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Norwegian University of Life Sciences
School of Economics and Business
Nicolay Andre Melsæter Worren

# Does Norway have the best cost control in road and fixed links projects? Comparative research of cost performance in Northern and Western Europe.

Ilya Lebedev
Master in Business Administration
School of Economics and Business

# Preface

This thesis is the final stage of my studies at the Norwegian University of Life Sciences.

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# Abstract

The comparative research of national studies across Northern and Western Europe shows the high level of cost performance for Norwegian Public Road Administration. The superior results are observed across the international samples of infrastructure projects. The average cost overrun for road and fixed links projects is estimated as of 11.5% with relatively average spread. However, the cost performance varies greatly for different project groups. The large projects over NOK 200 million show the best estimation accuracy with mean overrun of 4.9% and lowest standard deviation. Smaller projects have worst cost performance with highest cost overrun of 13.0%. The similar cost situation is observed in case of time overruns. The cost overrun also changes over time periods due to reorganizations of NPRA. The reforms positively affect the cost overrun for large projects but worsen the cost performance of small and medium projects greatly.

The explanations for such great cost performance are high level of transparency, advanced estimation practices, prioritizing the social benefits, thus avoiding public pressure, involvement of private organizations intro procurement and adopted practices for managing the strategic misrepresentation and optimism bias.

# Table of contents

# List of tables



# List of figures

# Chapter 1. Introduction

## 1.1 Background

The Norwegian Public Roads Administration is overall responsible for the planning, construction and operation of the national and county road networks. According to recent publications, the Norwegian Public Road administration plans to invest of total NOK 88.5 billion each year into infrastructure projects. The overall potential investments into the sector are estimated around NOK 400 billion oven the twelve-year period. These investments happen alongside the National Transport Plan for 2018-2029 that has been accepted by Norwegian parliament during 2016-2017.

The plan provides the general guidelines and decisions for developing of the national infrastructure. The main goal is to reduce transport costs, continue to link together the remote regions and locations, develop the modern transport system and promote the overall development of the Norway in order to achieve the economic growth and welfare. Another important task is to secure the high level of the environmental standards according to the Norwegian Climate Policy.

The information above underscores the fact that infrastructure projects are large investment projects that are extremely important for the entire country. Thus, securing the execution terms and construction quality, rational planning and accurate cost estimation are important tasks for the national prosperity. Most of the infrastructure projects are primarily financed by taxes and, in this case, the effective cost policy must be implied. Cost performance is the key factors for overall efficiency of the infrastructure projects on the national level.

In 2014 the Norwegian Public Road Administration were criticized by Office of the Auditor General of Norway for poor cost performance. They analysed the 70 contracts for road, bridges and tunnel construction projects of different sizes and found out the average cost overrun of 111% percent. Only 8 out of 70 projects were constructed within the initial budget. Among all the projects analysed there are presented many small and large projects with poor cost performance across different regions. For example, “E18 Bjørvikaprosjektet” with overrun of NOK 230 million equal to 576%, “FP3 Strandlykkja-Labbdalen” with NOK 75.5 million cost overrun or 141% and “E18 Gulli-Langåker” with 97% with NOK 55 million cost overrun and 97% over contract budget (Bordal, 2014).

This implies that cost overrun problem has not lost actuality over 30 years of academical research are prevalent (Cantarelli, 2011). Even technically advanced estimation methods cannot solve the problem completely due to many factors that affect the overall project cost performance. In addition, the political and psychological factors must be taken into consideration (Flyvbjerg, et al., 2002), as long as pathogenic influence of internal practices and policies (Love, et al., 2014b). The traditional methods for managing the cost performance in state organization imply reorganisations  (Odeck, 2014b) and enhancing of cost control practices with external and internal controllers (Andersen, et al., 2016). Different types of projects require different approaches, and improvement measures can unpredictably affect cost performance  (Økland, 2017).

The main threat of inaccurate cost estimate is infective usage of resources on regional and national level. This implies that resources spent on ineffective projects will later result in delays for implementation of other projects.  The negative effect can be observed in both cases of cost overrun and underrun. In first case the negative impact is obvious, but in the second case the project overpricing leads to budgeting of the unnecessary resources that affects the decision making with the same way (Flyvbjerg, et al., 2005).

