Cost increases in the front-end of Norwegian road projects

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1. Introduction

Planning of public investment projects is a complex process that includes clarification of a range of issues. To select the right projects, decision makers rely on a planning basis which provides exhaustive information about both the benefits and costs of implementation of the project. A good system of governance assesses all key assumptions of relevance to project proposals.

The investment cost is usually the parameter which attracts the most attention throughout both the front-end phase and the implementation phase of projects. Cost overruns, i.e. unexpected costs incurred in excess of budgeted amounts, have attracted increased attention over the last decades and are the source of much public debate. In many projects, however, even large cost overruns have had little effect on long-term economic viability. Yet in other cases, overruns may comprise a death blow. Cost is particularly well suited as a management parameter because it is expressed quantitatively with great precision and because it is continuously updated. This makes it suitable for making the responsible actors accountable, to gauge progress and performance, and to assess economic viability over time (Samset, 2013).

Accurate estimation of costs is not just a matter of project efficiency – doing the project right. Underestimation of costs might affect the much larger issue of choosing the right project. The investment costs are usually the most important parameter for both private and public investors in their appraisal of net benefits of a proposed scheme. If costs are underestimated, the basis for decision making could turn out to be flawed and the end result could be that the wrong projects are selected for implementation. Flyvbjerg (2009, p. 353) calls this the "Survival of the unfittest" in that "it is not the best projects that get implemented, but the projects that look best on paper". This not only increases the risk of economic failure, i.e. projects with negative economic returns – be that in social of financial terms, but also the risk of strategic failure - projects which are unsustainable in the long term and where societal needs cannot be met in the long term.

The issue of cost overruns is widely discussed in the academic transport literature and studies from countries throughout the world continue to be published - demonstrating that cost overrun is a major source of risk in project appraisal. In Table 1 we provide an overview of some of the studies.

Table 1: Studies of cost overruns in the transport sector

Year	Author (s)	Country of study	Study area	Sample (no.)	Overrun
1991	Morris and Hough	World	Public sector (mixed)	4000	40-200%
1992	Pickrell	USA	Light rail	8	17-250%
1997	Skamris and Flyvbjerg	Denmark	Bridges and tunnels	7	19%
2002	Mott MacDonald	UK	Roads	50	24-36%
2003	Flyvbjerg et al.	World	Transport (mixed)	250	20-45%
2004	Odeck	Norway	Roads	620	8,0%
2006	Berechman and Wu	Canada	Roads	163	5,9%
2007	National Audit Office	UK	Roads	36	40%
2011	Lundberg et al.	Sweden	Roads	102	11,1%
2012	Makovšek et. al	Slovenia	Roads	56	19-30%
2012	Cantarelli et al.	The Netherlands	Roads	37	18,6%

All of the studies cited above show that cost overruns are more common than underruns even if the magnitude of overruns differ between studies – from a relatively modest overrun of 5.9 % to formidable 250 %. This is clearly an issue of concern to governments and project sponsors and which warrants further investigations into the causes why and to which measures that could be applied to mitigate overruns.

All of these studies, and all others that we are aware of, have one thing in common though. They all focus on the projects' implementation phase. In reality, cost overruns in the implementation phase may only represent the tip of the iceberg. Projects that experience cost overruns in the implementation phase may very well have experienced cost escalations even before the formal decision to build was taken. In this paper we thus focus on an area largely ignored in the transport literature – namely that of cost increases in the front-end of projects.

Cost increase during the front-end or the accuracy of early estimates has, however, been researched outside the transport sector. A report by the Joint Legislative Audit and Review Committee in the state of Washington, US, (Fleming et al., 2009) studied the development of cost estimates for all major projects (over $5 million) in the state at ten public agencies over the period 2002-2009. The authors reviewed estimates developed from the concept phase, through the pre-design phase, at which the decision to commit funds for the project was taken - on to the design phase. Their main finding was that a large majority of capital project cost estimates met expectations for accuracy. In the concept phase 73% of projects fell within a range of +30% to -15% range measured against final project costs; in the pre-design phase 71% of estimates fell within the expected accuracy range of +20% to -10%; and finally, in the design phase 74% of projects fell within the expected accuracy range of +10% to -5%. The average by which final costs differed from estimates in the three phases was +15%, +9.2% and 3.7% respectively.

In a meta-study of research carried out over the last 50 years on cost estimate accuracy in different planning stages in different industries, Hollmann (2012) found that costs were generally underestimated at all levels of scope definition, with deviations from final costs from +260% to +36% in the concept screening phase to +9% to +58% at the decision to build, and concluded that "(…) one is dismayed by the extreme disconnect between our practices and the long-known reality. There is an ongoing failure to effectively address the reality of project cost uncertainty and there is a lack of good historical data with causal information."

Hollmann et al. (2014) readdressed this issue in an industry-specific study of the Canadian hydropower industry and investigated the development in cost estimates in projects at different maturity levels. They found that the mean actual-to-base-estimate ratio varied from 1.79 to 1.24 from the concept screening phase to budget authorisation, i.e. the decision to build. The implication of this was that, on average, a 24% contingency was needed in order to have a 50% confidence of underrunning. Their main conclusion was that construction cost risks are much higher than estimated and that the contingency reserves were too low during all project phases.

2. The front-end phase of projects

Large public investment projects, and transport projects in particular, rely on a long pre-sanctioning phases where the business case, project strategy and technical options are selected and developed. Through a broad investigation of the opportunity space, an alignment of needs with goals, the estimation of costs and benefits and a ranking of relevant solutions, we are able to ensure successful long term strategic performance.

The front-end phase of projects is the stage of planning from when the project concept is conceived until the final decision to build is taken. It includes concept identification, preparation and appraisal, but not detailed planning (Williams and Samset, 2010). The project management literature has traditionally been concerned with "doing the project right", but project governance has increasingly focused on "doing the right project". There is a strong theoretical basis for quality of entry (see e.g. Morris, 2011), yet as pointed out by Edkins et al. (2012) and Flyvbjerg (2013) the research literature on cost estimation and –quality during this phase of projects is scarce. This may be due to data issues in that reliable data before the formal decision to build may be difficult to obtain due to privacy issues and other cases for non-disclosure from the responsible organisations.

