Explaining cost overruns in infrastructural projects: A new framework with applications to Sweden

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Abstract

The first part of the article presents a new framework for analyzing cost overruns. It has a descriptive part in two dimensions: when during the process that the cost overrun arose and what part of the cost function was responsible (change in the product, change in quantities of the inputs and change in price of inputs. The explanatory part is a development of Flyvbjerg´s theories and identifies four possible explanations: political/strategic aspects, psychological aspects, competence related and bad luck. It is argued that Flyvbjerg´s technological explanation belongs to the descriptive part.

The empirical part of the paper uses this framework to analyze cost overruns in infrastructure projects in Sweden, primarily based on a questionnaire to experienced project managers. The results is that most of the cost overruns occur in the planning stages up to the final design and are related to design changes and to increases in the amount of inputs needed because of technical and administrative problems. Of the explanatory factors there is most support for lack of competence and optimism bias.

Keywords: cost overrun, theoretical framework, infrastructure, Sweden

1. Introduction

Cost overruns have been observed in a large share of infrastructural projects. Flyvbjerg, Skamris Holm, & Buhl (2003) presents results from a database with over 250 large infrastructural projects from a number of countries and from different time periods. The result can be summarized in the following points:

- 86% of the projects had cost overruns compared to forecasted costs. The average overrun was 28%.
- The overruns were highest in rail projects with cost overruns of 45%. For roads it was 20%.
- Cost overruns were somewhat lower in Europe compared to North America and "Other geographical areas".
- There was no historical trend. Cost overruns have the same magnitude today as they had 30 years ago. This point can be further substantiated by a recent Swedish dissertation that showed large cost-overruns in almost all major infrastructural projects in Sweden during the last decade (Lundman 2011).

There are a number of factors behind cost-overruns and e.g. Memon et al (2011) lists 78 explanatory factors. In order to understand why cost-overruns occur we believe that such long lists are not very helpful and that it is important to find a way to structure the possible explanations that relates to basic micro-economic theories about what determines cost. Starting from a rather simple theoretical framework, more detailed explanations can then be found and related to other factors. This article has two aims:

- The first aim is to present such a framework based on micro-economic theory.
- The second aim is to use the framework for investigating the causes of cost overruns in recent Swedish infrastructural projects.

The natural starting point when discussing explanations of cost overruns is of course the work of Bent Flyvbjerg. He discusses causes of cost overruns in a number of articles: Flyvbjerg, Skamris Holm, & Buhl (2003), Flyvbjerg, B, (2005) Flyvbjerg B, (2007), Flyvbjerg (2008), Flyvbjerg, Garbuio, & Lovallo, (2009) and Cantarelli, Flyvbjerg, Molin, & van Wee (2010). In several of these papers broader explanatory factors are presented, e.g. technical, psychological and political explanation. In this paper Flyvbjerg´s framework will be developed in several dimensions: first by differentiating between at what *stage* in the construction process that the overrun occurs, then by differentiating between explanations related to different parts of a microeconomic cost function.

In a recent paper about cost-overruns in the Netherlands (Cantarelli et al 2012, p 55) it is also underlined that it is important to study individual countries as the mechanism behind cost-overruns may depend on the institutional structure of the country. The second aim of this article is to add one more national study in order to make in-depth international comparisons possible,

The structure of the article is as follows. In section 2 the method in the article is presented. In section 3 Flyvbjerg´s explanatory frameworks are described. Section 4 presents the alternative framework and also arguments why it is an improvement in relation to Flyvbjerg. In section 5 the framework is used for structuring studies of cost-overruns in Sweden. In section 6 the results are related to a number of recent studies on cost overruns. As there is a continuous flow of new articles on cost-overuns it was decided to initially base the analysis on a number of Flyvbjerg´s works and literature that was available when our work was started in 2010. Later literature is therefore commented upon separately in section 6 after the presentation of our results. Conclusions can be found in section 7.

2. Method

The first part of the paper is conceptual and based on a literature review with a focus on the works of Bent Flyvbjerg. The choice of Flyvbjerg should be uncontroversial given his large number of publications in the area of cost-overruns and how often he is referred to. The aim is to get an overview of the explanations presented in his different papers.

Then a new framework is proposed and our starting point is microeconomic theory eory) and the concept of cost function. Investigating cost overruns starting with this established theory seems logical. With this as a starting point “deeper” explanations can be discussed and this is where several of Flyvbjerg´s explanatory factors fit in. Arguing that one conceptual framework is better than another is not easy, and it is similar to problems when comparing paradigms see e.g. Kuhn (1962), and it is of course up to the reader to evaluate whether the framework presented makes things clearer and the analysis of cost-overruns simpler.

The second empirical part of the paper is based on two questionnaires that was carried out late 2012 early 2013. The questionnaire was sent to two groups: project managers working for the Swedish Traffic Administration (Trafikverket) and to senior staff in contractor and consulting companies. The questions were directly based on the framework presented in section 4 below, and were a way of both showing how the framework can be used and to find out expert opinions about the main explanations for cost overruns in Swedish projects. More details about the questionnaire is presented in section 5.2.