Comparing the cost performance is also a challenge due to international differences including the geographical and climate conditions, remoteness, cost of materials and resources, cost of workforce, scale, innovativeness and many other differences that affect the overall national and cross-regional cost performance  (Cantarelli, 2011).

## 1.2 Research problem

The research problem of this study is to evaluate the cost performance in infrastructure projects of Norwegian Public Road Administration. The goal is to provide analysis of overall Norwegian experience in terms of cost estimation and to compare it with the results of similar national studies in Northern and Western Europe and worldwide. The problem is described with four research questions:

1. How has historically cost performance in Norway changed over time periods overall and for different types of projects?
2. How proficient is the Norwegian state organisation in comparison to other countries in t Northern and Western Europe in terms of cost estimation?
3. How do researchers explain the cost overrun in infrastructure projects in different regions?

4. What are possible ways to improve the national cost performance for road and fixed links projects?

## 1.3 Research objectives

The aim of this research may be divided into the following objectives:

1. To explore the background for cost estimation for the road and other infrastructure projects.
2. To explore the modern studies in cost performance.
3. To compare the Norwegian Public Roads Administration overall performance with state organizations from Northern and Western countries and worldwide.

## 1.4 Thesis structure

Chapter 1. Introduces the research problem, research questions and objectives.

Chapter 2. Describes the theoretical framework and presents two main Schools-of-though that research the problem of cost overruns in infrastructure projects. There are also provided potential causes and explanation to the phenomena.

Chapter 3. Describes the methodology for analysis of statistical data and for comparative analysis of studies in general. The chapter also presents challenges for comparative study. Explanations and limitations to the study object are given here.

Chapter 4. Introduces various national and international studies, samples and findings which are related to the study object.

Chapter 5. Provides case discussion in terms of qualitative and quantitative data found during the literature review. The cases are compared one by one with Norway in terms of overall cost performance, potential causes and solutions to the cost problem.

Chapter 6. Provides the summary of the previous chapter, common features and explanations found during the analysis. Detailed explanations for Norwegian cost performance and indicated potential threats are also provided in the chapter.

Chapter 7. Provides an overall conclusion to the study, recommendations, critics and answers to the research questions.

# Chapter 2. Theory

## 2.1 Schools-of-thought

A Business dictionary defines the “cost estimate” an approximates of the probable cost of a product, program, or project, computed on the basis of available information, and “cost overrun” as mount by which the actual cost exceeds the budgeted, estimated, original, or target cost.

According to modern researchers, nowadays there are two “*Schools of thought*” that try to explain the phenomenon of cost underestimation: “*Psycho Strategists*” and *“Evolution Theorists”* (as cited in Love, et al., 2016, p. 4).

The first school insists that underestimation of costs can be explained by a variety of groups of factors, but the *best fit* explanations to the research data are is exerted by psychological factors — "*optimism bias*"(underestimation of costs and overestimation of benefits) and political-economic — *“strategic misrepresentation”* (data manipulations for project initiation) (Flyvbjerg, et al., 2002, p. 14) (Flyvbjerg, 2007a, pp. 583-585). Later Flyvbjerg were criticised for making assumptions without the presenting the credible causality or scientific proofs to his conclusions (Love, et al., 2016, p. 5) and for overall generalization of findings on whole industry and chosen research method based on exclusively statistical information (Ahiaga-Dagbui & Smith, 2014a, pp. 8-9).

Opponents explain the underestimation of costs by the *theory of pathogens*, or, in other words, the hidden problems that the project actors do not suspect and do not take into consideration, however these pathogens affect the performance of the project. Theses pathogens are related to incorrect strategical decisions and lead to a large number of *change orders* from the initiation to completion phase and to excessive costs as a result (Ahiaga-Dagbui & Smith, 2014a). Supporting arguments for these statements can be found also in the studies of another modern researchers e.g Siemiatycki, (2015), Odeck, (2014a), Terrill, et al., (2016). Love refers to new methodology as *“balanced approach”* and his supporters try to contribute by enhancing usage of modern technologies for research and casualisation as for example artificial neural networks (Ahiaga-Dagbui & Smith, 2014b).