The risk of economic inefficiency due to underestimation of costs in the front-end phase may be further enhanced by the concept of *lock-in*. Cantarelli et al. (2010) have defined lock-in as the escalating commitment of decision-makers to an inefficient course of action. This means that the real decision to implement a project or a policy may be taken at a much earlier stage than the formal decision to build. As stated by the Federal Highway Administration in the US: "By the time the FHWA approves the cost of a large-dollar project, a public investment decision may have effectively been made because substantial funds will already have been spent on designing the project and acquiring property, and much of the increases in the project's estimated costs will have already occurred" (GAO, 1997, p. 3). As such, cost estimates made at an early state of project development may warrant the same scrutiny as estimates made at the time of decision to build.

Samset (2013) has illustrated a potential development of costs in a project as in Figure 1. The first estimate is usually provided by project promoters or local enthusiasts – typically parties with no financial responsibility. The estimate may be based on average costs for similar projects, wishful thinking or, even, a deliberate unrealistically low estimate to "get the discussion started". With time, information improves after which cost estimates rapidly starts to increase. Stakeholders demand improvements such as better facilities for walkers and cyclists and noise abatement measures; politicians require measures to meet the demand of their constituencies; other pressure groups appear – all this translates into increased cost estimates until the budget is finally approved at the time of decision to build. The final cost may be lower or, more often, higher than the cost frame approved by the decision makers, but more than often the increase in the cost estimate during the front-end is much higher than the increase during the implementation phase.

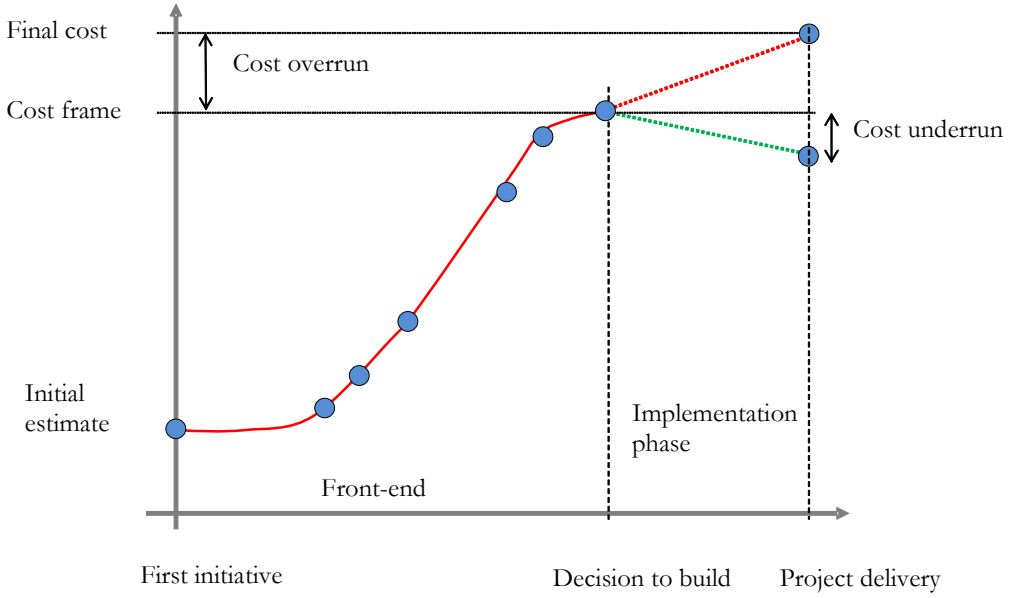


Figure 1: Up-front underestimation of costs

Despite this, a relatively modest cost overrun of, say, 20-30 % may spark public outrage and extensive and negative media coverage while an increase during the front-end many times of that during the implementation phase may go largely unnoticed. This may be due to the fact that increases in cost estimates during the front-end are seen as less serious as it is not a cost overrun *per se* as money has yet to start to flow. It is only once the construction has commenced that overruns may constitute a strain on the public purse.

Focusing on the cost control during the implementation phase rather than the front-end may be detrimental to successful delivery as the long term strategic performance of projects relies on a range of decisions in the front-end phase. Getting costs right from the start is thus crucial. Severe underestimation of costs in the front-end phase could jeopardise long term viability to a greater extent than cost overruns in the implementation phase as it increases the risk of choosing the wrong project concept or the wrong project altogether. As pointed out by Williams and Samset (2010) underestimation of costs in the front-end may be the prime reason why many poor projects are chosen. Many projects may have been unthinkable had more realistic estimates been presented in the first place. At the formal time of decision to build, the project may have created so much momentum and expectations from future users are so high that decision makers will approve the project even if the presented budget is three times that of the first estimate.

In this perspective, cost overruns in the implementation phase, as is the prime focus of the academic literature, may be less interesting. In many cases overruns may represent only a fraction of the lifetime benefits. One example of a project viable in strategic terms, but with considerable cost overruns, is the University Hospital in Oslo, Norway which was completed two years behind schedule in 2000 and with considerable cost overrun, adverse newspaper reports and public scrutiny. Cost overrun was considerable in absolute terms but was equivalent to only a few months' operational costs for the hospital, and therefore insignificant from a lifetime perspective. The overall conclusion after a few years of operation was that the University Hospital was a highly successful project, and it would perhaps be unfair to suggest that initial decisions should have been able to anticipate problems with a high level of precision (Williams and Samset, 2010). Another Norwegian project illustrates the opposite and a more serious problem – namely that of strategic failure. The Malangen torpedo battery in the north of the country was a huge and complex naval facility able to accommodate 150 military personnel for months at the time. It was

opened on time and without cost overrun in 2001 and then closed by Parliament one week later. The military risk for which it had been planned and built was no longer present and the technological development had rendered military installations at fixed locations obsolete. In 2012 the installation was put up for sale at 0.05% of the construction cost (Bråthen, 2012). It was bought by the local council which unsuccessfully tried to sell it to private investors and then tried to give it back to the Norwegian Defence Estates Agency a year later (Gedde-Dahl and Ekroll, 2013). Despite this obvious waste of the taxpayers' money, it got no attention in the media at the time of completion, possibly because it was delivered within budget.

