Title page:

How to Avoid Selecting Providers with Bids Based on Over-Optimistic Cost Estimates

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***Abstract**: It is well known that software development companies tend to produce over-optimistic cost estimates and that this over-optimism may lead to delivery problems for the clients as well as the providers. In this paper we summarize evidence suggesting that the clients can reduce the likelihood of selecting providers with bids based on over-optimistic cost estimates through their control of the bidding processes. Important means for this purpose include: avoid inviting many bidders when price is an important criterion for selection; avoid using price as an important criterion for selection when the ability to assess provider competence is low; apply bidding processes that ensure that the provider understands the complexity of the project; avoid budget or price expectation related information in the bidding material and avoid a negotiation process in which you ask for bid updates on reduced functionality. The evidence presented in this paper can also be used by software providers to identify bidding rounds where it is likely that they win only when strongly over-optimistic about the cost.*

Keywords: Cost estimation, bidding processes, provider selection, software acquisition

1 Introduction

Surveys on reasons for software cost overruns typically emphasize reasons related to frequent requests for changes, poor requirement specification, overlooked tasks, underestimation of complexity of application, and lack of development skill or experience. As far as we are aware of, none of the surveys report cost overrun reasons related to the bidding process. Does this imply that the bidding process has no impact on the degree of cost overruns? Probably not! The lack of reporting of reasons for overruns that are related to the bidding process may rather reflect the shortcomings of the survey designs as documented in [1], e.g., that the surveys reflect mainly the providers' perspectives and the direct reasons for cost overruns. Studies on the connections between elements of the bidding process and cost overruns may, on the other hand, require the inclusion of the client perspective and more complex networks of direct and indirect reasons.

In this paper we document that there are important connections between cost overruns and properties of the bidding processes and provide recommendations on how the software development project client should design his bidding process to avoid the selection of bids based on over-optimistic

cost estimates. The recommendations, we argue, decrease the risk of initiating projects with unrealistic plans, time overrun, low software quality, high maintenance costs and less flexible providers. Although the paper aims at improvement of the clients' bidding processes, we believe it has important implications for software providers, too. Software providers may for example use the reported results to identify bidding rounds where they are likely to win only when providing a bid based on strongly over-optimistic cost estimates. Software providers should carefully consider whether it is worthwhile to participate in bidding rounds where this is the case.

2. Bidding Process Recommendations

An important goal of this paper is to base the bidding process recommendations on empirical evidence related to the connection between client-controlled bidding process elements and over-optimistic cost estimates. We conducted a systematic search for relevant bidding process studies both in software development, human judgment, auction theory, agency theory, and social science. While we were able to identify only four relevant, empirical bidding studies in software development contexts (all of them our own), there were many relevant studies from other disciplines. In addition, we identified a few studies on software cost estimation with strong implications for bidding contexts. While all recommendations are based on empirical evidence, this paper could only include brief description of and reference to a few of the supporting empirical studies. To better understand the evidence and its validity the original papers describing these studies should be read. The papers that include the original studies may also be useful as starting points to navigate in the quite comprehensive literature on bidding processes. As an illustration, as part of the preparation for the recommendation related to the "winner's curse" phenomenon of bidding processes (see Section 2.1) we identified more than 100 relevant papers from many different domains. Our study on the "winner's curse" [2] provides references to a few of the most relevant of those papers.

The identified papers covered many results that could potentially lead to software development bidding process recommendations. We decided to restrict the examined elements of the bidding process as follows: 1) number of bidders, 2) selection of bidders, 3) bidding material, and 4) negotiation with bidders. For each of these elements, we selected a few relationships to over-optimistic cost estimates. Our selection of these particular elements and relationships is based on a combination of the assessed potential for improving software project bidding processes, the lack of awareness of the relationship among software professionals and the existence of empirical evidence in software development contexts.

2.1 Number of Bidders

From our interviews and discussions with software provider bidding managers, we have observed that a common reaction to a situation with many bidders is to bid as usual or more aggressively. Bidding more aggressively is an understandable reaction, given that the likelihood of winning the bidding round may otherwise be too small for it to be worth the effort writing a proposal. Economic theory, on the other hand, typically advices less aggressive bidding as the number of

competitors increases, see for example [3]. The rationale behind this advice is that unless bidding more conservatively when the number of bidders increase, the bidder will be more likely to be subject to the "winner's curse", i.e., to win only when being over-optimistic about the value of the bidding object. We have observed a lack of discussion of this topic in common software engineering and project management textbooks, which suggests that there is little awareness of how the "winner's curse" affects cost overruns.