## 2.2 Causes and explanations

### 2.2.1 Flyvbjerg's approach

The first" statistically significant" cost study for the construction of infrastructure projects belongs to Professor Bent Flyvbjerg from Oxford University. In 2002, he collected statistical information on 258 major construction projects in 20 countries on 5 continents, trying to cover both developed and developing countries (Flyvbjerg, et al., 2002). This study become the source of inspiration for many subsequent articles e.g. Flyvbjerg, et al., (2003a; 2004a; 2004b; 2005) and (Flyvbjerg, 2007a; 2007b; 2009). He found out that underestimation of costs in infrastructure construction is systemic and is observed in all countries without exception. According to his sample of data, 9 out of 10 projects estimates are inaccurate and with 86% chance a randomly chosen projects will have higher costs than estimated (Flyvbjerg, et al., 2002, p. 8).

The provided explanations were divided into four groups: technical, economic, psychological and political.

The technical explanations are related to the imperfection of techniques and methods for estimating costs, inadequate or inaccurate initial data, errors and lack of experience, as well as the unpredictability of future and the general uncertainty of information. Uncertainty can also be explained by specific circumstances for road, railroad and other types of construction projects (Flyvbjerg, et al., 2005, pp. 14-15). All it leads to inaccurate forecasts and underestimation of possible costs. At the same time, he stresses that the influence of technical errors on the forecast should decrease with time (Flyvbjerg, et al., 2002, p. 14) and lead to the less biased distribution of errors in forecasts around zero (Flyvbjerg, 2007a, p. 584). The accuracy of the forecasts should increase, due to an accumulation of experience and the evolution of forecasting techniques (Flyvbjerg, et al., 2002, pp. 14-15) (Flyvbjerg, 2007a, p. 585). The technical explanations are referred as *"honest errors"* and considered as *"variables that influence cost overruns"*. This includes scope changes that are considered as a hidden problem that could not be predicted at the design stage (Cantarelli, 2011, p. 22) or can be specific for some regions and geographical areas (Odeck, 2004, p. 50). However, later, Flybjerg was widely criticised for radical exclusion of technical explanation from the studies (Osland & Strand, 2010, p. 78) (Love, et al., 2016, pp. 4-5).

Additional technical explanations were given in (Siemiatycki, 2015). Author considered *scope changes and change orders* as process of communication between contractor and various stakeholders in order to ensure the benefits from the project. The additional explanations presented are "*handover problems"* — delays in vertical communication between stakeholders; *incomplete studies* — initiation before all complete technical studies and *labour and material cost escalation* due to long terms, project delays and unforeseen events such as weather, safety threats, undocumented conditions and archaeological artefacts (Siemiatycki, 2015, pp. 3-4).

Economic interest, in turn, also influences the assessment of costs. Flyvbjerg in study from 2002 and later insisted that the participants involved in the construction project pursue their own mercantile interests: starting from firms involved in the development and analysis of the project, ending with entire cities and countries. In other words, the main goal of lobbyists and those who share the economic interest is the approval of the project by the authorities and its initiation, as this could potentially lead to additional benefits for the stakeholders themselves (Flyvbjerg & COWI, 2004). Even on condition that such distortion of facts is caused by altruistic desires, in the long run, this leads to the fact that a cost-inefficient projects will be initiated and accepted instead of potentially more beneficial for society projects (Flyvbjerg, et al., 2002, pp. 16-17), (Flyvbjerg, 2007a, pp. 585-586).