These two examples clearly illustrate the need to focus on strategic performance rather than tactical performance alone. Focusing primarily on cost control in the implementation phase may thus be too narrow or even uninteresting. Ironically most of the academic literature on construction costs and cost control in the transport industry is focused on exactly that. Instead, and as pointed out by Samset (2013, p. 29) "Improving cost estimation in the front-end phase might be far more important than gaining control over cost overruns in implementation, as it may lead to fewer poor projects being chosen and thereby to increasing the overall benefit of investments". This paper aims to do that, namely to study the increase in cost estimates during the front-end in a sample of road projects. We are not aware of any similar studies from elsewhere. It is our hope that the paper might help raise awareness for this important issue and spark similar research initiatives from other countries and sectors. The remainder of the paper is organised as follows. Section 3 describes the framework for the planning and delivery of Norwegian road projects including previous studies of cost overruns in the Norwegian road sector. In Section 4 we present the data and methodology used in the study while section 5 presents the empirical results. In Section 6 we discuss our findings and provide some conclusions.

3. Planning Norwegian Roads

The planning of Norwegian road projects is closely linked to the National transport plan which outlines how the Government intends to prioritise resources within the transport sector. It is a ten-year-plan that is revised every fourth year. The plan, which also addresses other important policy issues, provides a comprehensive basis on which to make decisions. It seeks to ensure the efficient use of resources and to strengthen interaction between the various modes of transport. The transport plan is, however, not a budget and projects which are prioritised in the plan still rely on funds to be allocated through the annual state budget. As such, the formal decision to build is when a formal cost frame is approved in the state budget or in other formal parliamentary bills.

Figure 2 illustrates the main stages in Norwegian road planning. The framework corresponds well to the traditional four-stage view of project management: Conceptualisation, Planning, Execution and delivery and Utilisation. The first formal stage[1] is the Conceptual Appraisal in which all realistic solutions to a problem are evaluated. It is an open-ended appraisal process which aims to clarify the underlying problem which needs to be resolved, describe the conditions and requirements that have to be fulfilled and then identify solutions and then assess their feasibility (Samset and Volden, 2013). As part of the conceptual appraisal a first and rough cost-benefit analysis is carried out.

[1] Local enthusiasts and promoters may have campaigned for a project for decades, but the formal planning process only begins when the roads administration decides to carry out a conceptual appraisal. There might thus be a long and informal front-end phase which may include numerous cost estimates provided by different actors.

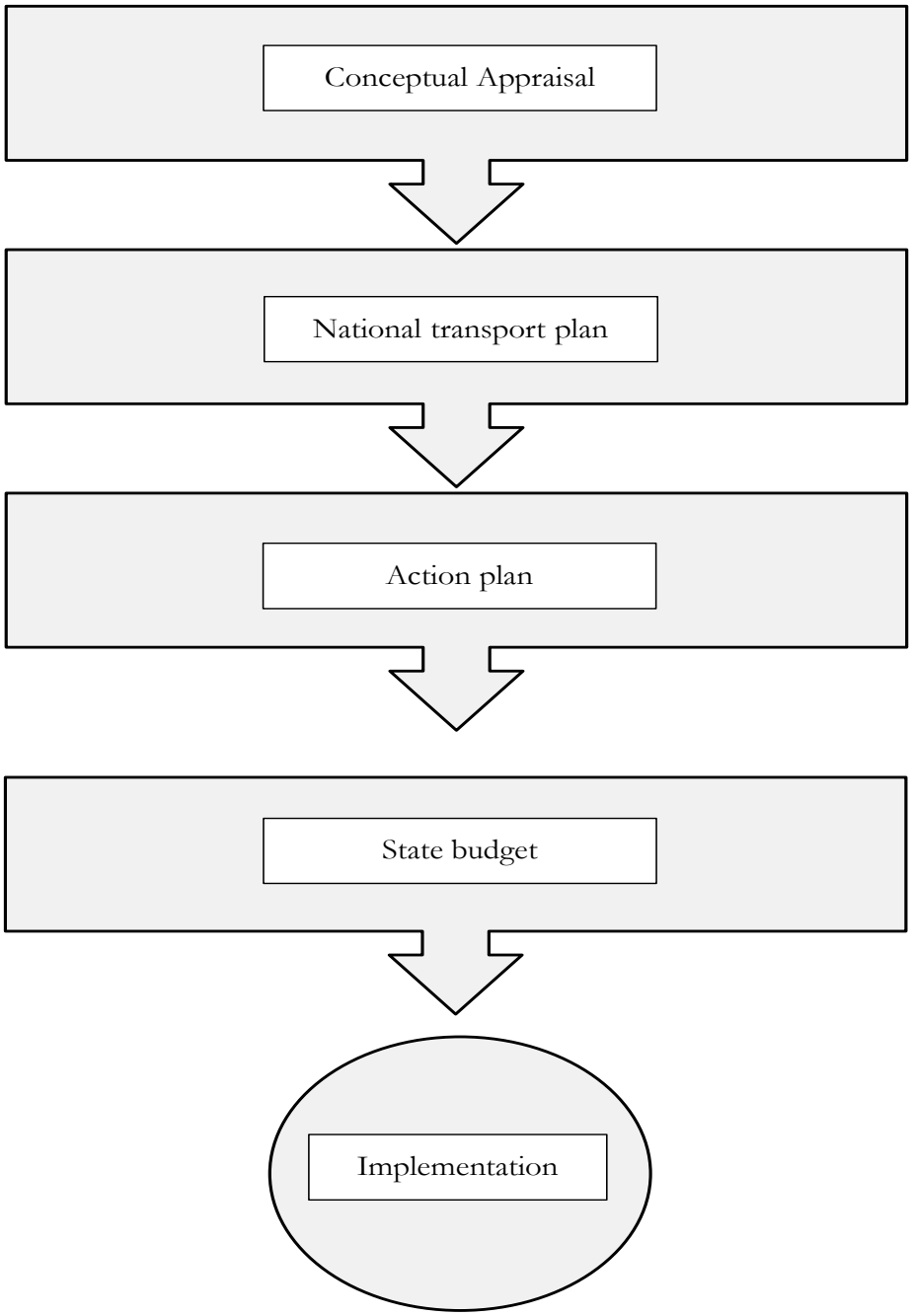


Figure 2: The main phases in Norwegian road planning

The recommended choice of concept then undergoes the scrutiny of external consultants as part of the Norwegian Quality Assurance Regime[2]. The consultants may or may not support the recommendation of the road authorities. The cabinet then takes the decision whether to allow the project to be developed further. If so, the project may be included in the National transport plan which is debated in Parliament and then approved with possible changes and amendments after the debate.