3. Flyvbjerg´s explanatory frameworks

Flyvbjerg divides the possible explanations of cost overruns in somewhat different ways in different articles. In Flyvbjerg (2008) three main groups of explanations are presented:

- *Technical explanations*: This explains cost overruns in terms of inaccurate and unreliable data. Technical complications of some kind arose in the project and led to increased costs.

- *Psychological explanations*: The core here is theories from behavioral studies, primarily optimism bias. Actors who are working with a specific project tend to be over-optimistic about the implementation of the project - "to judge future events in a more positive light than is warranted by actual experience" (p 6).

- *Political-economic explanations:* The cost overruns are here explained by strategic misrepresentation: "Here, when forecasting the outcomes of projects, forecasters and planners deliberately and strategically overestimate benefits and underestimate costs in order to increase the likelihood that it is their projects… that gain approval and funding." (p 6)

In other articles Flyvbjerg divided the explanations into "delusion" and "deception". Delusion is described in the following way:

> "Our first explanation—delusion—accounts for the cost underestimation and benefit overestimation that occurs when people generate predictions using the inside view. Executives adopt an inside view of the problem by focusing tightly on the case at hand, by considering the plan and the obstacles to its completion, by constructing scenarios of future progress, and by extrapolating current trends. In other words, by using typical bottom-up decision-making techniques, they think about a problem by bringing to bear all they know about it, with special attention to its unique details. There are two cognitive delusions the inside view facilitates: the planning fallacy and a heuristic rule-of-thumb called anchoring and adjustment." (Flyvbjerg et al 2009, p 173)

Deception is described in the following way:

> "Our second explanatory model—deception—accounts for flawed planning in decision making in terms of politics and agency issues. The political and organizational pressures in executive decision making involve: *the principal-agentproblem* and *the sources of strategic deception.*" (Flyvbjerg et al 2009, p 173)

In Cantarelli, Flyvbjerg, Molin, & van Wee (2010) the explanations are divided into four groups and the division seems to be based primarily on what types of theories that the explanations are based on or related to. It is argued that the "plausibility of an explanation is partly based on its theoretical embeddedness. When there are models, assumptions, premises or concepts behind the explanation, the likelihood of understanding the phenomenon of cost overruns increases."

The first group is *technical explanations* and this include

- Forecasting errors including price rises, poor project design, and incompleteness of estimations
- Scope changes
- Uncertainty
- Inappropriate organizational structure
- Inadequate decision-making process
- Inadequate planning process

Fundamental theories behind this type of explanations are Forecasting theory and Planning theory.

The second group of explanations is called *economical* which is exemplified with deliberate underestimation due to:

- lack of incentives,
- lack of resources,
- inefficient use of resources
- dedicated funding process
- poor financing / contract management
- strategic behaviour

The background theories mentioned here are Neoclassical economics and Rational choice theory.

The third type is *psychological explanations* and are exemplified by:

- Optimism bias among local officials
- Cognitive bias of people
- Cautious attitudes towards risk

Prospect theory and Rational choice theory are mentioned as the appropriate theories in this area.

The fourth and final type of explanation is *political* and includes:

- Deliberate cost underestimation
- Manipulation of forecasts
- Private information

Here Machiavellianism and Agency theory is mentioned.

After presenting our proposed new basic framework in the first part of the next section we will return to Flyvbjerg´s explanations.

4. An alternative framework for understanding cost overruns

A development of Flyvbjerg´s explanatory framework will be presented below. In summary our model divides the explanation into *a descriptive part* concerning when and where the cost overrun occurs and *an explanatory part*, focusing on why there are cost overruns (in this specific stage/part). The descriptive part can be seen as a search for correlations between e.g. a certain stage in the planning and construction process and cost overruns while the explanatory part concerns causality between certain factors and cost overruns. The motive for this separation between a descriptive and an explanatory part is the advantage of being able to know in which part of a process that the cost overrun occurs before one tries to find the causes of the cost overrun. The motive is to simplify the search for explanations of cost overruns. We will outline the two parts below in section 4.1 and 4.2.

4.1 Descriptive framework

Infrastructural projects are complex and take many years to complete and therefore it seems to be important to describe when the cost-overrun occur more in detail before one tries to explain them by e.g. the kind of factors that Flyvbjerg discusses. The descriptive framework consists of two parts: The first is *when* in the process the cost-overrun occurs, and the second is *which part of the cost-function* cost overruns occurs, see Lundman (2011) for a similar approach even if there are no explicit references to production theory in his work.

Descriptive framework 1. When in the process?

The first part of the descriptive framework concerns *when during the process that costs increases occurs*. Even if the exact process differs from country to country it is possible to identify a number of stages in the process where costs are estimated or measured, see figure 1.

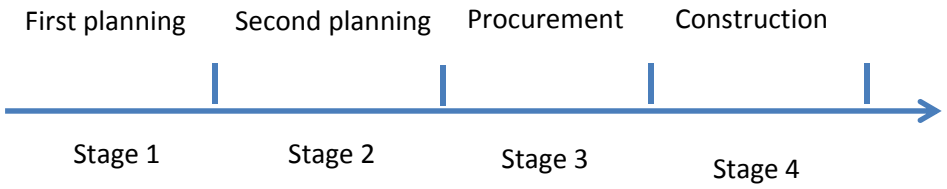

Figure 1 The different stages in a project

Stage 1. The cost estimate when the project was initiated is the first base for measuring cost-overruns. This is the result of *the first planning stage*. Lundman (2011) uses the term idea-study and pre-study when this part of the Swedish process is described. When cost overruns are measured it is in relation to the cost estimate at the end of this first planning stage.