To understand the phenomenon of the "winner's curse", consider the following assumptions on relationships between software providers' cost estimates, their bids, and, how the clients select the provider:

- Software providers differ in their levels of optimism when estimating the development cost. Some providers may be strongly over-optimistic, some less optimistic, some realistic, and others even over-pessimistic. The variation of optimism level depends on, among other things, the cost uncertainty and the number of bidders. On average, providers seems to be quite over-optimistic regarding the cost of software development projects [4].
- Software providers with the most over-optimistic cost estimates are more likely to make the lowest bids.
- Software clients tend to choose among those with the lowest bids. For example, they will tend to choose the provider with the lowest bid when two providers have similar competence and proposed solution.

From these assumptions it follows that software project bidding rounds tend to be won by providers that are among the most optimistic, and that the bias towards selecting bids based on over-optimistic cost estimates increases with the number of bidders and higher cost uncertainty. This is exactly the situation described as the "winner's curse" in, for example, auction studies. Unless nearly all software providers bid less aggressively in situations with many bidders and high cost uncertainty, which we believe is typically not the case, the level of over-optimism of the selected provider with respect to cost estimation will consequently tend to increase as the number of bidders increases. Empirical evidence supporting this claim includes the following:

- In a simulation study we investigated the relationship between number of bidders, cost uncertainty and over-optimism regarding cost estimation. We demonstrated that when a client selects the bidder with the lowest bid and the expected profit level of each provider is 25%, even five competent bidders would lead to substantial negative profit due to over-optimistic cost estimates for the selected provider in several quite realistic scenarios, e.g., scenarios that reflect typical levels of cost uncertainty and the average bias towards over-optimism. The assumptions and simulation process are documented in [2].
- In a field study on software project bidding [5] we invited 35 software providers to make fixed-price bids for the same software project. We selected four of them to implement the software. One provider was selected with a strong price focus. Two providers were selected on the basis of price in combination with competence, which yielded a medium-strong focus on price. This process excluded most of the providers with the lowest price and all of the providers with the highest prices. The fourth company was selected mainly on the basis of

competence. The provider selected mainly on basis on competence had a price that was more than seven times higher than the provider selected on basis of price and more than twice as high as the average price of the two providers selected on the basis of price and competence. As expected, the high number of bidders led us to choose strongly over-optimistic providers when price was included as an important selection criterion. While the three providers selected with a strong or medium-strong focus on price had cost overruns in the range from 130% to 174%, the company selected mainly on the basis of on competence had a cost overrun of only 15%. The software delivered by the provider selected with a strong price focus had a lower quality than that of the other providers. The overall pattern was that the lower the bid, the more effort the client had to add to support and monitor the development processes.

In combination with numerous results from more mature bidding disciplines, e.g. auction studies, there seems to be much evidence to support the claim that a high number of bidders in combination with high cost uncertainty increases the risk of choosing a bid based on strongly over-optimistic cost estimates in software projects. An evaluation of proposals from just a few software providers, on the other hand, may lead to less competent providers to choose from, i.e., there are essential advantages with many bidders, as well. This suggests to the following recommendation:

Recommendation 1: Avoid inviting many providers to bid when you plan to use price as an important selection criterion. In particular, avoid a large number of bidders and avoid using price as an important selection criterion in the following circumstances: the requirement specification of quality attributes of the software is incomplete; your own competence in monitoring the development process and product is poor; and the uncertainty related to development cost is high. We illustrate in the simulation-based study [2] that the meaning of “many” is strongly context dependent. While for example five bidders may be “many” in a context with high cost uncertainty and strong provider tendency towards over-optimism, five bidders may be an acceptable number of bidders in other contexts. It may therefore be difficult to assess when there are too many and when the number of bidders is acceptable. In addition, a high number of providers to select from increase the probability to find a highly competent one and is, consequently, an advantage. To solve this dilemma, we recommend that the client pre-selects a few providers, e.g., 2-3 providers, from a large set of providers on the basis of competence alone and ask for bids only from them.