The projects in the National transport plan may be at different stages of planning – not all may be ready for final government approval. The projects are then sorted in an Action plan which outlines when the different projects are to be commenced during the coming four-year period. Actual start-up of the individual projects relies, however, of the project being included in local

[2] For more details about the Norwegian Quality Assurance Regime, see: http://www.concept.ntnu.no/qa-scheme

development plans which sets out the road alignment and potential mitigating measures if the road has negative effects on the environment or local residents.

The formal decision to build is usually taken in the annual State budget in which the projects are described and the steering frame and cost frame (usually based on P50 and P85 respectively, see Figure 3) are approved. The cost estimate for large projects (> ≈ €95 million) must be subjected to external quality assurance by independent consultants before it can be presented to Parliament.

This implies that the total planning process or the front-end of Norwegian road projects may be a time-consuming process which involves multiple actors at different levels of government. The Norwegian Public Roads Administration (the NPRA), which is the responsible agency for trunk roads and other roads of national significance, must liaise both formally and informally with local stakeholders, municipalities and other government agencies. The front-end, which may take 5-10 years, thus involves considerable uncertainty with regards to road alignment, road standard and other crucial variables which are needed to estimate the total construction costs. It may not be until the last two years before the formal decision to build that the construction cost could be estimated with an acceptable degree of uncertainty.

All road projects are affected by uncertainty and the method of cost estimation applied should reflect this. There are different methods of estimation available which could allow for uncertainty in the input parameters. In Norway cost estimates for road projects are based on successive calculation which was first developed in the 1970s by Steen Lichtenberg of the Technical University of Denmark and has since been used with successes in a wide range of projects throughout the world. In short, the process could be described as follows:

1) Establish a suitable analysis group.
2) Identify all relevant objectives and other issues of importance
3) Organise all known cost elements into discrete groups, and define for each group a base case assumption coupled with worst and best case assumptions.
4) Add a reserve for unknown, but expected cost elements which we know will accrue (even if we don't know which elements they are). The size of the reserve depends on the stage of planning.
5) Define uncertainty for all input variables using probability distributions.
6) Calculate results and compile a list of the most critical items or activities.

The result of the analysis is presented by means of a cumulative graph that shows the range of possible outcomes and their relative likelihood of occurrence. This is illustrated in Figure 3.

The NPRA requires that the level of uncertainty measured by the standard deviation should be no more than 40% in the conceptual appraisal and maximum 10% at the time of decision to build. Note that uncertainty may entail both risk and opportunity. This implies that it should be equally likely that the final cost is 40 % lower as it is higher.

