In previous research we have focused on product manufacturers and we want to see if there is variation based on the overall organization type. Three research questions were designed for this purpose:

RQ1: How common do software practitioners perceive intentional estimate distortions to be?

RQ2: Are intentional estimate distortions affected by development and planning processes?

RQ3: Are intentional estimate distortions affected by company type?

To answer the research questions we use questionnaire responses from 48 software professionals from eight different companies and three narratives where estimation practices at three different companies were described together with the respondents' views of intentional estimate distortions at their company. Based on the findings from the empirically collected data we then seek explanatory models from the areas of Organizational Misbehaviors (OMB) and Organizational Politics (OP) to support the analysis of our findings.

II. Organizational Misbehavior and Politics

As there are only a few studies that focus on intentional distortions of software cost and effort estimates [14]–[16] we will use Organizational Beavior (OMB) and Organizational Politics (OP) literature to further analyze the results of this study.

The several and competing definitions of Organizational Misbehavior often focus on one or more of the following properties: personal and organizational consequences, the agents who decide what represents OMB and the criterions that define OMB. Vardi and Wiener definition of Organizational Misbehavior covers all three aspects and emphasizes the *intention* of the act [17]:

> *'Organizational Misbehavior is any intentional action by members of organizations that violates core organizational and/or social norms'*

Based on the definition above Vardi and Wiener suggest a general framework for Organizational Misbehavior where *antecedents* for OMB lead to an *intention* to misbehave, that in turn leads to different OMB *manifestations* (Table I) [17].

Antecedents are divided in four levels: individual (personality, value congruence, attitude and personal circumstances), position (job type), group level (the effects of internal and external pressure, but also the tendency of groups to choose members that are likely to misbehave in desired ways) and organizational (based on organizational goals, culture, climate etc.) It is often not a single antecedent but rather a combination of them that causes the intention to distort an estimate.

Manifestations of OMB can be intrapersonal, interpersonal, production related, property related an political and are further explained in (Table I). Among the five types of OMB manifestations we believe that the explanations for intentional estimate distortions are most likely to be found among the *political manifestations*.

Manifestations of Organizational Misbehavior
1. Intrapersonal manifestations such as substance abuse and workaholism
2. Interpersonal manifestations, for example inactivity, violence and aggression, sexual harassment and bullying.
3. Production manifestations which include absenteeism, social loafing and restriction of output (work effort, not information).
4. Property manifestations such as theft, vandalism and sabotage, misuse of assets or property and industrial espionage.
5. Political manifestations that include impression management, favoritism and misuse of power.

TABLE I
Manifestations of Organizational Misbehavior

A. Political manifestations of OMB

Political manifestations of OMB were by Vardi and Wiener divided in four categories [17]: whistle blowing, deception, impression management and political behavior.

Whistle blowing [17] is exposure of the organization's illegal or immoral activities to the public by its employees. Even though the act of whistle blowing might be positive for the society it is damaging to the organization and is thus classified as OMB.

Deception [17] in organizations can be either work related or personal (non-work related). Work related deception is often intentionally designed to maintain the impression of rationality, while it in reality serves another purpose, e.g. promoting own interests or the interests of one's organizational surrounding (sections, project teams, etc.) on the expense of others. Deception is exercised through *communication* (false or incomplete information), *decision making* where managers pretend to give in to demands while in reality trying to reach another goal and *presentation of self* where many managers hide high uncertainty in their tasks by faking confidence.

Impression management [17] is used to control others' impressions of oneself and can involve shifting blame to external circumstances or others in order to appear more competent, or pretending to be loyal or selfless in order to manipulate the ways other colleagues perceive oneself.

Political behavior [17] implies that individuals or groups use power to gain resources. Political strategies are manifested through a number of behaviors, e.g. use of demands, requests and strict deadlines, satisfying others' interests to make them feel important, bargaining, informal networking, attempts to appeal to higher management, controlling information, etc.

Among the four political manifestations *deception*, *impression management* and *political behavior* appear as most likely to offer further understanding of intentional estimate distortions. Impression management has been mentioned by the respondents in our earlier study [14] with a direction towards higher management. As that type of behavior already is included in *political behavior*, we will investigate it further through OP literature.

1) Deception: Deception is often referred to as *lying* and is considered to be an important cause of cost underestimation in, among other, public works projects [18]. Flyvbjerg et al [18] suggest that although estimation techniques have improved over time, the lack of improvement in estimate accuracy shows that there are other factors that distort the estimates and hinder the organizational learning, thus the authors reject the technical explanations of forecasting errors.