2.2 Selection of Bidders

If providers were realistic about the effect of lack of competence on the required work effort, the average work effort estimates of those with low competence would be higher than that of those with high competence. All other things equal, highly competent providers would then provide the lowest bids and one could use low bid as an indicator of high competence. In the real world, however, the opposite relation may be the case. Low bids and low cost estimates is frequently an indicator of low rather than high competence. This claim is supported by the results in [5], where we found that:

- Providers with documented relevant experience had, on average, bids that were as much as 60% higher than those without this experience, i.e., more experience correlated with substantial higher bids. Even when adjusting for differences in company size (because smaller and younger companies typically had both lower bids, less relevant experience and, probably, higher motivation to bid strategically) and other bid impacting factors, the difference was substantial. This suggests that the difference is bids were mainly related to differences in cost estimation over-optimism. McDonald [6] reports the same effect in pure cost estimating settings, i.e., his study support the interpretation that the decrease in bids is probably not solely a result of strategic bidding to gain relevant experience or reference clients.
- Providers who were involved early in the requirement specification development phase and so were more likely to have a better understanding of the product complexity made bids that were, on average, 70% higher than the bids of providers who became involved at a later stage. This finding corresponds with results from other disciplines, which show that the less one knows about a problem, the more likely one is to be over-optimistic about one's own abilities [7].

The finding that lower bids sometimes indicate lower competence would not be a problem if the clients were fully informed about the competence of the providers. Unfortunately, as far as we have experienced, this is not the case in most software project bidding contexts. Software clients may have limited and biased information about the competence of the provider, e.g., based on the provider's self-evaluated competence and self-selected reference clients. An unfortunate consequence of this problem of limited and biased information is that the most competent providers may be at a disadvantage on three counts: (i) it is likely that clients will underestimate their advantage with respect to competence (the less a client knows about a provider's actual competence, the more he tends to predict that all providers have approximately the same level of competence), (ii) their bids are likely to be higher because they understand the problem better, and, (iii) they are more likely to plan the delivery of high quality software with higher initial, but lower life-time costs. This tendency to select less competent providers or poorer products in situations when price is an important criterion for selection and the competence or quality is difficult to evaluate is well documented in other disciplines, e.g., in economics papers discussing the phenomenon of "adverse selection".

Note that we do not claim that a low price always, or even on average, indicates low competence. There will, for example, be many situations in which the cost reduction related to superior competence is greater than the increased over-optimism related to lower competence. It may also be the case that a client is lucky and experiences that the provider with the lowest bid indeed was the most competent. The risk of experiencing the opposite, however, may be substantial. The main problem is that clients who are poor at evaluating the provider's competence will typically not know when a low price is the result of high competence and when it is the result of low competence. These considerations yield the following recommendations.

Recommendation 2: Avoid using price as an important criterion for selection when your ability to assess provider competence is low. A focus on price in this type of situation may increase the risk of selecting a provider with low competence, a higher level of over-optimism regarding cost estimation, lower software quality and higher life-time software costs.

A low ability to assess provider competence means that a client will have a high risk of selection of a incompetent provider with bid based on over-optimistic plans even when selecting a provider with medium or high price, i.e., there is no good substitute for an ability and willingness to evaluate provider competence. This motivates Recommendation 3.

Recommendation 3: Increase your ability to assess, and your willingness to expend resources on assessing, the competence of the providers, e.g., by hiring external experts or improving your processes of evaluation. Competent clients not only make better selections of providers, but may also attract more competent providers that have more realistic cost estimates and that behave more in accordance with the long term goals of the clients.

Evaluating software providers is not a simple tasks and no bullet-proof method for this exists. Potential, non exclusive, methods that may improve the clients' evaluation processes include:

- Competence evaluation based on external organizations assessment of the providers' software development, management and quality assurance processes, such as ISO 9001 and CMMI. The strength of this type of evaluation is that the providers' self-assessment is replaced with a more objective external evaluation. A weakness may be that the evaluation is not tailored to a particular client's competence evaluation needs. Neither ISO 9001 nor CMMI do, for example, address how to evaluate a particular project leader's competence in leading projects of the particular type requested by the client.
- Competence evaluation based on principles from evidence-based software engineering (EBSE), i.e., evidence-based provider selection. The client should then start with an answerable question relevant for the particular situation at hand, e.g., "Which provider has the best success record regarding projects of the type and size we request?" Then a systematic information collection and evaluation should begin. This data collection should aim at collecting neutral and valid information to avoid over-optimism in the competence evaluation. Information from provider selected reference clients and the providers' self-assessed level of competence are examples of potentially biased and competence evaluation over-optimism inducing information. Examples of more valid and neutral information are information about client satisfaction and average cost estimation accuracy of previous project of similar types by the providers.
- Competence-evaluation based on performance on benchmark tasks. If it is crucial to avoid incompetent providers, it may be worthwhile to ask the 2-3 most promising providers to complete the same pilot project and use the information about their processes and solutions as evidence to support the final selection.