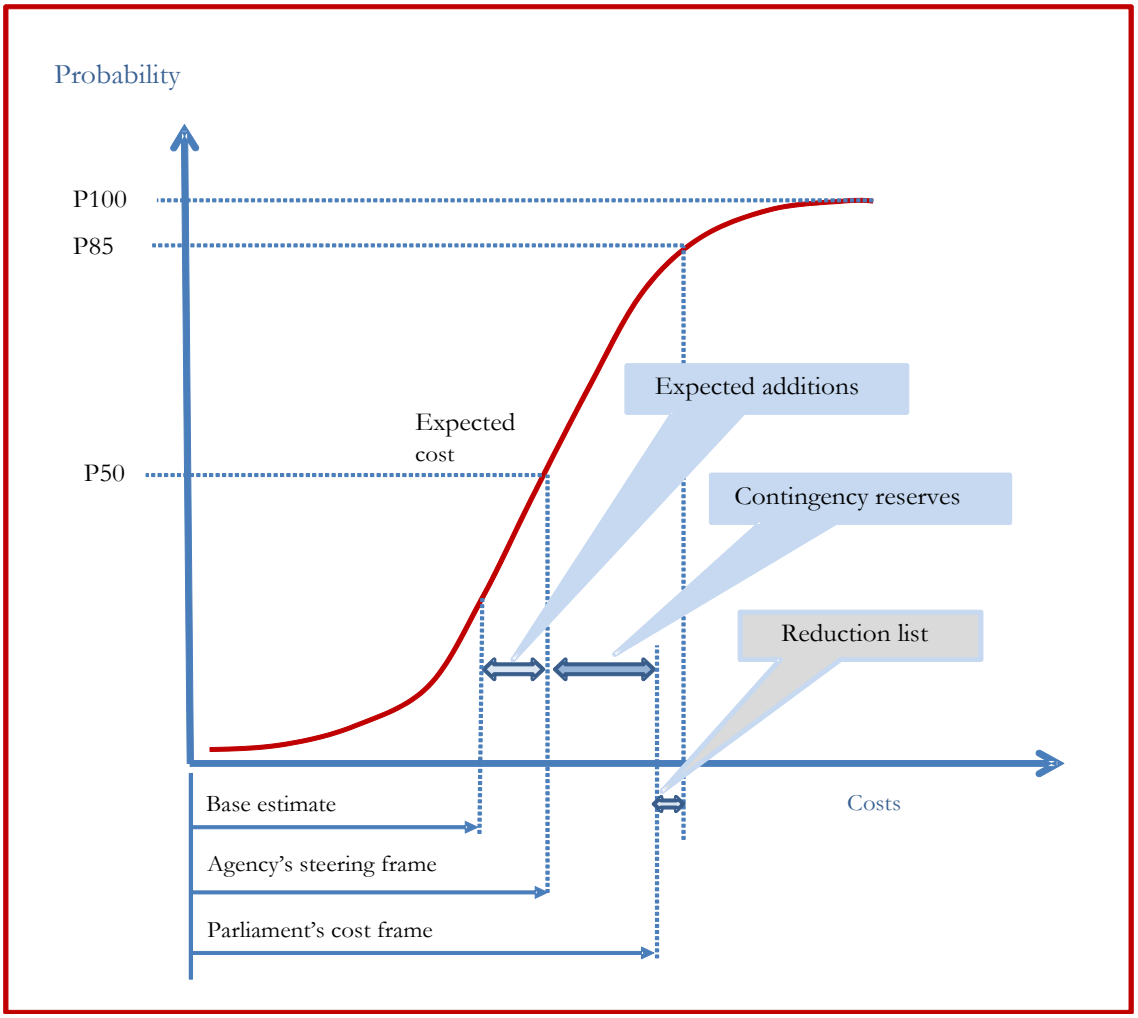


Figure 3: Probability distribution construction costs. Definition of key terms.

Traditionally the administration, politician and the general public have focused more on cost overruns during the implementation phase, but the front-end of Norwegian road projects clearly has much scope for cost escalation. If the real decision to build is taken at an earlier stage than the formal decision to build, this long front-end could imply that cost increases before the decision to build is more serious than cost overruns after. In the next sub-section we will look briefly at how Norwegian road projects perform in terms of cost overrun in the implementation phase before we turn our attention to the main focus of this paper, namely that of cost increases during the front-end.

3.1 Cost overruns in Norwegian road projects

During the 1980s and 90s, Norway suffered numerous high-profile scandals surrounding large-scale public investment projects. The Government thus commissioned a study into the planning, implementation and follow-up of large public investment projects. The study by Berg et al. (1999) concluded that cost overruns were the norm rather than the exception in both road projects and in other projects. They found that 8 out of 11 projects had cost overruns and concluded that even if there were signs of improvement there was a need to standardise planning procedures and cost estimation methodologies. The combined cost overrun in the projects studied was 84%.

The first comprehensive study of cost overruns in Norwegian road projects was carried out by Odeck (2004) which studied 620 projects from 1992 to 1995 - the majority of which was small or very small projects (>10 million euros). He found that about half the projects experienced cost

overruns; the average among all projects was 7.9% with variations from -58.5% to +183%. In a later study Odeck (2014) expanded the sample to 1045 projects from 1993 to 2007 and found that cost performance had improved over time and that the average cost overrun of projects carried out from 2004 to 2007 was only 4%.

All the studies above concluded that cost overruns were more common among small than among large projects. Odeck et al. (*in press*) thus studied large road projects in particular. The aim was to compare the magnitudes of cost overruns before and after the quality assurance regime was implemented in 2000. They found that among 22 projects with construction costs ranging from €75 to €370 million and subjected to external quality assurance the average cost underrun was -11%; 7 out of 10 projects experienced underruns and the highest overrun was only 20%. The authors explained these encouraging results as a result of the quality assurance regime and suggested that small projects which have shown to be vulnerable to cost overruns should be placed under increased scrutiny with respect to their construction costs.

The Norwegian State Project Model is today recognised as an example of a successful project governance system. It is a gateway model which specifically targets the Government´s need for decision support in the early project phases. It provided a standardized, yet flexible framework for appraising and planning large public sector projects. At its core is external quality assurance carried out by independent consultants of the assumptions made by the responsible agencies. As has been documented in the studies above, the Norwegian road authorities have come a long way over the last 15-20 years in improving cost control in the projects' implementation phase yet very little is known about how cost estimates have developed during the front-end phase of the projects. This paper aims to address this academic imbalance by providing the first study of this topic.

4. Data and Methodology

The data for this study consists of 30 Norwegian road projects which all have been subjected to external quality assurance.

The cost estimates were retrieved from official documents available at the road authorities' archives containing planning data and documents on completed projects, including estimated costs provided by the authorities. All estimates are adjusted to the year of the final cost by the use of the construction cost index which measures changes in input prices for road construction.

The data set includes cost estimates from the following project stages:

1) First official description as presented in parliamentary bill or equivalent official document.
2) National transport plan.
3) Project steering document developed by the Norwegian Public Roads Administration.
4) Quality assurance report (QA2).
5) Investment decision
6) Final cost

To estimate the accuracy of the cost estimates, we compared the final costs with the estimates using the measure commonly used on the literature – the Percentage Cost Overrun:

$$PCO = ((X_a - X_{est}) \times 100) / X_{est} \quad (1)$$

where *MPE* is the percent inaccuracy, X_a is the actual final cost and X_{est} is the estimated cost. Note that X_{est} represents the steering frame, i.e., the P50 value in Figure 3. The cost frame, the P85 value, is usually some 5-15% higher.

Equation (1) presents the cost accuracy of the individual projects. For comparisons on portfolio-level, an averaging measure is required. The appropriate averaging is the so-called Mean Percentage Overrun (MPO), which is defined based on (1), as follows:

$$MPCO = \frac{1}{n}\sum_{i=1}^{n} PCO_i \qquad (2)$$

where *MPCO* is the mean percentage cost overrun. The *MPCO* is likely to have a small value because the negative and positive values tend to offset each other. It does, however, show which way the overruns tend to go, namely, positive or negative.

Ideally all projects should be completed at the estimated expected value as represented by the steering frame. However, given that all projects are implemented under uncertainty, we must not just expect, but also accept deviations. For the NPRA, which is responsible for a large number of road projects annually, it is the result at portfolio-level that is the relevant measure. If a portfolio of projects is completed with equal sizes of overruns and underruns, the average will be around the expected value. As such, the measure of success for a sample as ours would be an *MPCO* of zero and with overruns and underruns normally distributed around the expected value.

Table 2 presents some descriptive statistics regarding the size of the projects measured by their final cost in million NOK[3].