The estimation studies in public work projects have shown that practitioners believe that cost reduction is more important than estimating correctly and the will to lower costs can lead to too low estimates [19]. Estimate reduction driven by the will to lower costs can even be perceived as noble, a type of deceit that is by Bok [20] considered the most dangerous as the final project cost might be much higher than can be afforded, or as projects can be initiated instead of projects that would be more beneficial for the public [18].

Flyvbjerg et al [18] divide reasons for underestimation into *psychological* and thus unconscious, and *intentional*. For intentional estimate decrease, also the focus of this study, they refer to the theory of organizational politics.

2) Organizational politics: Definition of organizational politics is a disputed subject where focus often lies on influence, self-interest and damage [21]. However, political behavior does not always lead to damage and is not always caused by self-interest, something that Mayes and Allen's take into account when suggesting the following definition of Organizational Politics [21]:

> *'... the management of influence to obtain ends not sanctioned by the organization or to obtain sanctioned ends through non-sanctioned means.'*

Organizational politics can be practiced through many strategies. Vredenburgh and Maurer [22] presents a list of strategies that can also have effects on cost estimates. These strategies will be used in data analysis and discussion of the results.

III. Research Methodology

To answer the research questions we have collected and analyzed data from two different sources: questionnaire responses from 48 software practitioners from eight different companies, and three narratives provided by line and project managers describing the estimation practice and distortions in one company each.

A. Questionnaire

In our earlier study [14] we have reported cost and effort estimate distortions caused by intentional as well as unintentional acts. In this study we have, using a questionnaire based on the distortions described in [14], investigated whether the reported distortions were recognized by other practitioners and if they were perceived as common. Two of the earlier reported distortions were not included in the questionnaire (one cognitive and one experience based). Three questions were added in order to investigate preconditions for distortions.

The 48 collected questionnaire responses come from eight different companies. Five of the companies use plan driven development and planning processes and are final product manufacturers (FPM) that assemble and sell the end products to their customers. Two of the remaining three companies use agile processes, one of them is a contractor while the other one is a FPM company. The last company mainly uses a plan-driven process, however it differs from the five FPM companies as it is a contractor supplying software for embedded systems. We have not measured the degree to which the companies actually employ the reported development processes, but instead rely on the information provided by the respondents in this and our previous study.

The questionnaires were distributed and collected in three steps. First the questionnaire was handed out to 13 software practitioners during a seminar held for employees from two companies that participated in our earlier study [14]. Next, the questionnaire was sent to six managers at five other companies. All of them responded. In the final step the questionnaire was sent to a mailing list reaching practitioners with project manager related roles at a contractor company that develops software systems using agile development process. According to our contact at the company the mailing list we used is dynamic and changes to include new and exclude past project managers. It should consist of roughly 170 e-mail addresses at the moment the questionnaire was sent out. We received 29 responses, thus the response rate was 17%.

The questionnaire consisted of two parts. The first part was voluntary and consisted of personal information (company, position and e-mail address). All but two respondents provided information of their position and company, however, as these responses came from the seminar described in step 1, we could deduce their origin to one of two FPM companies using plan-driven processes, thus, the data was included in this study. The respondents from the agile contractor were project managers and the respondents from the rest of the companies were line managers, technical specialists and developers.

In the second part of the questionnaire the respondents were asked how often they had seen evidence of different types of behaviors ranging from 0 (don't know), 1 (never), 2 (seldom), 3 (sometimes), 4 (often) and 5 (always). The questions were in Swedish, in this paper they are translated to English and shortened in order to provide a better overlook.

B. Narratives

As the results of our previous study on intentional estimate distortions were based on data from large companies with traditional, plan-driven development processes in this study we wanted to investigate whether the agile processes help the companies avoid distortions of the intentional type (the information about the development process was provided by the interviewees). Also, we were interested in whether distortions differed depending on whether a company was a FPM company or a contractor. In order to understand the questionnaire data better we chose to interview managers from three different companies, one agile contractor, one FPM with agile development process and one FPM with plan-driven development process .

The interviews were divided in two parts, first the results of our previous study were discussed with the subjects and they were asked to tell us whether they recognized the described distortions in their companies. During second part of the interview the respondents were asked to describe the estimation practice in their company and any additional issues they face in their estimation work.

IV. Estimate distortions, questionnaire responses

Among the total of 48 responses, 17 were from FPM companies that use plan-driven processes, one from an agile FPM company, two from a contractor where plan-driven processes are used and 29 from an agile contractor company. The response rate from the agile contractor was 17% while the response rate for the rest of the companies was 100%.