Excessive optimism and underestimation of the project risks can also serve as an explanation for biases. An explanation of this *"optimism biases"* can be a desire to initiate a project faster due to certain ambitions, personal attitude to the project or the expectation of a certain benefit over the economic interest. The additional factors of misinterpretations can be lack of knowledge and experience, inadequate perception of initial data or, an underestimation of risks, (Flyvbjerg, et al., 2002, p. 18), enforced by own organization (Siemiatycki, 2015, pp. 4-5) or due to unconscious nature of optimism bias — in other words, there is self-deception, which leads to errors in the estimates at the planning stage (Flyvbjerg, 2007a, p. 585). The researcher can fall under the influence of project's promoters which deliberately or not can lead to the "self-deception". Flyvbjerg also explains this with the fact that there is no significant penalty for overoptimistic estimates— therefore there is a trend (inheritage) for underestimation that has been going on for many decades, but he rejects "*appraisal bias*" (researcher-related) as a primary cause of inaccurate cost estimates (Flyvbjerg, et al., 2002, pp. 17-19).

Political explanations involve manipulating information. Numbers for large infrastructure projects are adjusted to the necessary requirements in order for the project to be initiated. This, in turn, leads to the fact that researchers can draw wrong conclusions, because the initial information for analysis does not reflect the reality. Any infrastructure project includes many risk groups that must be taken into account during planning and estimating costs (Flyvbjerg, et al., 2002), but they however are often gets deemphasised (Flyvbjerg & COWI, 2004) . Interested parties can submit a project without consideration of possible risks, in other words, if the project will occur in ideal conditions. Project promoters can also withhold some information from the decision makers to initiate the project. Thus, "hidden stones" will be discovered at a later stage of the project, for example during fulfilment phase and cause additional costs (Flyvbjerg, et al., 2002, pp. 17-19) (Flyvbjerg, et al., 2005, pp. 13-16) (Flyvbjerg & COWI, 2004). Although the explanation of the underestimation of costs by political and economic reasons has found considerable support among researchers (Cantarelli, 2011) (Siemiatycki, 2015), some authors emphasize that there are not enough studies for such controversial conclusions (Osland & Strand, 2010) and conclusions are that he “simply assumed optimism bias and strategic misrepresentation occurred without proving causal connections” (Love, et al., 2014b, p. 3)

On the basis of statistical information and based on own studies (Flyvbjerg, et al., 2002) (Flyvbjerg, et al., 2005) concludes that the main reason for underestimation of costs is the strategic misrepresentations. Therefore, he encourages other interested stakeholders who may suffer from such manipulations to demand transparency of information and to establish control over the evaluation, planning and implementation of construction projects. He arguments in addition for the involvement of private capital, as well as the establishment of regulatory procedures for the project development and implementation in order to improve the accountability of information for decision makers (Flyvbjerg, et al., 2002, pp. 22-24). He emphasizes, in addition, benchmarking, external and independent control and involvement of the different groups of institutes and researcher in order to force them to defend and argue their predictions and forecasts (Flyvbjerg, 2009, pp. 359-360). Involvement of private capital allows to establish the additional external control over the project and to test the project against market conditions, the government in this case must ensure concerns about safety and environment restrictions, as long as risk insurance and “effective usage of funds” (Flyvbjerg, 2009, p. 360). This idea was also supported by (Siemiatycki, 2015) who emphasises to take also into consideration technical causes and arguments for enhancing the techniques for analysis and estimating using the innovative methods and instruments. The other important proposals are to enhance sharing information using reporting and monitoring function and to increase the overall management and research competency of the staff (Siemiatycki, 2015, pp. 6-7).

### 2.2.2 Balanced approach

*The theory of pathogens* is based on (Busby & Hughes, 2004) as cited in (Love, et al., 2011). The summary of the ideas and various citations of these researchers are presented in the following text.

The procurement environment depends on the decisions made. In turn, the specifics of complex infrastructural projects do not allow one to fully predict how a particular decision will affect the project in the future. These wrong decisions remain dormant, neither for researchers, nor for performers, nor for decision-makers until their consequences become observable. Wrong decisions, in this case, appear in the form of pathogens, which are the result of a strategic misrepresentation and optimism bias. Pathogens exist for a long time and are invisible, in contrast to, for example, technical errors, but they affect the frequency and quality of errors, in other words, are the cause of error chronic occurrence. Pathogens include:

1) *Practice*: arising from people’s deliberate practices.

2) *Task*: arising from the nature of the task being performed.

3) *Circumstance*: arising from the situation or environment the project was operating in.