Table 2: Summary of data by the size of the projects

	Final cost (opening)	QA2	National transport plan	First description
No. of cases	30	30	21	15
Total investment cost	47.800	46.992	25.657	16.397
Mean investment cost	1.600	1.516	1.222	1.093
Standard deviation	1.300	1.042	858	879
Minimum	430	579	519	370
Maxsimum	7.150	5.598	3.709	4.238

The size of the projects is much dispersed. Final investment costs vary from modest 430 million NOK to 7130 million NOK. We are, however, not concerned with representativeness of the sample as it covers all road projects subjected to external quality assurance and for which the final costs have been made available.

We notice that the number of projects for which we have cost estimates decreases from project delivery and towards the first initiative. Cost estimates presented at the projects' front-end are often very uncertain and sometimes not included in official documents at all. This may have obscured the discussion on whether to proceed with planning or not. The lack of meaningful cost estimates in the front-end of projects is part of the reason why the government introduced a mandatory conceptual appraisal with external quality assurance (QA1) in 2006, see Figure 2. So

[3] 1 NOK ≈ 0.12 EUR or 0.1 GBP.

far though, only a handful of projects which have undergone QA1 and QA2 have been implemented. It is thus too early to determine whether the conceptual appraisal have increased transparency and improved the quality of cost estimates in the front-end of projects.

Table 2 shows that we should be able to make robust conclusions regarding the accuracy of cost estimates in the implementation phase of large Norwegian road number of projects. As the number of observations decreases over time, the conclusions regarding the front-end must be treated with some caution.

5. Empirical Results

The purpose of this paper is to assess the accuracy of cost estimates in road projects subjected to external quality assurance as part of the Norwegian State Project Model. We also investigate whether estimates become more accurate over time. In this section, we present the results of our findings.

Table 3 presents the results as measured by the MPCO defined in Equation (2).

Table 3: Mean percentage cost overrun in different project stages

	Final cost	External quality assurance (QA2)	NPRA estimate	National transport plan	First project description
Mean	2 %	1 %	2 %	38 %	53 %
Median	0 %	0 %	1 %	19 %	40 %
Min	-40 %	-40 %	-38 %	-25 %	-8 %
Max	49 %	43 %	37 %	237 %	137 %
St. Dev.	18 %	18 %	18 %	58 %	43 %
No. of projects	30	30	30	21	15
% of accurate estimates	50 %	50 %	50 %	57 %	47 %
% cost overruns	57 %	53 %	53 %	71 %	93 %
% cost underruns	43 %	47 %	47 %	29 %	7 %

We notice that the overall accuracy of cost estimates in large Norwegian road projects is very good. A mean cost overrun of only 2% and a median of 0% show that there is no bias in Norwegian cost estimates. There is, however, a degree of inaccuracy as the minimum and maximum are quite large and the standard deviation is relatively high and higher than the NPRA's formal requirement which states that cost estimates at the time of decision to build should have a standard deviation of no more than 10%. Only 50% of projects have estimates with a level of accuracy within ±10%.

The two next columns reveal the accuracy of estimates preceding the government's decision to build. The NPRA prepares an estimate which are scrutinised by external consultants in the QA2 process. The government decides which estimate to rely on - or alternatively, if new information has come to light, if totally new assumptions regarding the construction costs should be relied on. We notice that the difference between the estimates made by the NPRA and the consultants are only marginally different. This is interesting. Internationally, road authorities have been accused

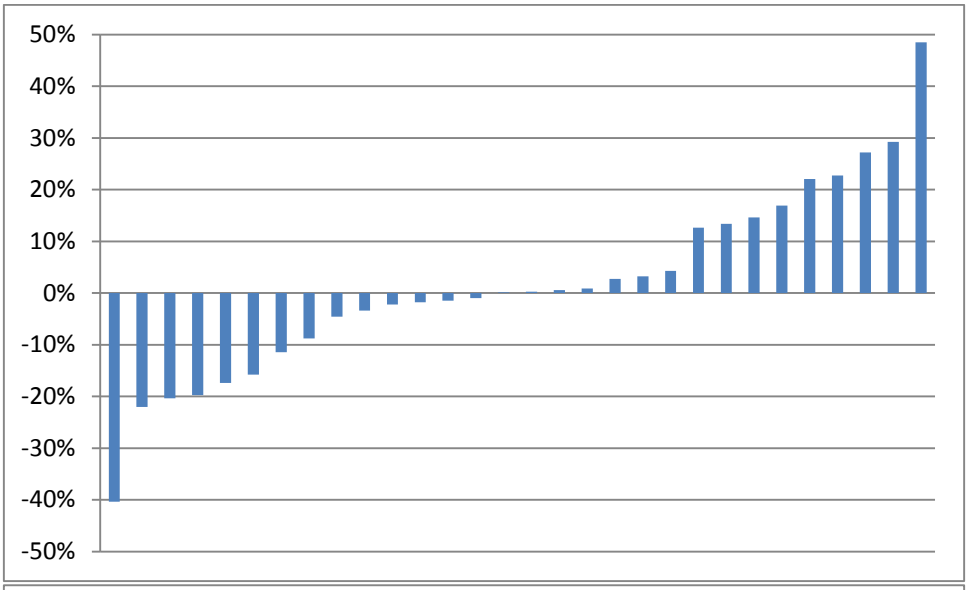
of deliberately providing biased estimates, i.e. misleading decision-makers into approving projects where real costs inevitably will be much higher that what has been presented. The results presented in Table 3 indicate that the Norwegian system of external quality assurance may provide a solution to strategic underestimation. When the road authorities know that their estimates will be scrutinised by an impartial third party, they are much less likely to deliberately underplay the real costs of implementation. These results confirm those of Odeck et al. (in press) who concluded that quality assurance has led to a reduction in cost overruns.