Stage 2. When the planning process continues the more detailed design or detailed specifications are determined in order to procure the project. This is here called *planning stage 2* and it is assumed that new cost estimations are made before it is decided to continue and procure the project. The first cost-increases can occur between the end of the first planning stage and the end of the second planning stage.

Stage 3. Procurement of the construction works. Cost increases in this stage means that the bids from contractors are higher than the estimated cost at the end of planning stage 2.

Stage 4. Construction then starts and the final cost is the actual cost when construction works are ready. It should be underlined that in this article cost overruns are primarily seen from a client perspective. With a fixed price contract there might be cost-overruns from a contractor perspective during stage 4, which simply means that the actual profit for the contractor is lower than the expected profit. [1]

[1] A recent Swedish example is the new arena in Stockholm (Tele2 Arena) where the contractor made large losses because a number of cost increases partly related to the bankruptcy of a subcontractor. The cost overruns were however limited from the perspective of the client.

Descriptive framework 2. Which part in the cost function?

The second part of the descriptive framework concerns different components in a standard cost function in micro-economic theory. There the cost is determined by three factors: The good produced, the amount of the factors of production needed and finally the price of each of the inputs. This means that cost overruns can be related to one or more of these factors. When discussing cost functions it is typically assumed that the firms are efficient and do not use more factors of production that technologically necessary, but in reality waste might occur and explain cost overruns. This is the fourth factor below.

1. *Design ("the good produced)*: Cost overruns can occur because there is a change in the produced good. In Flyvbjerg´s categorization described above "scope changes" is mentioned and this means that that the characteristics and qualities of the project change between different stages in the planning and construction process. The project has changed content and the new design has led to increased costs.

2. *Input quantities*: This can be described as a *change in the production function* – the planned quantities of the inputs is simply not enough to accomplish the planned project. During the development of the project it is found that higher quantities of the factors of production are needed to produce a given project. Geotechnical conditions were e.g. worse than believed which created need for more man-hours and more material than expected in order to produce the given object.

3. *Prices (real)* A change in *the price of the factors of production, including materials*. Cost overruns can be caused by things that become more expensive than estimated. Here there are some interesting complications concerning how to take inflation into account. When cost-overruns are seen as a problem it is natural to assume that the "real cost" has increased and not only the nominal price. This comes back to the question of how the estimated costs are

presented. Are they explicitly presented as the cost in current prices at the time of the calculation, or at the time when the projects is expected to be carried out? If a bridge to be built in five years' time is said to cost 500 million SEK - without any specific statement of the value of money - our interpretation is that it then is expected to cost 500 million adjusted for the predicted general inflation. Any increase above that would be cost overrun, e.g. because prices increased more than the expected inflation.

Riksrevisionen (The Swedish National Audit Office) (2010, 2011a) discuss the possibility that the responsible authorities have hidden some cost overruns by presenting figures that have been deflated with a special road or rail construction index that has increased much more than inflation. They criticize the responsible authorities for underestimated the "true" cost overrun by this deflation procedure. The lesson learned from this is that it is important to be very clear about what kind of prices that the cost estimation and the final cost are based on.

4. *Waste*: This means that production is not efficient and that larger amounts of the factors of production than necessary is used. In Flyvbjerg´s framework above "inefficient use of resources" is mentioned, and this can be interpreted as that more resources are used than is necessary according to the production function. Leibenstein´s famous concept of X-inefficiency is a term for such inefficiencies (see e.g. Leibenstein 1966). As it in practice is difficult to know how large these inefficiencies are cost overruns related to waste will in the rest of the paper be included in category 2 above: Cost increased related to higher input quantities than expected.

Descriptive framework: Overview

Let's now add the two descriptive dimensions together, see table 1. It can be seen that there are nine different combinations concerning when and where cost overruns might occur. A first step in analyzing cost overruns would according to this framework be to find out how the

design, the estimated quantities of the factors of production and the estimated price of these factors have changed during the planning and construction process.

Table 1. Cost overruns related to stages and proximate causes

When and where does cost overruns occur?		**When in process**		
		2. Planning stage (compared to idea stage 1)	*3. Cost according to procurement contract (compared to 2)*	*4. Final cost (compared to 3)*
Which part of production function	*Design*	??	??	??
	Input Quantity	??	??	??
	Prices of inputs	??	??	??

When the descriptive phase of cost overruns is ready the next question becomes; why has design, quantity of inputs or input prices changed from stage one to stage two etc. This will be dealt with in the next section.

4.2 Explanatory framework

Now when the descriptive part is ready, a explanatory analysis of cost overruns can be started. And the question is how possible explanations should be structured. Here a number of Flyvbjerg´s different hypotheses become relevant, but it should be noted that Flyvbjerg mixes what here is called the descriptive and explanatory factors. The descriptive framework above, e.g. covers scope changes (“change in the quantity produced”) and technical complications (“quantity of factors of production has increased”). The possible explanations will here be

directly related to the different descriptive types outlined above: Why has design changed? Why has estimated input quantities changed and why have estimated prices been changed?