We will present overall results in Table II, a comparison of plan-driven and agile companies in in Table III and a comparison between contractor and FPM companies in Table IV and describe the results further in the related subsections.

A. Overall responses

Eleven of the 17 investigated behaviors were by the respondents perceived to happen sometimes (median 3 or higher and average 2.5 or higher), two of which are perceived to happen often (median 4 or higher and average 3.5 or higher) (see Table II).

The two highest ranked distortions represent intentional acts. *Expecting the first estimates to correspond to the end results* (13) is to expect the impossible, as project requirements change during project execution. Use of *point estimates* (12) implies disregard for uncertainty imposed by unclear requirements. The issues ranked as third and fourth most important are both unintentional, *overlooking tasks and risks* (17) is not done intentionally and *inadequate communication* (16) is often caused by lack of time.

Another two behaviors were ranked as happening often or more (average of 3 or higher), namely *Increase of estimates in order to not overspend* (4) and *Ordering of too low estimates* (7) by the management, often driven by the wish to decrease project costs. The first behavior can be related to *Deviations between estimates and actuals are uncomfortable to discuss* (15), reported as happening "sometimes" in this study, as well as more personal reasons.

Six behaviors had average values of 2.5 or higher and median values of 3. *Awarding of accurate estimates* (14) is not a distortion but a precondition exploring the award systems (the standard deviation of this issue was the highest among the behaviors investigated in this study suggesting high disagreement among the respondents). *Increase and decrease of estimates prior to negotiations* (5) is intentional and happens when the involved parties have different objectives. *Organizational agendas affect the estimates* (10) describes adjustment of estimates to benefit own organizational unit. *Deviations between estimates and actuals are uncomfortable to discuss* (15) might lead to intentional increase of estimates in order to avoid such discussions. *Hiding smaller projects or functionality in estimates for larger projects* (2) leads to increased estimates for the official set of requirements. *Decrease of estimates to sell ideas* (8) for projects or functionality is also perceived to happen "sometimes".

To keep sustainable work pace (3), e.g. increasing the estimates to reduce overtime caused by later changes in requirements, was reported to happen "seldom", however it does happen as does *Increase of estimates to avoid functionality* (6) that developers or managers perceive as unnecessary or not urgent. *Personal agendas* (9) were also stated to "seldom" affect the estimates. *Job securing* (1), e.g. increase of estimates to keep own staff or increase amount of subordinates was reported as least common.

B. Plan-driven vs. agile companies

We received 18 responses from companies that use plan-driven processes and 30 responses from companies that use agile development processes. The results are presented in Table III.

How common are following behaviors	A	STD	M
13. First estimates are expected to correspond to the end result (actuals)	3.7	0.98	4
12. Point estimates are used instead of intervals	3.6	0.97	4
17. Overlooked tasks and risks	3.5	0.75	3
16. Inadequate communication	3.4	0.97	3
4. Increase of estimates to ensure not to overspend	3.2	0.83	3
7. Ordering of too low estimates	3.0	0.83	3
14. Accurate estimates are awarded	2.9	1.3	3
5. Increase/decrease prior to negotiations	2.8	0.97	3
10. Organizational agendas affect the estimates	2.8	1.0	3
15. Deviations between estimates and actuals are uncomfortable to discuss	2.8	1.0	3
2. Hiding smaller projects or functionality in estimates for larger projects	2.5	0.92	3
8. Decrease of estimates to sell ideas	2.5	0.86	3
11. Estimates are based on budget	2.5	0.89	2
3. To keep sustainable work pace	2.3	0.96	2
6. Increase of estimates to avoid functionality	2.0	0.77	2
9. Personal agendas affect the estimates	2.0	1.0	2
1. Job securing	1.7	0.96	1

TABLE II
QUESTIONNAIRE RESPONSES, OVERALL RESULTS RANKED BY AVERAGE PERCEIVED OCCURANCE (A = AVERAGE, STD = STANDARD DEVIATION, M = MEDIAN)