The estimates presented in the National transport plan, and shown in column five of Table 3, show, however, that there is scope for improvement in the front-end of Norwegian road projects. Of the 21 projects which have been included in previous transport plans, the final costs have been, on average, 38% higher than estimates. Only 57% of estimates have been within ±25% of final costs and 71% of projects have final costs higher than estimated. The implications of these results are twofold. First, of the 30 completed projects only 21 have been presented in the National transport plan accompanied with cost estimates. This may indicate that projects have been implemented without first being prioritised in the National transport plan, or alternatively, that projects have been prioritised without cost estimates. Neither of which is in accordance with the formal requirements to Norwegian road planning. Secondly, the results show that cost estimates presented at the early stages of projects planning are inaccurate and, possibly, biased. Further research is needed to determine whether low estimates (and not scrutinised by external consultants) have been presented to "get a foot in the door" or if other reasons than deliberate underestimation may better explain why early cost estimates in Norwegian road projects fail to provide decision makers with a solid foundation for decision making.

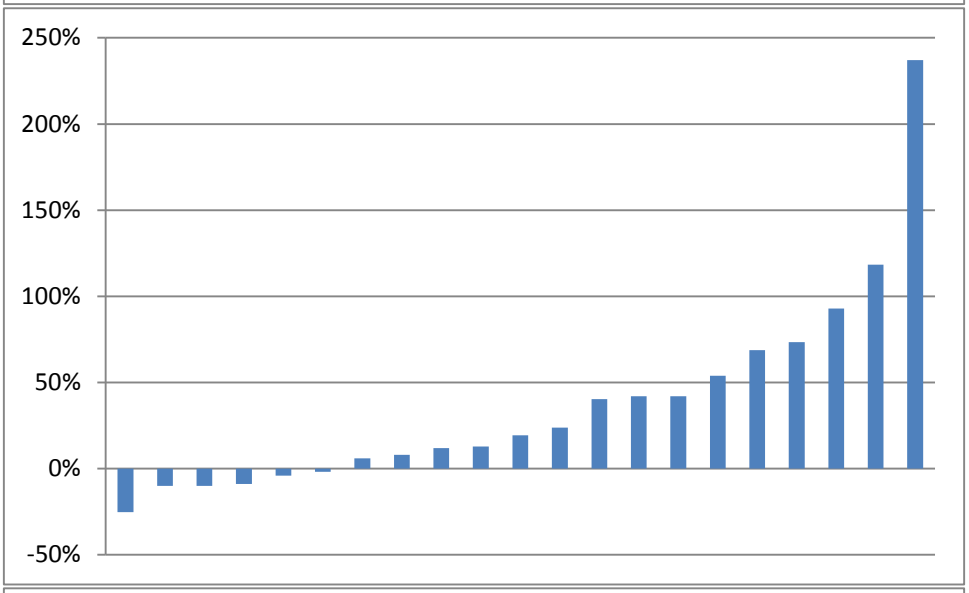
The last column merely confirms that of preceding one. The older a cost estimate is, the more inaccurate it is. That is unsurprising, but if the problem was merely inaccuracy the distribution between overruns and underruns would be more symmetrical. As it is, nine out of ten projects become more expensive to build than estimated when the project was first referred to in official documents.

Figure 4 shows the distribution of cost overruns in different project stages. The number of projects in the two first stages is limited so that the results should be interpreted with care, but it is apparent that the distribution of final costs to estimates is much more skewed to the right in the early stages of project planning.

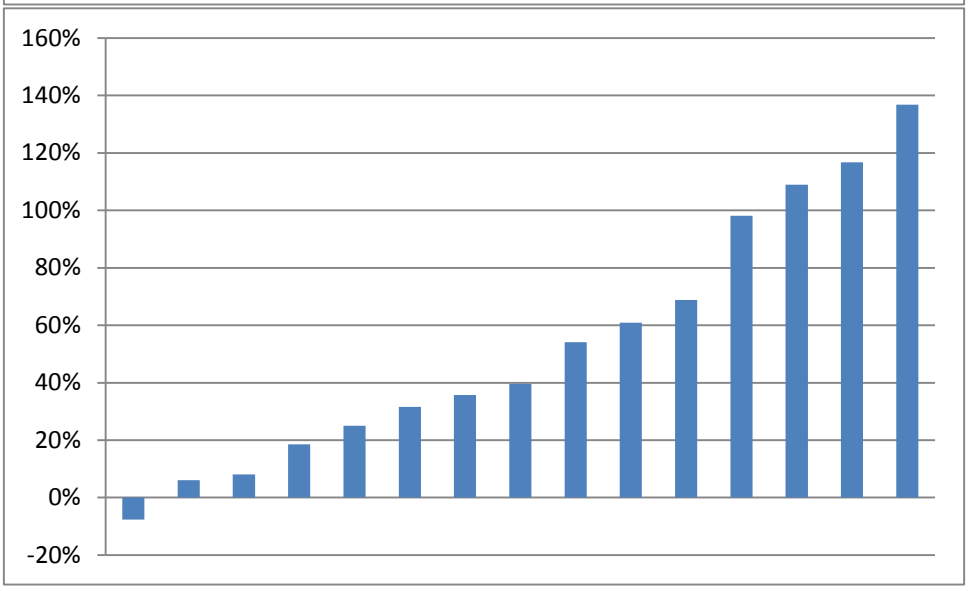
Figure 4 might, however, be slightly misleading as estimates are not available for all projects at different stages. Figure 5 thus shows the development in average estimates compared to final costs in 13 projects for which we have cost estimates in all four project stages. For these projects, the overrun on the implementation phase is non-existent while the average overrun from the first project description and from the National transport plan is 31% and 23% respectively. We would hence argue that repeated studies of the costs during the implementation phase are less interesting and that attention should be diverted to the front-end of projects.