1. Why has design changed between different stages?

There might be several explanations why the design (the project) has changed. Here it is possible to formulate a number of hypotheses that relate to some of the explanations that Flyvbjerg presents.

1. Design changes during the planning stages: The original project was not "realistic" and it was obvious for a well-informed person that higher quality/standard was necessary and that the simpler project was presented for tactical reasons in accordance with Flyvbjergs “Political-economic explanation” or “deception”.
2. Design changes during procurement phase: The construction companies that should carry out the project pointed out problems with the planned design, and therefore changes were made. This can fit into Flyvbjerg´s “Delusion” category (e.g. optimism bias) and can also be seen as the result of a lack of competence in the client organization.
3. Design changes during the construction phase: New regulations might be decided when the project is just started and the design has to be changed. This is a factor completely external to the project and might be seen as a form of “technical explanation” in Flyvbjerg`s framework

2. Why has the quantity of inputs changed between different stages?

Increase in the input quantity is the same as that more resources, material or labor, is needed to complete the project. Here it is possible to formulate a couple of hypotheses that at least fit into some of Flyvbjerg´s explanations. Below are four different general possibilities

1. Input quantity changes during the planning stages: The original estimations were not "realistic" and the underestimation of the resources needed was made for strategic/tactical reasons.
2. Input quantity changes during the procurement phase: The original estimation contained mistakes, but this was simply mistakes without any special tactical intention, reflecting lack of competence in the client organization and/or optimism bias. This was found when the contractors made their estimations.
3. Input quantity changes during the construction phase**:** The original estimations were correct given the information at hand at the time, but new information (e.g. about geotechnical conditions) showed that more resources were needed. This of course raises the issue why not more information was collected from the beginning and then the answer should be either strategic reasons, lack of competence or that there were rational reasons not to collect this information given the initial information. More resources than expected could also be needed because of mistakes, errors, and/or accidents during the construction period ("bad luck").

3. Why has the input price changed between different stages?

There might be several explanations why the estimated input price has changed over time.

1. The estimations of prices in an earlier stage were not "realistic" and the underestimation of future prices wase made for tactical reasons or because of optimism bias.
2. The estimation in an earlier stage contained mistakes, but this was simply mistakes without any special tactical intention.

3. The price changes that occurred were caused by events that were not rational to expect given the initial information. The price increase could in this case be seen as a case of pure bad luck. Everyone had done their best and there were no mistakes.

4.3 Back to Flyvbjerg

As seen above a criticism against Flyvbjerg is that his three basic factors – technical, political and psychological – belongs to different levels of the explanation. The "technical" explanation is in our framework part of the descriptive framework while the other two factors belong to the explanatory part where causal explanations are looked for. The "*delusion*" versus "*deception*" version of Flyvbjerg´s explanations then seems more logical – even if one should add two more factors given the discussion above: *lack of competence* and *bad luck* to the framework and then end of with four possible causal factors:

1. Political/strategic manipulation: The actors knew all along that cost would be higher than the estimead
2. Psychological bias: The actors should have know that costs would be higher but various psychological mechanisms made them not see this.
3. Lack of competence in the client organization: The actors had no specific bias and where not affected by psychological biases, but they underestimated the costs because the lacked the competence to estimate them correctly.
4. Bad luck: Unexpected events occurred – even from the perspective of knowledgable and unbiased actors.

4.4 The complete framework

Putting together the descriptive and the explanatory framework the result is table 2. The hypothesis is that by using this framework the understanding of cost overruns can increase. It

would also be helpful when comparing cost overruns in different countries – do they occur in the same stages, in the same part of the production function and for the same causal reasons?

Table 2. Why has design, quantity and price changed at different stages?

<table>
<tr><td colspan="2">Framework for analyzing cost overruns</td><td colspan="3">When in the process</td></tr>
<tr><td colspan="2"></td><td>2. Planning stage (compared to idea stage 1)</td><td>3. Cost according to procurement contract (compared to 2)</td><td>4. Final cost (compared to 3)</td></tr>
<tr><td rowspan="3">Which part of the production function</td><td>Design changes</td><td colspan="3" rowspan="3">Why?
Political/strategic,
Psychological
Competence related
Bad luck</td></tr>
<tr><td>Changes in quantity of input</td></tr>
<tr><td>Changes in input prices</td></tr>
</table>

5. Application of the framework to recent cost overruns in Sweden

In this section the framework presented above will be used in a survey to experienced project managers about cost-overruns in Sweden. The first step is to explain the design of the questionnaire and the selection of respondents.

5.1 Survey

The questions

The first part of the questionnaire (questions 1-6) focused on general issues. The aim was to get a view of the respondents: Their experience, how long they had worked in the business and in what kind of companies. Important was also if they themselves had experience of cost overruns and how common they thought the problem was.

The second part of the questionnaire, question 7even to 15, is devoted to the descriptive analysis of cost overruns. Questions 7-9 were related to the cost function. Question seven: "Cost overruns often depend on scope changes" focused on design as explanation to cost overruns. Question eight "Cost overruns often depend on misjudgments of price development" concerned price as explaining the cost overrun. Question nine "Cost overruns depend on unexpected technical problems which were difficult to foresee" was about changes in input quantities.