How common are following behaviors	AP	MP	AA	MA	D
13. First estimates are expected to correspond to the end results (actuals)	3.2	3	4.0	4	0.79
14. Accurate estimates are awarded	2.4	2	3.1	3.5	0.78
9. Personal agendas affect the estimates	1.5	1	2.3	2	0.77
10. Organizational agendas affect the estimates	2.5	3	3.0	3	0.54
5. Increase/decrease prior to negotiations	3.1	3	2.6	3	0.52
6. Increase of estimates to avoid functionality	1.8	2	2.1	2	0.36
1. Job securing	1.9	2	1.6	1	0.32
7. Ordering of too low estimates	3.2	3	2.9	3	0.32
8. Decrease of estimates to sell ideas	2.4	2	2.7	3	0.31
15. Deviations between estimates and actuals are uncomfortable to discuss	2.6	3	2.9	3	0.31
16. Inadequate communication	3.2	3	3.5	3.5	0.23
12. Point estimates are used instead of intervals	3.7	4	3.5	4	0.21
17. Overlooked tasks and risks	3.4	3	3.6	3.5	0.15
2. Hiding smaller projects or functionality in estimates for larger projects	2.6	3	2.5	2	0.04
3. To keep sustainable work pace	2.3	2	2.3	2	0.04
11. Estimates are based on budget	2.5	3	2.5	2	0.04
4. Increase of estimates to ensure not to overspend	3.2	3	3.2	3	0

TABLE III
QUESTIONNAIRE RESPONSES, PLAN-DRIVEN AND AGILE COMPANIES RANKED BY DIFFERENCE IN AVERAGE VALUES (AP = AVERAGE PLAN-DRIVEN, MP = MEDIAN PLAN-DRIVEN, AA = AVERAGE AGILE, MA = MEDIAN AGILE, D= DIFFERENCE BETWEEN AP AND AA)

How common are following behaviors	AF	MF	AC	MC	D
5. Increase/decrease prior to negotiations	3.2	3	2.5	2.5	0.70
9. Personal agendas affect the estimates	1.5	1	2.2	2	0.69
14. Accurate estimates are awarded	2.5	2	3.1	3	0.59
13. First estimates are expected to correspond to the end results (actuals)	3.3	3.5	3.9	4	0.55
7. Ordering of too low estimates	3.3	3	2.9	3	0.41
12. Point estimates are used instead of intervals	3.8	4	3.4	4	0.41
1. Job securing	1.9	2	1.6	1	0.39
2. Hiding smaller projects or functionality in estimates for larger projects	2.7	3	2.4	2	0.28
11. Estimates are based on budget	2.65	3	2.4	2	0.27
15. Deviations between estimates and actuals are uncomfortable to discuss	2.6	3	2.9	3	0.25
16. Inadequate communication	3.2	3	3.5	3.5	0.23
4. Increase of estimates to ensure not to overspend	3.3	3	3.1	3	0.19
17. Overlooked tasks and risks	3.4	3	3.6	3.5	0.15
8. Decrease of estimates to sell ideas	2.4	2.5	2.6	3	0.13
6. Increase of estimates to avoid functionality	2.0	2	2.1	2	0.06
10. Organizational agendas affect the estimates	2.8	3	2.8	3	0.04
3. To keep sustainable work pace	2.3	2	2.3	2	0.01

TABLE IV
QUESTIONNAIRE RESPONSES, FPM AND CONTRACTORS RANKED BY DIFFERENCE IN AVERAGE VALUES (AF = AVERAGE FPM, MF = MEDIAN FPM, AA = AVERAGE CONTRACTOR, MA = MEDIAN CONTRACTOR, D = DIFFERENCE BETWEEN AF AND AC)

The biggest difference between the companies using plan-driven processes and agile processes was recorded in question 13, *First estimates are expected to correspond to the end results*. This type of behavior was reported to happen "sometimes" in plan-driven companies while the respondents in the agile companies experienced this type of behavior "often".

The difference in results of the next issue, *Accurate estimates are awarded* (14) was also large. While practitioners in plan-driven companies perceive that they "seldom" are awarded for good estimates, the respondents from the agile companies perceive that the awards "sometimes" are given for the estimate accuracy. The highest standard deviations were recorded for this issue regardless of the company type (1.2 for both) which suggests high level of disagreement among the respondents. Another issue where difference in results was high was *Personal agendas affect the estimates* (9) even though neither plan-driven nor agile companies recognized the behavior as common ("never" in plan-driven, "seldom" in agile). Another two issues had difference in average values larger than 0.5. The first issue, *Organizational agendas affect the estimates* (10) was reported as less common in plan-driven companies, *Increase/decrease of estimates prior to negotiations* (5) was reported to be less common in agile companies.