4) *Organization*: arising from organizational structure or operation.

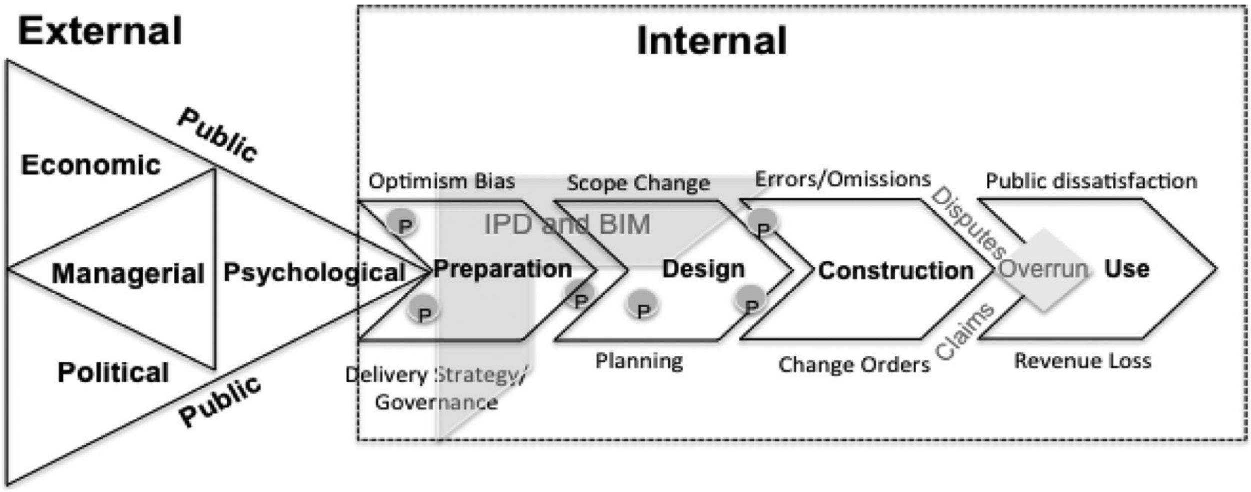
5) *System*: arising from an organizational system.

6) *Industry*: arising from the structural property of the industry.

7) *Tool*: arising from the technical characteristic of the tool (e.g., software).

A balanced approach presupposes an “*outside view*” and “*inside view*” on the causes of the cost and schedule overrun and how their impact on the project. Flyvbjerg's approach presupposes the influence of external factors on the project isolated, while internal factors presented above are also cause errors and inaccurate cost estimates. Thus, it is necessary to take into account not only the "outside view" which includes economic, political and psychological factors, but also factors that characterize the internal environment influencing decision-making - "inside view", because on the basis of one-sided analysis one cannot trace the causal relationship according to Love, et al., (2014b) Figure 1, demonstrates the relationship of these two points of view.

*Figure 1. External (outside) and internal (inside) views of cost overruns. P denotes pathogens, IPD is integrated project delivery, BIM is building-information modelling (Love, et al., 2014b).*




According to the author, the inside view takes into account internal technical reasons, which include "*changes in scope, change orders, planning mistakes, and errors or omissions in contract documentation"* as cited in (Love, et al., 2014b, p. 8). Unlike the outside view, which *"relies on precedent"* (Love, et al., 2014b, p. 2). Thus, Love emphasizes the importance of an innovative approach to cost estimation. This applies not only to evaluation methods and tools that are getting upgraded alongside with evolution of the research thought, but also usage of qualitative research in order to modernize the internal organizational environment, since generally accepted practices are not always keeping up with progress. For the same reason, the use of past experience to modern realities is impossible, because the system changes with time and its dynamics does not remain constant (Love, et al., 2014b, p. 15)

# Chapter 3. Methodology

## 3.1 Methodology

The research objects in this work are the national studies of the countries of Northern and Western Europe, as well as international studies of Europe and the world. The provided basis of data will help to characterize the regional and the world experience in the management of cost overrun. In Chapter 4, 12 studies of cost performance have been analysed in detail. On their basis, summary tables have been compiled. They include data on project samples systematized by time periods, type, size and author. The data include the results of quantitative studies in Norway, Sweden, the Netherlands and Germany, as well as well-known international samples for Europe and the world. The methodology is directly related to research questions.