Question 10 to 14 focused on the explanatory part of the framework. Starting with question 10 "Cost overruns depend on that the budget was set too low" was about strategic behavior. Question 11 "Cost overruns depend on to optimistic judgments" focused on the problem with inside view in projects. Question 12 "Cost overruns depend on lack of competence of the contractor" and question 13 "Cost overruns depend on lack of competence from those conducting the budget" focus on the competence within the contractor organization and if cost overruns can be cured by education. Question 14 "Cost overruns depend on bad luck" was asked to see if the cost overrun was seen as totally out of control. For each question there was a commentator field for respondent to voluntarily develop their views. Added to this was question 15 were it was recommended that the respondents could state other issues that had

not been dealt with in the first 14 questions. The remaining questions concerned possible policies to reduce cost overruns and they are analyzed in another article (Brunes and Lind 2014) and are therefore not included in the appendix.

No attempt was made in the questionnaire to find out when in the process that cost overruns occurred, as it was believed that this would make the questionnaire to complex.

The respondents

The first questionnaire (Q1) was sent to project managers in The Swedish Transport Administration (STA). They were found by going through current projects on the STA website. The second questionnaire (Q2) was sent to projects managers in three largest construction companies, see table 5.1. These project managers were found by asking leading staff in each company to recommend competent and experienced project managers that could participate in a questionnaire about cost over-runs in infrastructure projects. It is therefore a strategic sample and not a stochastic sample, and this has limitations when generalizing the view of cost overruns for the whole population of project managers in Sweden. The advantage with this strategic sample is that it was possible to choose competent and experienced project managers were many had worked on both contractor and client side. Almost all of them had worked more than 10 years in the industry. With this competence it was assumed that the respondents would give better information about cost overruns than a stochastic sample of project managers would have given.

From this sample it would also be possible to see if there is a difference between clients' and contractors' view on cost overruns and statistical test have been used for this purpose, see below. The number of questionnaires sent out was om total 230 and the completed

questionnaires was 97, which gives at total response rate of 42%, see table 5.1. As presented in table 3 the number of started questionnaires was 106 and some respondents did not answer every question.

Table 3. The number of survey participants and the response rate.

	Sent out	**Totally started surved**	**Completed**	**Response rate**
Q1	190	81	74	39%
Q2	40	25	23	58%
Total	230	106	97	42%

We have checked the difference between respondents and non-respondents and could not find any systematic difference. The questionnaire Q1 was sent to project managers within The Swedish Transport Administration and there was e.g. no difference in response rates from different regions or types of projects. The questionnaire Q2 was sent to mainly three big construction companies in Sweden and the respondent rate were almost the same for all companies.

The survey was constructed following some general principles. There were five possible answers concerning to what extent they agreed with the statement made. It was believed that it would be difficult for the respondents to distinguish between more alternatives. We used a neutral “maybe” and added a “don’t know” option in order to have an exhaustive list of possible answers. The complete questionnaires are presented in appendix 1.

It was statistically significant[2] that the population of project managers had experienced cost overruns, see table 4. Cost-overruns had in the introduction of the questionnaire been defined as significant increases in costs compared to expected (budgeted) costs.The general view of prevalence of cost overruns was that cost overruns were common. 89% of the project managers from STA and 96% of the project managers on the contractor side had experience from participating in projects where there had been cost overruns.[3]

Table 4 Question: What is your view on the prevalence of cost overruns in infrastructure projects?

	Q1 (Client)	**Q2 (Contractor)**	**Q1 + Q2**
Occurs often	41 (52%)	13 (52%)	54 (52%)
Occurs sometimes	34 (43%)	12 (48%)	46 (44%)
Occurs rarely	3 (4%)	0	3 (3%)
Do not know	1 (1%)	0	1 (1%)
Number of answers	79	25	104

5.2 The descriptive part of the framework

Design changes

The first question deals with design changes, and the results are presented in tables 5. It can be seen that design changes is seen as common in projects with cost overruns.

[2] Hypothesis testing at a 95% confidence level showed the populations opinion difference between the sum of answers “often” and ”sometimes” from the answer “rarely”.
[3] As the number of respondents to Q2 is so small, it was judged to be meaningless to carry out formal statistical tests of the difference between the groups. The comparisons below should only be seen as indicative.

Table 5 Question: Cost-overruns often depend on changes in the design of the project?

	Q1	**Q2**
Yes, definitely	18 (23%)	12 (50%)
Yes, probably	29 (38%)	7 (29%)
Maybe	21 (27%)	4 (17%)
No, probably not	9 (12%)	1 (4%
No, definitely not	0	0
Do not know	0	0
Number of answers	77	24

Price changes

The result dealing with price changes, are presented in table 6, and price changes was not seen as a very common in projects with cost overruns.

Table 6 Question: Cost-overruns often depend on misjudged price changes

	Q1	**Q2**
Yes, definitely	3 (4%)	1 (4%)
Yes, probably	15 (20%)	2 (8%)
Maybe	26 (34%)	6 (25%)
No, probably not	31 (40%)	8 (33%)
No, definitely not	2 (2%)	7 (30%)
Do not know	0	0
Number of answers	77	24

Changes in input quantities

The next question dealt with input quantities in the form of unexpected technical problems, see table 7. We interpret this as when there are technical problems there will be a need for extra material, extra work hours etc. which in turn lead to cost overruns. As can be seen in the

table the answers indicated that changes in input quantities was not as common as design changes but more common than price changes.