The average values for the rest of the twelve investigated issues differ to some extent with regard to development process, five of them differ by 0.3 or more, and additional three by 0.15 or more. Average values for four issues differ to a very small extent (0.04 or less): *Hiding smaller projects or functionality in estimates for larger projects* (2), *To keep sustainable work pace* (3), *Estimates are based on budget* (11) and *Increase of estimates to ensure not to overspend* (4).

C. FPM companies vs. contractors

We received 17 responses from the FPM companies and 31 responses from contractors. The results are presented in Table IV and ranked by difference in average values.

The average values for four issues differ more than 0.5 depending on the company type: *Increase/decrease prior to the negotiations* (5) is perceived as less common in the contractor companies, however it happens "sometimes" in both. *Personal agendas affect the estimates* (9) and happen "seldom" in contractor companies and almost "never" in the FPM companies. *Accurate estimates are awarded* (14) "seldom" in FPM companies and "sometimes" in contractors, however standard deviations are high in both cases (1.2 for contractors and 1.3 for FPM companies) implying a high degree of disagreement among the respondents. Lastly, *The first estimates are expected to correspond to the end results* (13) "sometimes" in FPM companies and "often" in contractors.

Three of the remaining issues had differences of more than 0.3 in average values for different company types, seven issues differed in more than 0.13. Three of the issues differed barely at all (0.06 or less), namely *Increase of estimates to avoid functionality* (6), *Organizational agendas affect the estimates* (10) and *To keep sustainable work pace* (3).

V. ESTIMATE DISTORTION, NARRATIVES

We have in our previous studies focused on large traditional firms with plan driven development processes and estimation. However, it is interesting to explore whether agile development and planning processes help mend some of the problems we have previously reported [14] and also if those problems are affected by company type (FPM or contractor). In this section we will provide a description of three large companies - one contractor with agile development process, one final product manufacturer with agile development process and lastly one final product manufacturer with mainly plan-driven development processes. We will focus on descriptions of estimation practice and the respondents' views on estimate distortions.

A. Company A

The description of estimation practices at company A and estimate distortions they experience was provided by an upper line manager. Company A is a large FPM company internationally spread development sites and organized in a matrix where line and project organizations intersect. The product is a software business system bought and used by other companies. The development and planning processes used by the company are by the interviewee described as agile.

Among the unintentional distortions the cognitive biases, such as optimism, pessimism, etc. are according to the interviewee lessened by the company's agile estimation practice

that always involves discussions with several individuals. However, missed tasks and risks are still a problem.

Intentional estimate distortions are according to the line manager more difficult to manage. He explained: ”The overshadowing paradigm in our company is that overspending is not allowed. The punishment for overspending is very damaging for your career, underspending is easier tolerated. So overspending almost never happens.” The line manager said that project managers ensure that they estimates are ”correct” by padding what they believe to be most likely costs of the project, a behavior driven by the organizational culture where the higher management expects the first estimates to correspond to the final results and the deviance between the two is uncomfortable to discuss. The interviewee also stated that if the padding is too large the extra resources are spent on gold-plating of the product. Further, the line manager stated that estimate negotiations are common and that there sometimes is pressure from higher management to lower the estimates.

The interviewee also told us that project managers are unlikely to lend resources (in form of team members) to other projects that are late explaining: ”Success of a project manager is measured only using data from the projects he or she has managed and how well estimates respond to the actual results. No project manager is punished because other projects overspend.” So, in order to ensure that their projects will be finished in time the project managers tend to not lend staff to projects that are overrunning the schedule. One of the explanations the interviewee offered for this type of behavior was that even if the staff is lent out to another project for a month, they will often be kept longer, and when they do return they’ll need to be trained to rejoin the project, which also costs valuable time and might cost more money than first estimated.

The difference between the plan driven estimation and estimation in the new agile organization was also discussed by the line manager who said that the introduction of agile processes has helped decrease one of the estimate distortions reported by the practitioners in more traditional organizations [14]: budgets do not affect estimates as much.

B. Company B

The description of estimation processes and practices at company B were provided by an upper project manager. Company B is a contractor hired by other companies to develop software business systems. The projects are run and planned according to agile methodology, with 3 week long sprints. The company faces competition with other contractors and negotiations with the customer, which affects the estimate practice, both internally and externally. Internally, the focus of projects is often put on delivery, functioning product, and less on estimates according to the interviewee. Externally, as the customer wants to reduce the price estimate negotiations are to be expected. Usually the customers presents ”challenges” to Company B, i.e. ”Develop this product for less.”. Company B is aware of this, and thus increases the initial estimates. The project manager also explained this ”game” often leads to, underestimated projects, something that is frustrating for the customer. In the end of the project the customer asks: ”Why was the project so expensive?” getting back the answer: ”Otherwise it would not have been accepted.” As external pressure to lower costs is so high distortion of estimates due to job securing is lessened.