The purpose of the study is to characterize the Norwegian Public Road Administration which has the overall responsibility for transport and infrastructure construction in Norway, including roads, bridges, tunnels and other related projects such as modernization and maintenance.

The national research data from other countries includes other types of infrastructure projects, such as railway projects, dams, airports and others. In order to compare the results of quantitative research, the summary data in most studies need to be revised and projects that are not of interest for the current study must be excluded. In Chapters 4 and 6, many of the samples submitted by the authors were recalculated according to the reduced sample sizes.

To correct the mean cost overrun data, the standard weighted average formula was used. This method of calculation is chosen based on following researches: Økland, (2017), Odeck, (2014b) and Cantarelli, (2011), where the calculation method is adopted for grouping the samples of data.The formulas for mean cost overrun and standard deviation are shown below, where $f$ is the number of occurrences, and $x$ is cost overrun:

$$Mean = \frac{\sum f_i x_i}{\sum f}$$

The mean is useful for characterising the samples or grouped data. It provides information about what cost overrun is the most expected among projects in the sample. But at the same time, with a very scattered distribution of cost overruns, the parameter can provide a deceitful perception about the sample. In order to provide a more detailed picture it needs to correlate the results with spread around the mean. The simplest way to describe the dispersion of data is to calculate the standard deviation using the following formula:

$$Standard\ deviation(SD) = \sqrt{\frac{\sum f_i {x_i}^2}{\sum f_i} - \left(\frac{\sum f_i x_i}{\sum f_i}\right)^2}$$

For the grouped data we use weighted average formula proportionally distributing the mean across the grouped sample and dividing by sum of all weights. However, to find an average standard deviation, the following formula is used:

$$Pooled\ Standard\ Deviation = \sqrt{\frac{\sum f_i SD_i^2}{\sum f_i}}$$

Taking these two parameters together we can avoid the potential pitfalls by using the average numbers, but in all cases the statistical method has their limitations. However, the cross-case analysis is adopted by the researchers and follows this general framework when providing a conclusion for their findings in almost all presented studies in Chapter 4. Formulas are commonly known and presented in various studies across the literature for statistical analysis for example in Cohen, (1988) and Hedges & Olkin, (1985).

Comparative analysis of the studies is not limited to statistical analysis. The findings, conclusions and explanations are also used in Chapter 4 and 5 for discussion. It needs to not only present the numerical data, but also to provide a qualitative analysis for common causes and potential solutions to the cost overrun problems and poor performance in terms of cost estimation. Therefore, it is needed to provide a detailed literature overview and include the all sort of data from international studies. This will allow to make an augmented conclusion about the Norwegian cost performance in comparison with other national studies.

## 3.2 Challenges

It is necessary to take into account *the limited data* and the fact that the presented samples cannot accurately characterize the region, since they do not include enough data on the projects. The problem is simply persist due to the lack of a sufficient number of national studies, so one has to rely on small amount of the studies in this area. This problem implies the possible low reliability of the data obtained when characterizing entire countries and regions. This problem will decrease with time, as new national and international studies appear. Many conclusions and hypotheses can be confirmed and refuted with the appearance of a sufficient basis for the study (Flyvbjerg, 2016). In addition, there are formal barriers can still take place when information about projects is provided only to a narrow group of researchers. It is difficult or impossible to find in open sources, or it requires a large number of resources. Due to the limited data from national studies, the research object remains relatively small. This is possible to compensate for through international research, but some of the data on national projects can be included into international samples. This information cannot be isolated from the study without detailed data which only the researchers themselves have such as in case of sample from Cantarelli, (2011). For the same reason, railway projects are excluded from the study and the sample data is recalculated in Chapter 5. Also, little attention is paid to the problem of time overruns due to the fact that these studies are not presented in the national studies.