PCO - Decision to build, *n* = 30



PCO – National transport plan, *n* = 21



PCO – First project description, *n* = 15

Figure 4: Distribution of cost overruns through different project stages

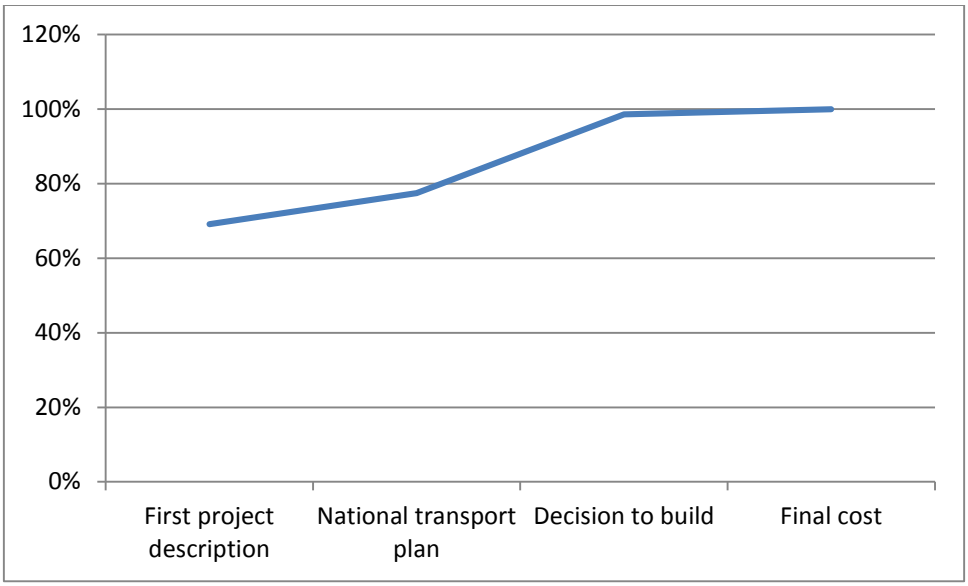


Figure 5: Cost estimates and final costs (n = 13)

The implications of these results are several. In the next section we proceed to discuss potential causes of the differences observed in Table 3 and Figures 4-5 including which measures which could improve the accuracy of cost estimates in the front-end of projects.

6. Discussion and conclusions

Accurate project cost estimates are essential to the government capital budget process and crucial for ranking projects for implementation. Accurate cost estimates are also critical to project managers responsible for constructing facilities within appropriations. In the preceding section we showed that cost estimates in Norwegian road projects are accurate and probably better than what has been demonstrated in numerous international studies. However, and as is the issue that this paper aims to address, cost estimates in projects' front-end are inaccurate and possibly biased. That presents a severe problem which must be brought to the road authorities' and decision makers' attention.

As we discussed in Section 2, underestimation of costs in the front-end of projects may increase the risk of strategic failure, i.e. choosing the wrong projects or the wrong project concept for implementation. Although there are worse cases of early underestimation of costs (Welde et al. (2014) presented a study of 12 public sector projects with increases in cost estimates during the front-end from 70 to almost 1300%), the distribution of cost overruns presented in Figure 4 with final costs up to twice that of first estimates warrants the question of whether these projects would have been planned further and then implemented had the real costs been known at an earlier stage. At the time of the formal decision to build the project may have created so much momentum and expectations from future users that the government decision may be just a formality.

Crucial to cost estimates at different stages is the expected uncertainty of the estimates. The NPRA allows for an uncertainty of 40% at the conceptual appraisal stage; 25% at the municipal sector plan stage (usually when the project is included in the National transport plan); and 10% at the time of decision to build. However, as demonstrated in this paper, either are these uncertainty allowances too low or are the estimates of a sufficient quality as the standard deviation at sample-level is higher than the allowed uncertainty. This is similar to the findings of Hollmann et al. (2014) which found observed inaccuracies in early estimates to be much higher than the allowed contingencies. Hollmann et al. speaks up for increased contingency resverves (p. 8): "(…)

contingency should always be based on risk analyses. However, if a company's risk analyses regularly result in 10-15% contingency and narrow ranges, it is likely that risks and their impacts are not being identified or quantified properly and/or optimism bias is controlling."

The tendency to downplay risks either deliberately or because of over-optimism is one of main issues why project promoters are unable to estimate the construction costs with an acceptable degree of accuracy. Research has shown that humans beings are routinely unable to assess own performance (Lovallo and Kahneman, 2003). As the first estimates in projects often are provided by project promoters or other enthusiasts, these estimates may be highly unreliable. However, as projects are described in official parliamentary documents and then in the National transport plan, cost estimation would normally be within the responsibility of the NPRA. One potential explanation is *anchoring* which is the tendency to rely too heavily on the first piece of information offered. The first estimates, however unrealistic, may thus influence the quality of later estimates.

In our case, many of the first estimates were prepared over 10 years before the project was finally approved by government. By that time many things may have changed and above all society's and the users' expectations may have changed. As an example, our tolerance for environmental and social adverse effects to large scale construction projects have diminished over time. Flyvbjerg et al. (2004) found that cost escalation was strongly dependent on the length of the implementation phase. Delays and long implementation phases translate into risks of substantial cost escalations. They also observed that projects grow larger over time, and for some project types, larger projects have larger percentage cost escalation. This is in accordance with our view and also with the findings of Welde et al. (2014). Large infrastructure projects are highly vulnerable to scope creep over time. This should, however, be reflected in the estimates. Scope creep is a risk which should be included in the cost estimates. Planners and cost engineers routinely fail to do this. By estimating the "project at hand" rather than the project as it probably will be once numerous interest groups have had their say and once politicians have used the project as an instrument to solve other local issues, we risk severely underestimating the project's final cost.

The risk of scope creep is similar to the strategic risks suggested by Westney (2012) as one of the major causes why projects overrun. Standard practice in cost estimation has long been to assess the risks we can control by setting ranges around the deterministic estimates of costs. This practice discourages the use of early risk assessments and tends to anchor project teams to optimistic early estimates. Strategic risks, on the other hand, are issues outside the project team's control and are often ignored until they occur. Examples of strategic risks are scope creep, market conditions, location factors, legal changes etc. The framework for cost estimation used by the NPRA includes some strategic risks, but given the observed underestimation of costs in the front-end of projects observed in this paper, we would suggest that the NPRA review their methodology to better include unexpected events.

A striking feature of cost estimates in Norwegian road projects is that it appears to be much better than what has been demonstrated in studies from elsewhere. And moreover, among Norwegian road projects, projects that have been subjected to the scrutiny of external consultants through QA2 perform better. This should transfer into greater use of external quality assurance at an earlier stage and where front-end cost estimates provided by the NPRA should be the subject of ex post studies such as this which may help to highlight issues needing further attention.

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