Table 7. Question: Cost-overruns often depend on unexpected technical problems that were difficult to predict

	Q1	**Q2**
Yes, definitely	8 (11%)	2 (8%)
Yes, probably	39 (51%)	15 (62%)
Maybe	24 (32%)	5 (21%)
No, probably not	5 (7%)	2 (8%)
No, definitely not	0	0
Do not know	0	0
Number of answers	76	24

Overview and conclusion

To get an overview, both of the "yes-answers" and both of the "no-answers" were summed up and analysed, see table 8. These answers also indicate that the project managers consider design and technical problems as a source of cost overruns. The results also show that project managers do not consider price increases as a source of cost overruns. The results are statistically significant[4].

[4] Hypothesis testing at a 95% confidence level showed that the population of project managers regards design as a source for cost overrun, do not regard price as a source for cost overrun and changes in the input quantity as a source for cost overrun.

Table 8. Result with aggregated answers.

Factor	Yes	No	Maybe	Amount of respondent
Design changes	65%	10%	25%	101
Changes in input prices	20%	48%	32%	101
Technical problems (increase in quantity of factors of production)	64%	29%	7%	100

5.3 Explanatory analysis

In this section of the questionnaire the aim was to see which of the explanatory factors described in the framework that got most support.

In Table 9 below the results concerning the deception -explanation are presented. It gets some support but not very strong. Even if it is not possible to test statistically, it is interesting to note that all answers of “yes, definitely” comes from the client side. Initially it was believed that maybe the answers to the questions would be biased from the client side as they might want to underestimate deceptive practices, but then the opposite result would have been expected.

Table 9. Question: Cost-overruns often depend on a budget that consciously was set too low

	Q1	**Q2**
Yes, definitely	5 (7%)	0
Yes, probably	10 (13%)	4 (17%)
Maybe	22 (29%)	4 (17%)
No, probably not	28 (37%)	13 (56%)
No, definitely not	11 (14%)	0
Do not know	0	2 (9%
Number of answers	76	23

As mentioned above there might be incentives to be too optimistic in order to get your favorite projects on the list (or get more projects squeezed into the budget). The results presented in Table 10 shows more support for this hypothesis compared to the earlier one. It can be noted that also in this case there seems to be somewhat more support from the client side.

Table 10. Question: Cost-overruns often depend on too optimistic judgments

	Q1	**Q2**
Yes, definitely	5 (7%)	0
Yes, probably	32 (42%)	7 (29%)
Maybe	27 (35%)	9 (38%)
No, probably not	10 (13%)	6 (25%)
No, definitely not	3 (4%)	2 (8%)
Number of answers	76	23

Two questions relate to lack of competence of clients. The answers are presented in table 11 and 12. These statements get considerable support, and especially from the contractors´ side which is of course what should be expected as that there is a strong risk that there is a bias in the answers from the client side to questions like this.

Table 11. Question: Cost-overruns often depend on lack of client competence.

	Q1	**Q2**
Yes, definitely	2 (3%)	5 (21%
Yes, probably	13 (17%)	10 (42%)
Maybe	31 (40%)	2 (8%)
No, probably not	26 (37%)	6 (25%)
No, definitely not	4 (5%)	1 (4 %)
Do not know	1 (1%)	0
Number of answers	77	23

Table 12. Question: Cost-overruns often depend on lack of competence among the staff that makes budgets.

	Q1	**Q2**
Yes, definitely	4 (5%)	6 (25%)
Yes, probably	21 (27%)	5 (21%)
Maybe	34 (44%)	10 (42%)
No, probably not	15 (20%)	2 (8%)
No, definitely not	1 (1%)	0
Do not know	2 (3%)	0
Number of answers	77	23

The final question concerned the role of (bad) luck and it can be seen that “bad luck” is not something that the respondents believe in, see table 13. This should mean that they think that that there is a specific cause and that the cost overruns could have been avoided if everything was done in the right way.

Table 13. Question: Cost-overruns often depend on bad luck.

	Q1	**Q2**
Yes, definitely	0	0
Yes, probably	0	0
Maybe	11 (14%)	1 (4%)
No, probably not	43 (56%)	11 (50%)
No, definitely not	23 (30%)	10 (42%)
Do not know	0	1 (4%)
Number of answers	77	23

At the end of the part about explanations in the questionnaire there were room for adding further explanations. Among the TA-staff 42% said that they had nothing to add and among the contractors´ this share was 30%. In table 14 below there are examples of explanatory factors that they wanted to add.