The development at Company B is spread out over several international development sites. The price per hour for developer differs for different sites, and the project manager believes that the competence in developing software does as well. According to the interviewee this affects the estimates, as development of functionality that is perceived as expensive is sometimes moved to less expensive sites not considering that the amount of hours needed to finish the project might increase as well, which can lead to less decrease in costs than planned.

Early estimates for projects are according to the interviewee produced using expert judgment. If the uncertainty in requirements is perceived as high the estimates are increased by the estimators. However, as requirement uncertainty decreases and requirements are better understood the estimates become more realistic. The costs for later changes are handled with change requests. The project manager stated that the realism of estimates is also affected by the trust between the project manager and the customer.

Larger projects’ estimates were by the project manager perceived as more ”sloppy” as larger margins are put on top of them due to the increased complexity of the product and communication difficulties. Also with many change requests in requirements the project managers know that the estimates will become outdated soon. Some managers doubt that estimates are even needed. Smaller projects’ estimates are on the other hand worked through in more detail. The resources are less and the project managers need to keep better track of costs.

The interviewee also believed that more experienced project managers accept too low estimates in order to sell projects, as they know they will be able to spread out additional costs on costs of other projects.

C. Company C

The description of estimation practice and related estimate distortions in company C was provided by a line manager. Company C is a final product manufacturer with several international development sites. The products are mechanical with embedded software. The overall development process is plan-driven.

The interviewee explained a part of intentional estimate increase as a by-product of matrix organization’s dynamics where project managers are instructed to only focus on their own projects. However, the interviewee also said that intentional increase of estimates often ends up being realistic, possibly because first estimates are optimistic to begin with. The interviewee does not regard asking for additional resources as uncomfortable, the problem is instead the risk of

not getting access to additional staff if the need of staff was underestimated to begin with.

Job securing (keeping more staff than needed) was by the interviewee not recognized as a problem, rather the line manager stated that staff is kept in order to not loose competent employees or in order to train new staff for the upcoming bigger projects.

When it comes to intentional decrease in estimates the interviewee said that although the estimates are lowered by removal of functionality, the cost decrease is expected to be higher than possible, thus projects often overrun their estimates. Lowering of estimates for the ideas (projects or functionality) that one wants to promote, is more common internally within the company, not as much externally when the product is sold to the customers. The interviewee perceived the internal selling of ideas as connected to positive thinking and quite natural explaining: ”If you have a good idea, you are passionate about it”.

The line manager also recognized personal and organizational agendas as reasons for distorted estimates, especially in contacts with other development sites, finding it curious how some managers never overrun their estimates.

Missed risks and tasks are often caused by inexperience, as is the low understanding of requirements according to the interviewee. Company C has in order to lessen the estimate inaccuracy decided to implement a tool to manage the knowledge gained in previous projects. The interviewee hoped this tool will help overcome some of the other problems mentioned in this narrative and also help the company produce better estimates faster, as time available to produce an estimate is an issue that affects the estimates' quality.

VI. Discussion

We have in an earlier paper [14] presented a model of estimate evolution where the starting point is an *ideal estimate*, a fictional estimate affected only by requirements uncertainty and inaccurate feedback. The next step, *raw estimate* is further affected by method, tool and cognitive biases, all of which are unintentional. *Distorted estimate* is an intentionally distorted raw estimate where increase and decrease of estimates are not the core goals of distortive behaviors, rather the distortions are used to achieve other goals, e.g to sell project ideas or promote own carrier. The results of this study confirm existence of intentional estimate distortions, 12 out of 17 distortions investigated in this study were reported to happen ”sometimes”, three of which happen ”often”. Two of the three highest ranked distortions were intentional: *First estimates are expected to correspond to the actuals* and disregard of requirement uncertainty by use of *Point estimates*. One distortion was unintentional, *Overlooked tasks and risks*.

