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Cost estimation in major public projects' front-end phase – how to ensure realistic estimates under high uncertainty

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## **Cost estimation in major public projects' front-end phase – how to ensure realistic estimates under high uncertainty**

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## English summary

Norwegian agencies show good practice related to ensuring realistic budgets for major public projects prior to parliamentary decisions. This has previously been documented by the Concept Research Programme. It is also documented that the earliest cost estimates related to the conceptual choice are far less realistic, showing an average cost escalation of 40 per cent from QA1 towards QA2. Similar insufficiencies in early cost estimates for investment projects are also seen internationally.

Some studies are made on this topic at a national level. We also find international studies where the literature points at different explanations for the lack of realism in early cost estimates. There is considerable interest among the actors associated with the Norwegian State Project Model to obtain more knowledge regarding this topic. The actors and agencies request appropriate tools for providing the best possible estimate in the projects' front-end.

The current study aimed at answering questions regarding how to enable a sufficient basis for information for making realistic cost estimates in the front-end, and further which methodologies are suitable for this purpose, despite the front-end's characteristics showing a high level of uncertainty and lack of information. The study describes practices and challenges pertaining to early cost estimates in different Norwegian agencies. This will hopefully serve as a step towards more insight and knowledge regarding our abilities for making realistic cost estimates in the front-end phase of a project.

### **Cost estimation in the front-end phase**

Estimation is an important activity for planning and steering. It should not be treated as an equivalent of a plan or an objective. Rather it should serve as an opinion or reflection regarding the final cost of the project. Such statements are made based on the available information at that time. The front-end is characterised by a high level of uncertainty and lack of information representing a highly complex context. Thus, a fundamental part of the estimation is to acknowledge the inherent uncertainty and being able to handle it throughout the process. Even if the context is challenging it is possible to say something about the project cost at the front-end. That is if one is willing to accept inaccurate estimates or forecasts that may actually be wrong.

Cost estimation gives us the answer to what the project specifications currently on the table will cost to acquire, while the forecast tells us what the final cost of the project will be. The forecast is tightly linked to the uncertainty analyses which is an essential activity. The estimates and forecasts represent snapshots. They will gain more precision as the information become more precise. Major public projects have a multitude of stakeholders. These stakeholders have limited knowledge of the challenges that come with cost estimation in a highly uncertain context. This often leads to the fact that numbers or values expressed early on will be associated with the project for all time. By describing the perspectives of both the estimator and the owner this study aims at clarifying some of these challenges.

The estimation is based on prerequisites set by both the agencies and the project itself. The most important thing to do at the outset is to describe the purpose of the estimate and how it should be used. Initial prerequisites are present throughout the estimation process together with the assessments and assumptions made by the estimator. Thus, it is important to get a good start. The estimation process is a maturation process carrying different degrees of uncertainty. This requires consciousness regarding prerequisites and conditions. These need to be looked upon critically. This may lead to adjustments, need for new information and calculations making the way of working iterative and time consuming. The estimation process can mainly be divided into four steps:

1. Make a methodological choice based on accessible information and initial conditions.
2. Make a cost model.
3. Feed the model with numbers based on accessible data.
4. Assess the model output by analysing it with respect to the situation as a whole.

Throughout the estimation process, and especially after the result is available, it is important to make sure that the chosen method is used correctly: the order of magnitude of the input and output must be reasonable, the result should be realistic regarding the overall uncertainty and currently fit its purpose. Furthermore, the result should be documented and communicated to the persons in need of this information.

Cost estimation in the front-end phase should be conceptual, typically expert judgements, analogical or parametric approaches. The purpose of the front-end is to make a choice of concept. One of the assessment criteria separating different alternatives are the investment costs. To enable an efficient process, the estimates should be fast to produce. The different alternatives should be handled equally in

order to make informed choices. The conceptual choice made in the front-end phase is very important for the project's strategic or long-term success.

Regardless the choice of model, the fundamental challenge for estimation or forecast methods is to establish a relation between the maturity level of the estimation basis and the produced output. In the front-end phase the estimation basis is immature and uncertain. It will change during the process. Moreover, those responsible for planning or decision-making are susceptible to behavioural biases. This will always be a fundamental challenge in the front-end context.