Table 14. Question: Other factors that can explain cost overruns (except repetitions)

Factors mentioned by Transport Authority staff	**Factors mentions by Contractor Staff**
Political decisions that make long term planning difficult	Bad documents, bad design documents , bad tender documents
Bad documents, changes in the project documents partly related to technical changes	Bad design documents and tight schedules where the contractor comes in at a late stage
More problematic geotechnical conditions	More problematic geotechnical conditions
Unclear tender documents	Plans are delayed because of appeals
Communication problems	Bad project management
Too tight time schedules for tendering	Bad documents related to lack of competence among consultants
Wrong persons in project group	
Lack of calculation competence, lack of competence among project managers and higher level staff	
Too little resources spent on preparation, design and preparing documents	
Easy to add things to the project over time	
Do not use the right price index or neglect general price increases	
The estimated cost is set in such a way that it should hold with at least 50% probability so cost overruns are expected in 50% of the cases	
Underestimate cost related to the formal process (appeals etc)	
Incomplete contracts with contractors	
Changing regulations and demand from the public, (and the authority “gives in” too easy)	
The budget is made by a unit that is not responsible for the carrying out of the project	

Inexperienced project managers that make to optimistic estimation	
Too optimistic timetables	

As a summary of the explanatory part the four possible explanations identified in the framework can be ranked in the following way for infrastructural projects in Sweden in recent. The explanations that is number 1 got most support:

1. Lack of competence
2. Psychological bias (optimism bias)
3. Strategic behaviour
4. Bad luck

6. Results in recent studies related to our framework

Lundmark (2011) did a case study on the Bothnia Line in Sweden. He also studied eight other large infrastructure projects in Sweden. The dissertation had several aims where one was to detect cost overruns. What caused cost overruns and when in projects did they occur? Lundmark (2011) found that most of the cost overruns in the nine projects occurred during the planning. If it is assumed that the procurement contracts were signed at the time of detailed design there were only minor cost overruns in the procurement and construction stages.

85% of the cost overruns were due to indirect costs such as administration, detailed design, purchase of land and preparatory work. Direct costs were the remaining 15%. If our framework is applied it seems that most of the cost increase occurred during the planning phase and that the cost increase depended most on quantitative changes (administration, preparation work and design took more time) and a combination of quantity and price changes

for the land cost. As prices increased much over time the delays in the project also led to price increases. The delays can be also be seen as a quantity change as interest cost occurred for a longer period of time. A similar result can be found in Cars et al (2009).

There have also been several government investigations on cost overruns in recent years Riksrevisionen (2010, 2011a, 2011b) but they do not discuss causes in a systematic way that is possible to relate to our framework. They especially point out that data is not registrered in such a way that it it easy to analyse what really has happened during the process and when and where cost overruns have occurred.

A few of the recent studies that was found (Love et al 2013 and Cantarelli et al 2012) are primarily interested in finding a statistical pattern in the cost overruns and if this pattern differ between procurement types and project types. As these studies do not concern explanations of cost overruns they will be put aside here.

Some studies are starting with a very long list of factors and then try to find out which of these are most important by sending out a questionnaire and letting actors in the sector rank them,. Through more or less advanced statistical methods the most important ones are identified. Rahman et al (2013) and Doloi (2013) are examples of this. There are several problems with these studies as we see it. The first is that there are problems with overlaps between the factors and whether come factors cover the same underlying factors. This can be illustrated by Rahman et al (2013, p 1965) where one factor is *Design and Documentation related factors* and another is *Information and Communication related factors* – but isn´t it likely that problems with information leads to problems with design? Asking people to rank these factors then becomes questionable for how can they be ranked if one factor at least

partly is a cause of the other. The conclusion (p 1970) that site management factors were major factors contributing to cost overruns then do not become convincing. A common problem in these studies is also the quality of the answers when the respondents have to answer so many questions, and also that they lack a distinction between what above is called descriptive and explanatory factors.

Several recent studies concern cost overruns in the Netherlands. Cantarelli, van Wee, Molin & Flyvbjerg (2012) come to the same conclusion as Lundmark (2011) concerning the stage in which cost-overruns occur:

> "The main problem with cost-overruns lies in the pre-construction phase" (p 90).

They have not collected any material concerning explanations but they write:

> "Considering the three main explanations for cost overruns.. – technical, psychological and political-economical explanations – the latter seems the most likely."

Empirically distinguishing between political-economical explanations and optimism and competence related factors are not easy, but our questionnaire support the latter factors and not political-economical factors.

Cantarelli, Flyvbjerg and Buhl (2012) also look at the Netherlands, but focus on the geographical variation and relations to studies from other countries for different project types. They find that cost overruns seems largest in fixed link projects and also argue (p 329) that such projects might be more prestigious and therefore more prone to strategic behavior from central actors.

Love (2011) presents several Australian case studies and writes in the concluding section (p 1202)

> "The association between strategic misrepresentation and optimism bias with project overruns which has been promulgated does not adequately explain why social infrastructure projects consistently under perform in terms of time and cost. The limitation in Flyvbjerg´s and his colleagues´ theorem is that intermediary conditions and events that lead to project overruns occurring are not examined or explained. A chronological lacuna exists between the initial event and the final outcome.

This can be interpreted as a demand for the kind of framework we have presented above, even if we do not see this as in conflict with Flyvbjerg´s more fundamental explanations. Looking at Love´s results from the perspective of our framework he points to lack of competence and optimism bias in a number of respects, e.g. in the planning and procurement stage where enough time is not given to various tasks and wrong types of procurement are chosen (p 1203). This is very much in line with the results from the Swedish questionnaire.