We found high differences in average values (more than 0.5) between agile and plan-driven companies in five of the issues. *First estimates are expected to correspond to the actuals* happens ”sometimes” in plan-driven companies, while the respondents from agile companies seem to experience it ”often”. This difference is also brought up in the narratives where the interviewee at company A (agile) finds the organizational culture to be run by the ”no overspending paradigm” while the plan-driven company C is seems more forgiving. This paradigm might also be related to differences in *awarding of accurate estimates* (”often” in agile companies and ”seldom” in plan-driven ones). *Personal and organizational agendas'* are perceived as more common in agile companies (”seldom” and ”sometimes”) than in the plan-driven ones (”never” and ”seldom”), which differs from the narrative findings in that the issues only were brought up by the interviewee at the plan-driven company. *Increase/decrease of estimates prior to negotiations* is also lower in the agile companies according to the questionnaire responses. The interviewee from company A told us that transition to agile development process has improved one of the issues, *Estimates are based on budgets*. However, this could bot be confirmed by the questionnaire data where the difference between the average values for agile and plan-driven companies was very low (0.04).

The differences between FPM and contractor organizations were somewhat smaller, although still high (0.5 or more) for four of the distortions. Most distinct was the difference in *Increase/decrease of estimates prior to negotiations* where FPM companies experienced the distortion ”sometimes” while it at the contractor companies was experienced ”seldom”. The company B interviewee provided an explanation saying that internally no negotiations are needed as everybody works toward the same goal, instead the effort is put on the external customer negotiations. *Personal agendas* affect the estimates more often, but still only ”seldom” in contractor companies. *Accurate estimates are awarded* to a higher extent in contractor companies (”sometimes”), perhaps since overestimating might lead to loss of an important customer, while underestimating might lead to contract breach. The same mechanisms could also explain why *first estimates are expected to correspond to the actuals* more often in contractor companies (”often”) than in plan-driven ones (”sometimes”).

Similar for many of the reported distortions, regardless of grouping (all, company type or process), is that standard deviations are high, which suggests that opinions differ.

Based on our results and strategies of organizational politics presented in [22] we propose a list of organizational politics tactics where estimates are used and distorted (Table V). Five of the initial strategies proposed in [22] were excluded as they were not reported in this or our earlier study [14] and were judged to be non-related to the process of estimation as such. Two tactics were added based on the findings of this study: *managing functionality* and *disregarding uncertainty*.

Accumulation and control resources includes job securing and unwillingness to share resources, *Bargaining aggressively* includes ordering of too low estimates, *Forming coalitions and informal teams* includes personal and organizational agendas, *Maintaining flexibility* includes avoiding overspending and keeping sustainable work pace, *Anticipating and preparing for others' actions and reactions* includes preparations for negotiations, *Managing career* includes personal agendas, *Managing functionality* includes selling of ideas, avoiding functionality,

OP related tactics that affect the estimates
1. Accumulation and control of resources
2. Bargaining aggressively
3. Forming coalitions and informal teams
4. Maintaining flexibility
5. Anticipating and preparing for others' actions and reactions
6. Managing career
7. Managing functionality (added)
9. Disregarding uncertainty (added)

TABLE V
OP RELATED TACTICS THAT AFFECT THE ESTIMATES

hiding functionality in other projects and *Disregarding uncertainty* includes expectations that estimate will correspond to actuals, uncomfortable discussions about differences between the two, use of point estimates and budget determined estimates.

A. Validity discussion

The validity of this study is limited by the low amount of questionnaire responses and low response rate for the agile contractor company, thus the results should not be regarded as representative for larger population than the included eight companies. Further, the large overlap between agile and contractor companies likely affects the results and makes it more difficult to separate the findings. Also there might be differences in the typical project sizes used with agile methodologies; this is a factor we have not controlled for and that might explain some of the differences seen between development methods. For example, it could be the case that for smaller projects there is less room for intentional distortions since there is less variation and uncertainty factors to consider in the estimation process.

We have only used one interviewee per narrative which might lead to inaccurate picture of estimate practice in the companies. However, the interviewees are experienced managers with long work experience and should have enough knowledge to provide a correct description.

Future work should consider to use statistical tests to compare which differences between the sub-groups are statistically significant. The current comparison of means is only indicative, especially for sub-groups with few respondents.

VII. CONCLUSIONS AND FURTHER WORK

This study confirms existence of intentional estimate distortions, a subject not often regarded in estimation research. The results also suggest that prevalence of distortions varies depending on the organizational factors, such as company type (contractor or FPM) and development process (agile or plan-driven). These variations should be explored further by adding more responses symmetrically divided between the included companies. Also a future questionnaire should include information on age, experience and role as it might cause the high standard deviations in the results of this study.

REFERENCES

[1] A. L. Lederer and J. Prasad, "Causes of Inaccurate Software Development Cost Estimates," *Journal of Systems and Software*, vol. 31, no. 2, pp. 125 – 134, 1995.