### **Methodological approach for this study**

The explorative nature of the research questions in this study called for a qualitative study design. The study's fundament is a systematic literature review serving as a frame of reference for this work and defined a point of departure for the interview guide. The interview guide was divided into five main topics, where we asked:

- I. *How are cost estimates made in projects' front-end phase?*
- II. *How do boundary conditions affect the estimation?*
- III. *How does the process of cost estimation affect the estimate?*
- IV. *How is the relationship between cost estimation and succeeding cost steering?*
- V. *How, according to the informants, realistic are the cost estimates?*

The main source of empirical data is semi-structured interviews with 31 informants, mainly carried out in groups. The informants represent the different public agencies included in the Norwegian State Project Model. There were also representatives from the seven consortia of external advisors performing quality assurance. We also held a seminar where we presented preliminary findings from the interviews, where all agencies and external advisors' consortia were invited. The seminar comprised 53 participants. They were all skilled and experienced in cost estimation. The purpose of the seminar was to elaborate on the preliminary findings and to enable joint discussions of current issues regarding the topic of cost estimation. The seminar participants had break-out meetings. Here, they discussed the most challenging issues pertaining to cost estimation, potential differences among the public agencies. They were also asked to come up with examples of good practices and experiences. The results from this work were presented and discussed in a plenary session. The overall results from the seminar are incorporated in this report.

Additionally, we have investigated practices and guidelines for cost estimation in different Norwegian public sectors (roads and rails, defence and construction).

### **Literature review**

In general, the magnitude of scientific literature on cost estimation in the front-end phase of (public) projects is less compared to literature pertaining to later project phases. There are several international studies on cost overruns in public projects. These are elucidating challenges and potential ways for improvement. However, for most of these studies the empirical data come from budgets set closer to the project execution phase, rather than from the front-end phase. In general, both older and more recent international literature shows that major cost overruns are the rule rather than the exception for different types of projects and in different public sectors, as opposed to results from Norwegian studies on the State Project Model. One of the studies reviewed stated that the cost overruns have decreased over the years, contrasting former findings.

There are several complex reasons for cost overruns. Some authors divide the reasons into four categories: technical (e.g., insufficient data, honest errors), economic (deliberate underestimation based on perverse incentives, or originating from strategic behaviour), psychological (overoptimism) and political (deliberate underestimation of costs, to secure the start of a project).

Two main explanations for unrealistic early cost estimates have developed over the years. One explanation is based on behavioural biases and hold strategic misrepresentation and optimism bias as the most probable causes. The other explanation is based on inaccurate prerequisites following the front-end uncertainty and project immaturity which impose changes upon the cost estimation process. We argue that both explanations are needed to account for the unrealistic early cost estimates. This is due to multiple challenges faced in this process such as lack of information, project immaturity and lack of continuity combined with different understandings and expectations.

The literature review was conducted by searching three databases. Main contributions came from construction or infrastructure projects. We did not find any literature reviews explicitly covering practices of front-end estimation. The scientific papers included in our study share references to some form of methodological contributions for front-end estimation and report the use of empirical data in some form to test and evaluate different methods and actions for improved accuracy of the early cost estimate. Studies covering cost overruns and practices for cost control in later project phases are more abundant than contributions covering the front-end phase. Thus, there is lack of knowledge regarding cost estimation in the front-end phase.

### **Interviews, seminar, and main findings**

Our informants were skilled and experienced in cost estimating both as project participants and as external quality assurers. The informants were unison in describing cost estimation in the front-end as demanding. In the following, we present highlights from the study findings:

Increasing complexity: Generally, findings show that the projects are becoming more complex and comprehensive. The complexity can be attributed both to an increasing project scope and to technological development, both affecting the cost estimation. The need for interdisciplinary teams including subject matter experts is more pronounced and cost estimation methods are more sophisticated. Finding the right level of competence is a challenge.

Larger and more differentiated groups carrying out the estimation require good coordination and communication between the parties. Challenges also exist due to different use of terminology and a risk of being too engaged and being too focused on details regarding one's own field of expertise. Thus, it becomes important to ensure a mutual understanding of the project by providing a common terminology and knowledge-based guidelines. Furthermore, the importance of establishing the project's distinctive characteristics was highlighted. This was to provide a sufficient understanding of what needs to be done, and the needs pertaining to the cost estimation process in order to produce the best possible estimate.

Too optimistic regarding project maturity: The projects' level of maturity is mentioned by the informants, claiming that the level of optimism regarding project maturity often seems too high. This may lead to misjudgements of the estimate's uncertainty. Only one of the public agencies has tested tools for assessing project maturity.

Need for documentation: The importance of documentation throughout the entire process of cost estimation is emphasised. Lack of documentation makes it more difficult to check and understand the initial prerequisites and assumptions. Documentation practices vary among the public agencies, but our informants point to a considerable potential for improvement.