Different countries use *a variety of methods* to estimate project costs. However, statistical information in research basis is used to model and create tools for more accurate cost estimation. The goal of the researchers is to improve the methods and model the cost problem, but the initial data itself is objective — taking into account the *reliability of the sources* (Osland & Strand, 2010). The same methods for statistical analysis are adopted by the majority of the researchers in this paper. They follow the standard methods for statistical analysis are commonly known and presented in Cohen, (1988) and Hedges & Olkin, (1985) and in different special litterature that provides theoretical basis for statistical analysis. Initial data is primarily based on projects planned and actual cost. The source of such data is the documentation from initiation and control documents. One must not exclude the fact that researchers could receive incomplete or false data if the source was not interested in an objective research (Flyvbjerg, et al., 2002).

## 3.3 Initial data

The initial data and its analysis are detailed in the next chapter in order to avoid duplication of information. The data includes national studies from Norway, Sweden, the Netherlands and Germany. Also, the analysis includes a wide bibliography from other regions as examples and arguments for the conclusions in Chapter 5. The most complete data about national studies is related to Norway. The studies are grouped by data sources. Thus, several cases were formed to accordance with country of origin. Findings and comparative analysis presented in Chapter 5. The main focus is on the comparison of Norwegian case results with other national and international cases.

# Chapter 4. Data Analysis.

## 4.1 Norway

The last 15 years in Norway are characterized by huge state financial investments in infrastructure development.

Over the past few decades, state organizations in Norway have undergone many changes, in particular the Norwegian Public Road Administration has been restructured several times in the period 1993-2015. Thus, all major empirical studies on the excess costs in infrastructure are differentiated not only by the size of the projects, but also by the period in which they were completed (Odeck, 2014a), (Økland, 2017). This creates certain problems for data comparison, because some projects overlap the conditional boundaries between the evaluation periods (Odeck, 2014a, p. 72). Odeck, (2014b, p. 5) defines three main periods depending on the organizational form for NPRA:

1) *Monopolistic organization 1993 - 1996* - government organization only was in charge for procurement and fulfilment of road construction projects.
2) *Semi-monopolistic organization 1997 - 2002* - restructured NPRA consisted of two separate divisions responsible for project planning and construction.
3) *Full competition period 2003 - 2007* - building division was privatized and started to compete on tenders with other market participants, NPRA became a procurer only.

The most meaningful, last period was characterized by the involvement of private entrepreneurs, as well as external audit from third part organizations. There are several major studies devoted to Norwegian infrastructure construction projects. The selection of data represents a construction projects completed by the Norwegian Public Road Administration in the period 1993-2015 arranged by periods and projects sizes and summarized in Table 1 (Odeck, 2014a) (Økland, 2017).

*Table 1. Summary of cost overrun quantitative studies for Norway.*

| Source | Type | Projects total | Projects with overrun | Freq. overrun | Mean overrun | Standard deviation | Min (%) | Max (%) |
|---|---|---|---|---|---|---|---|---|
| **Odeck, 2004** | Roads | 620 | 325 | 52.4% | 7.9%* | 29.2% | -58.5% | 182.7% |
| **Odeck, 2014** | Roads | 1045 | - | - | 10.3%* | 36.9%* | -67.0% | 800.0% |
| **Økland, 2017** | Roads | 1987 | 1171 | 59.0% | 11.5%* | 35.4%* | -69.0% | 800.0% |
| | Roads/time | 1987 | 739 | 37.4% | 17.0%* | 71.0%* | -97.8% | 1833.0% |
| **Welde, 2017** | Roads | 41 | 12 | 29.3% | -6.7% | 17.6% | - | - |
| | Railroads | 7 | 1 | 14.3% | -6.1% | 10.4% | - | - |

** The data were derived from the data presented, but were calculated using the formula weighted average of projects total in percent and pooled standard deviation*

The table presents the final results of the analysis of statistical data for three different samples, sorted by authors. The studies from Odeck, (2004) indicate that about half of all road construction projects occur with an underestimation of costs and exceed planned cost margins. Mean overrun is 7.9%, while in the extended sample from 2014 of 1045 projects shows a higher cost overrun and is 10.3%. The most comprehensive study of Økland shows mean cost overrun of 11.5% based on larger sample of 1987 projects.