- Competence evaluation of individual developers. Clearly, it does not help that the provider is certified and can document previous successes with similar projects if the team supposed to complete the project consists of inexperienced project leader and software developers. What frequently matters more for the clients than the overall competence, or process maturity of the provider is, consequently, the competence of the project leader and developers who will work in their project. Unfortunately, the CVs of individual developers and project leaders typically contain only brief descriptions of experience and self-assessed competence. They do seldom contain objective, unbiased competence evaluation of the type that would have been most useful for the client. It may therefore be necessary for the client to collect such information from other sources. This can, for example, be done through interviews, contact with the clients of their previous projects, evaluation of previously developed code, and, benchmark tests of design and programming skills. Knowing that the key success factor in a project frequently is the competence of the individuals, we find it strange that that many clients do not spend more time ensuring that the project members of their project have the necessary competence. The importance of this is exemplified in [8], which report that 27% of the programmer did 78% of the work.

Recommendation 4: Compare the bids with your own independent cost estimate and/or the average of all bids. Providers with bids that are much lower than your own independent cost estimates or the average of all bids should be avoided, unless the proposal includes convincing arguments that explains the low bid, e.g., simplified design, pre-made components, or, empirical data that document an unusually high productivity. A client may for example hire an independent, highly skilled, external project leader with experience from similar projects. An external estimator has the benefit that it is easier to be realistic about other people's and provider's performance, than about one's own. Be aware of that an independent, over-optimistic cost estimate used as comparison may be worse than no independent cost estimate at all, i.e., it is essential that the estimator has the required experience and is not impacted to provide a low cost estimate.

Recommendation 5: Ensure that you allow the software providers to collect sufficient information regarding the project for an analysis to yield a proper understanding of its complexity, and aid the providers in their analysis. Less involvement in, and understanding of, the project may easily lead to over-optimistic cost estimates.

2.3 Bidding Material

In [9] we report how the realism of the cost estimates can be destroyed by inclusion of estimation irrelevant and/or misleading information. Examples of information that should be avoided are:

- Information about the client's budget. We found that this information is likely to act as an estimation anchor and, if the budget is unrealistically low, lead to over-optimistic cost estimates.
- Descriptions of development tasks using size- or complexity-loaded terminology. We found, for example, that the cost estimates of the same development tasks were much more optimistic when described as a "minor extension" or "extension" than when they were described as "development of new functionality". It is therefore important to apply as size and complexity neutral terminology as possible.
- Inclusion of information on attractive future opportunities, e.g., that the selected provider will be selected to maintain the software on a paid per work-hour basis or future projects. This information may easily to lead to wishful thinking, i.e., to difficulties in separating what one wishes would be the case from what more realistically will be the case.

Overall, available studies suggest that it is amazingly easy to mislead the estimation of software development effort, on purpose or by accident. An important reason for this seems to be that common estimation processes are based on unconscious, judgmental processes. The use of unconscious judgmental processes means that the estimation steps and use of information are neither fully controlled nor completely known by the estimator. It may, for example, be that a client's comment, "*I hope that the project will not cost more than my preliminary budget of $10 000*", unconsciously direct the estimator's to think of the project as "small". The estimator's mental model of the project as small may, in turn, lead him to interpret and collect information in support of his mental model of a small project. Most people are, as documented in several studies, much better at confirming than disconfirming models, i.e., to conduct "theory laden observations". Note that even formal estimation models require judgemental input to work properly and are, consequently, subject to similar type of problems due to misleading information.

In [9] we evaluated ways of avoiding the influence of misleading information, e.g., the use of cost estimation models and more experienced estimators. We found that the only really effective way of avoiding the influence of such information is to avoid being exposed to it. Our recommendation is based on that finding.