Clear prerequisites are important for a good point of departure: The prerequisites should be as clear as possible to enable a sound starting point for the cost estimation. The contextual uncertainty that characterises the front-end phase makes the situation unclear. Although this is regarded as natural by the informants, they stress the importance of acknowledging the front-end's inherent uncertainty and having a plan for how to handle it. An explicit understanding of the need

triggering the project and clear descriptions of the project scope are necessary for being confident regarding what to do. Poor descriptions regarding scope and needs may lead to subsequent substantial costly changes.

The opportunity to make a genuine conceptual choice: The purpose of the front-end phase is to make a conceptual choice. Several informants indicated that there is no opportunity to make a genuine conceptual choice due to what seems like predetermined choices of an actual solution. It was pointed out by the informants that the concepts are too similar and that the front-end phase becomes more of a budgetary cost estimate, rather than an effort to lay the grounds for making a conceptual choice.

The consistency is challenged: The State Project model is sequential and requires consistency between the different phases. Since the projects are time-consuming and increasingly complex, the needed consistency is challenged. Our findings indicate lack of consistency both regarding personnel, expertise, documentation, and communication. All these factors are needed for making the cost estimation process as good as possible, and at the same time being able to handle the inherent uncertainty by providing enough time to perform iterations, to increase the cost estimate's precision. Even if the informants advise the use of top-down approaches for early estimates and to avoid early detailing levels, this happens. The reasons for this unfortunate practice are ambiguous. However, the informants point at a tendency to navigate the inherent uncertainty by using what is at hand and to quantify the quantifiable. Another reason may be the decision-makers need or wish for relating to one fixed or precise number.

Varying uncertainty analyses: All public agencies carried out uncertainty analyses. However, the practices and experiences vary. Common to all informants was that this is one of the most difficult things to do during the cost estimation process. Some agencies possess the competence and resources to perform the analyses, while others need external expertise. The informants also indicated that the uncertainty analyses should be adapted to the project phases. The aim would be to enable a growing level of details following the growing project maturity. Further, the informants point at challenges in communicating the uncertainty, especially when linked to the range of uncertainty and how this could be used to outline a potential outcome.

The use, systematics and sharing of historical input data: There is a considerable potential for improvement regarding the use, systematics and sharing of historical data. The informants described that historical data are largely linked to local and informal systems and to individual competence and experience. There is little

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sharing and exchange of information between the public agencies or between the agencies and the external quality assurers.

Thus, the findings highlight several challenges that keep us from making realistic front-end estimates. The informants further exemplified good practices and measures for accommodating these challenges, e.g., enabling the project to mature gradually and to provide sufficient time to make iterations of the estimate, avoiding a high level of details in early project phases, clarity and documentation regarding prerequisites and communication among the different project levels regarding prerequisites and uncertainty, developing a culture for using and sharing historical input data and having a robust system for project governance.

### **Recommendations and conclusion**

Despite a multitude of challenges regarding front-end estimation, most informants agree that early cost estimates have improved and become more realistic. Over the years, the estimators have gained more experience and knowledge regarding different pitfalls in early estimation, and early cost estimation has become more professionalised.

The last chapter of this report presents recommendations for making good cost estimates in the front-end related to the prerequisites, the cost estimation process, and the deliveries.

Finally, we present the conclusion by answering the research questions regarding how correct and sufficient information for cost estimation in the front end be ensured, and which methods and practices that have a potential to provide realistic estimates in this phase of a project. To ensure a sufficient basis of information, the agencies should make sure that historical input data are accessible, which has a considerable potential for improvement. Additionally, it essential to avoid predetermined solutions to the problem at hand. The project should be given sufficient time to mature before the conceptual choice (including costs and uncertainty) is made. Further, the front-end requires simple and fast methodological approaches. Some approaches are well-defined, but we also need new methods, and the ability to assess the estimate's reasonableness

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Forskningsprogrammet Concept skal utvikle kunnskap som sikrer bedre ressursutnyttning og effekt av store, statlige investeringer. Programmet driver følgeforskning knyttet til de største statlige investeringsprosjektene over en rekke år. En skal trekke erfaringer fra disse som kan bedre utformingen og kvalitetssikringen av nye investeringsprosjekter før de settes i gang.

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*The Concept research program aims to develop know-how to help make more efficient use of resources and improve the effect of major public investments. The Program is designed to follow up on the largest public projects over a period of several years, and help improve design and quality assurance of future public projects before they are formally approved.*

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