[2] D. Phan, D. Vogel, and J. Nunamaker, "The Search for Perfect Project Management," *Computerworld*, vol. 22, no. 39, p. 95, 1988.

[3] M. van Genuchten, "Why is Software Late? An Empirical Study of Reasons for Delay in Software Development," *Software Engineering, IEEE Transactions on*, vol. 17, no. 6, pp. 582 –590, 1991.

[4] F. J. Heemstra, "Software Cost Estimation," *Information and Software Technology*, vol. 34, no. 10, pp. 627 – 639, 1992.

[5] A. L. Lederer and J. Prasad, "Informations Systems Software Cost Estimating: a Current Assessment," pp. 22–33, 1993.

[6] C. Sauer and C. Cuthbertson, "The State of IT Project Management in the UK 2002 - 2003," *Tempelton College, University of Oxford*, 2003.

[7] K. Moløekken-Østvold, M. Jøergensen, S. Tanilkan, H. Gallis, A. Lien, and S. Hove, "A Survey on Software Estimation in the Norwegian Industry," in *2004. Proceedings. 10th International Symposium on Software Metrics*, 2004, pp. 208 – 219.

[8] S. Grimstad and M. Jørgensen, "A Framework for the Analysis of Software Cost Estimation Accuracy," in *Proceedings of the 2006 ACM/IEEE International Symposium on Empirical Software Engineering*, ser. ISESE '06. New York, NY, USA: ACM, 2006, pp. 58–65.

[9] M. Jørgensen, K. Teigen, and M. Moløkken, "Better Sure Than Safe? Over-confidence in Judgement Based Software Development Effort Prediction Intervals," *Journal of Systems and Software*, vol. 1, no. 2, pp. 79–93, 2004.

[10] J. Aranda and S. Easterbrook, "Anchoring and Adjustment in Software Estimation," *SIGSOFT Software Engineering Notes*, vol. 30, pp. 346–355, 2005.

[11] S. Grimstad and M. Jørgensen, "The Impact of Irrelevant Information on Estimates of Software Development Effort," in *18th Australian Software Engineering Conference, ASWEC 2007*, 2007, pp. 359 –368.

[12] G. H. Subramanian and S. Breslawski, "An Empirical Analysis of Software Effort Estimate Alterations," *Journal of Systems and Software*, vol. 31, no. 2, pp. 135 – 141, 1995.

[13] A. Magazinovic and J. Pernstål, "Any Other Cost Estimation Inhibitors?" in *Proceedings of the Second ACM-IEEE international symposium on Empirical Software Engineering and Measurement*, ser. ESEM '08. New York, NY, USA: ACM, 2008, pp. 233–242.

[14] A. Magazinius, S. Börjesson, and R. Feldt, "Exploring Intentional Distortions in Software Cost Estimation," *In submission*, 2011.

[15] A. L. Lederer, R. Mirani, B. S. Neo, C. Pollard, J. Prasad, and K. Ramamurthy, "Information System Cost Estimating: a Management Perspective," *MIS Q.*, vol. 14, pp. 159–176, 1990.

[16] A. L. Lederer and J. Prasad, "The Validation of a Political Model of Information Systems Development Cost Estimating," in *Proceedings of the 1991 Conference on SIGCPR*, ser. SIGCPR '91. New York, NY, USA: ACM, 1991, pp. 164–173.

[17] Y. Vardi and E. Weitz, *Misbehavior in Organizations: Theory, Research, and Management (Applied Psychology Series)*, 1st ed. Psychology Press, 2003.

[18] B. Flyvebjerg, B. Holm, and S. Buhl, "Underestimating Costs in Public Works Projects - Error or Lie?" *Journal of American Planning Association*, vol. 68, no. 3, 2022.

[19] L. Merewitz, "Cost Overruns in Public Works," *In W. Niskanen, A.C. Hansen, R.H. Havermann, R. Turvey and R. Zeckhauser (Eds.), Benefit cost and policy analysis, Chicago: Aldine*, pp. 277–295, 1973.

[20] S. Bok, *Lying: Moral Choice in Public and Private Life*. New York: Vintage Books USA, 2001.

[21] A. Drory and T. Romm, "The Definition of Organizational Politics: A Review," *Human Relations*, vol. 43, no. 11, pp. 1133–1154, 1990.

[22] D. J. Vredenburgh and J. G. Maurer, "A Process Framework of Organizational Politics," *Human Relations*, vol. 37, no. 1, pp. 47–65, 1984.