An interesting recent theoretical contribution can be found in Cantarelli, Chorus and Cunningham (2013) where they show how cost overruns can occur in a "signaling game" where the client cannot distinguish between competent and less competent contractors, and whether a low offered price reflects high efficiency or lack of contractor competence. Sometimes the result with be that a less competent contractor will be chosen that in the end leads to cost overruns. As a comment it can be said that this mainly concerns cost overruns during the construction stage, which does not seem to be the dominating form in Sweden. There is however an interesting example of this currently in Stockholm where one large

subcontractor in a tunnel project just went bankrupt and the comment from the Swedish Traffic Authority was that this probably leads to cost overruns.

7. Conclusions

The contribution in this paper is on two levels. The first is the development of a better theory based framework for analyzing cost overruns which can be summarized in table 15 below, where there are two descriptive elements (in what stage of the process, which part of the cost function) and a set of more fundamental explanatory factors listed in the middle of the table.

Table 15 Summary of proposed framework

<table>
<tr><td colspan="2" rowspan="2">Framework for analyzing cost overruns</td><td colspan="3">When in the process</td></tr>
<tr><td>2. Planning stage (compared to idea stage 1)</td><td>3. Cost according to procurement contract (compared to 2)</td><td>4. Final cost (compared to 3)</td></tr>
<tr><td rowspan="3">Which part of the production function</td><td>Design changes</td><td colspan="3" rowspan="3">Why?
Political/strategic,
Psychological
Competence related
Bad luck</td></tr>
<tr><td>Changes in quantity of input</td></tr>
<tr><td>Changes in input prices</td></tr>
</table>

The second contribution concerns cost overruns in Swedish infrastructural projects in recent years and if the result from Lindmark (2011) are combined with the results from our questionnaire the conclusions would be the following:

- Most of the cost overruns occur in the planning stages up to the final design and are related to design changes and to increases in the amount of inputs needed because of technical and administrative problems.
- Of the explanatory factors lack of competence and optimism bias gets most support.

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Appendix 1 – The questionnaire

At present there is a research project at the Royal Institute of Technology (KTH) concerning causes of cost overruns on infrastructure projects are performed and possible arrangements to lower cost overruns. As a part of the project a questionnaire is sent out to agents in the field to catch their experience and view about the case. All answers will be treated confidentially.

With cost overruns in the text is meant a essential difference (10% or more above inflation) between the clients final and budget cost early in the project. It can also be seen from a contractors perspective when cost overruns means actual cost is higher than budget witch was as base for the offer.

If you want to know more about the project or other questions contact Fredrik Brunes (fredrik.brunes@abe.kth.se). Project leader is Hans Lind (hans.lind@abe.kth.se)

Put a cross in the square that agrees with your judgment.

Part 1 General

1. I work with or have worked with infrastructure projects (road, railway)

☐ Yes
☐ No

2. I work for

☐ Client organization such as Swedish Transport Administration, municipality etc.
☐ Contractor company such as NCC, PEAB etc.
☐ Consultant company such as ÅF. WSP, Swecot
☐ Other
Comment:

3. My working experience is (several alternatives possible)

☐ I have worked both for clients and contractors/consultants.
☐ I have substantial experience of employment in other sectors than the construction sector.
Comment:

4. Your experience/worked years within the business is

☐ Less than three years
☐ Four to 10 years
☐ More than 10 years
Comment:

5. I have participated in projects that have experienced cost overruns!

☐ Yes
☐ No
☐ Do not know
Comment:

6. What is your opinion of the occurrence of cost overruns in infrastructure projects?

□ Occur often
□ Occur sometimes
□ Occur seldom
□ Do not know
Comment:

Part 2 Causation for cost overruns

Below are a couple of statements about possible causes for cost overruns. Mark the alternative which best fits your opinion.

7. ”Cost overruns are often caused by changes in the projects shape”

□ Yes, absolutely
□ Yes, probably
□ Maybe
□ No, probably not
□ No, absolutely not
□ Do not know
Comment:

8. ”Cost overruns are often caused by changes in price development that has been wrongly estimated”

□ Yes, absolutely
□ Yes, probably
□ Maybe
□ No, probably not
□ No, absolutely not
□ Do not know
Comment:

9. ”Cost overruns are often caused by unexpected technical problems which was difficult to foresee”

□ Yes, absolutely
□ Yes, probably
□ Maybe
□ No, probably not
□ No, absolutely not
□ Do not know
Comment:

10. ”Cost overruns are often caused by a budget that was deliberately too low”

□ Yes, absolutely
□ Yes, probably
□ Maybe
□ No, probably not
□ No, absolutely not
□ Do not know
Comment:

11. ”Cost overruns often depends on too optimistic judgments”

□ Yes, absolutely
□ Yes, probably
□ Maybe
□ No, probably not
□ No, absolutely not
□ Do not know
Comment:

12. ”Cost overruns are often caused by lack of competence from the client”

□ Yes, absolutely
□ Yes, probably
□ Maybe
□ No, probably not
□ No, absolutely not
□ Do not know
Comment:

13. ”Cost overruns are often caused by lack of competence among those who conducted the budget”

□ Yes, absolutely
□ Yes, probably
□ Maybe
□ No, probably not
□ No, absolutely not
□ Do not know
Comment:

14. ”Cost overruns are often caused by un luck”

□ Yes, absolutely
□ Yes, probably
□ Maybe
□ No, probably not
□ No, absolutely not
□ Do not know
Comment:

15. Are there any other factors besides the above which you consider important?

□ No
□ Yes, namely….