Recommendation 6: Avoid as much as possible the inclusion of information that has the potential to mislead the estimation of most likely effort. In particular, try to avoid that the providers know your budget or price expectations. Make it easy for the providers to apply the cost estimation process elements suggested in [9], e.g., by separating information that is important for the bidding but potentially misleading for the cost estimate from the material likely to be used by the cost estimators.

Notice that the situation may change after a provider is selected. It may, for example, be a good idea to inform the selected provider about future opportunities to motivate the provider to deliver a high quality product.

2.4 Negotiations with Bidders

In bidding with negotiation, the client receives bids and negotiates price and solution with a selected few of the bidders. We have experienced that several providers describe this negotiation as leading them to squeeze cost estimates and to become even more optimistic and also observed that clients sometimes uses the negotiation to try to get an even lower price or more functionality for the same price. This behaviour may be based on recommendations like the one we found in [10]: "*After proposals have been reviewed and a definite winner or two potential winners have been selected you may request a best and final offer (BAFO). Having a BAFO is an option used most often by government agencies. However, the idea is generally sound, because after proposals are reviewed and suppliers have answered questions, suppliers may realize that they have overestimated some requirements.*" We believe that this is not a good advice in most software development contexts and that the client should be aware of that bidding with negotiation situations are vulnerable to several well-known psychological effects that can lead easily to even more over-optimistic cost estimates. This has been documented in several studies on, for example, "wishful thinking" and the "endowment effect"[1] [11].

The following study illustrates how bid updates (which here is considered as a type of negotiation) may lead to more over-optimism. We invited 30 international outsourcing companies to bid for the same project and then asked for a bid updates [12]. A participating company either started with the provision of a bid based on the reduced version of the specification and then updated the bid based on the full specification, or started with the full specification and then updated the bid based on the reduced specification. Surprisingly, we found that those companies that started with the full specification made bids on the reduced specification that were, on average, 27% lower than the bids of the companies that started with the reduced specification. This means that negotiating with the bidders about the price for a reduced version may increase the cost over-optimism. A follow-up experiment showed the same result in a pure cost-estimation context [13].

Recommendation 7: Be aware of the pitfalls of bidding with negotiations and how it may lead to more over-optimism in the cost estimates. Try to avoid sending signals that can be interpreted to mean that you want the provider to reduce the cost without a corresponding reduction in functionality or quality, unless the price is obviously too high. Avoid a negotiation process where you ask for bid updates on a reduced set of features. Ask instead for project bids that contain a breakdown of prices for each set of requirement elements.

3 Final Remarks

Software providers have a strong tendency to provide over-optimistic cost estimates. No doubt, the software providers should be held responsible for this over-optimism and the problems connected with cost overruns. Many providers lack, for example, systematic processes for learning

[1] The endowment effect implies that a bidder will assess the value of winning a project to be higher when the psychological ownership to the project increases, e.g., as a result of being selected to participate in the final negotiation round.

from experience and proper estimation processes. In this article we have provided a survey of references to empirical evidence suggesting that the clients' bidding processes also contribute to cost estimation overrun. An example of a bidding process likely to lead to a low price, but also to the selection of a provider with a bid based on a strongly over-optimistic cost estimate is the following:

1. Invitation of many bidders.
2. Focus on price in the selection of providers.
3. Lack of resources on thorough provider competence evaluation.
4. No comparison of independent cost estimate from an expert with relevant experience and compare the received bids.
5. No support provided to the bidders in gaining a thorough understanding of the complexity of the project.
6. Information about price expectations, description of the project as "small", and emphasize on future opportunities of the selected provider.
7. Requests for bid updates based on a reduced set of features.

While inclusion of these elements in a bidding round is likely to result in a low price, it is far from obvious that the client will benefit from the low price. As documented in [14] and [15] a low price based on strongly over-optimistic cost estimates is likely to lead to client problems related to product delivery and quality. Given the high risk of not benefiting from a low price based on over-optimistic cost estimates, we advise software clients to follow the bidding recommendations provided in this article. This way they will increase the likelihood of selecting a provider with realistic cost estimates and, as a consequence, increase the likelihood of better managed projects and higher quality products. Software providers should, we believe, use the observations presented in this paper as means to identify bidding processes where they are likely to win only when providing bids based on over-optimistic cost estimates. If a bidding round is of that type, they should carefully consider whether participation in such bidding rounds is worthwhile or not.

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