The overall standard deviation for all three periods remains approximately at the same level but differs significantly between groups of different sizes (Odeck, 2014a, p. 74). That is demonstrated in Table 2. The standard deviation is relatively big for all projects, but given the heterogeneity of the projects, this is not surprising. The greatest standard deviation is observed for time overruns, which indicates that there is a strong deviation from mean estimate in the sample, in other words, the estimate values are much scattered and is higher for schedule overruns than for cost overruns.

On the basis of generalized data from the table from 1993 to 2015, one can draw a hasty conclusion that overall the reforms did not bring any benefit, but this is not true. The average simplified data from the table does not provide a complete picture, since the calculation formula takes into account only the number of projects but ignores the structure for cost overrun in absolute values. A summary table is presented below.

*Table 2. Summary of cost studies by James Odeck.*

| Source | Type/ Size | Group (ml of units) | Sample structure | Mean overrun | Mean abs. value | Absolut overrun (ml NOK) |
|---|---|---|---|---|---|---|
| **Odeck, 2004** | Roads | | 100% | 7.9% | 0.84% | 519 |
| **(1992-1995)** | Very small | <15 NOK | 67.7% | 7.6% | 0.4% | 146 |
| | Small | 15-100 NOK | 25.2% | 10.6% | 3.3% | 517 |
| | Medium | 100-350 NOK | 5.3% | 2.5% | 1.7% | 58 |
| | Large | >350 NOK | 1.8% | -2.5% | -18.3% | -202 |
| **Odeck, 2014** | Roads | | 100% | 10.3% | 41.6% | 1743 |
| **(1993-2007)** | Small | <50 NOK | 84.4% | 11.0% | 43.7% | 761 |
| | Medium | 50-100 NOK | 6.3% | 6.5% | 15.4% | 268 |
| | Large | >100 NOK | 9.3% | 6.9% | 41.0% | 714 |
| **Odeck, 2014** | Roads | | 100% | 8.2% | -16.6% | -442 |
| **(2004-2007)** | Small | <50 NOK | 76.4% | 11.0% | -54.1% | 239 |
| | Medium | 50-100 NOK | 8.7% | 4.0% | -27.8% | 123 |
| | Large | >100 NOK | 14.9% | -4.0% | 181.9% | -804 |

The distribution by size of projects in all three samples is uneven. The largest group is projects less than NOK 50 million that are considered as small or very small projects. In all three periods this group dominates by the number of projects. The share of small projects in the first study from 2004 is 67.7% in the second and third 84.4% and 76.4% respectively. The share for the larger scale projects increases by the third period of study, whereas share of medium projects decreases over time. This distribution of number of projects affects the mean cost overrun parameter, since calculation formula evaluates projects of different sizes equality and without any priority, considering only deviation from planned cost in percentage.

The cost overrun is observed on average in 52.4% of the projects. The study from 2004 shows that in very small projects the expected cost overrun is 7.6%, in small 10.6% in medium and large - 2.5% and -2.5% respectively. The cost overrun for the bigger sample from 2014 shows cost overrun of 11.0% for small projects, 6.5% for medium and 6.9% for larger-scale projects over NOK 350 million. However, the results from the third period of full competition vary greatly from average cost overrun from all three periods. The latest results demonstrate 11.0% cost overrun for small projects, 4.0% for medium and - 4.0% for the major projects which are close to the study from monopolistic period in terms of distribution among different group sizes. However, they latest study shows the dramatical increase in the number of major projects and this greatly changes the perspective from which we must evaluate the overall results of the study.

Although the cost overrun in percentage for large projects is relatively small, the distribution of shares in overall cost overrun for the country is completely different. In the first study, the share of large projects group in absolute overrun was accounted for 58%, but from the 2004 researchers observe an increase in total number of larger projects. The share of major projects in the absolute value of costs for the period was approximately 77% (Odeck, 2014b). This corresponds that small and medium projects account for only one fourth of the total costs overrun for the whole infrastructure sector. Since this group experienced the cost underrun then the expected mean cost overrun in absolute value is -16.6% and equal to NOK 804 million underrun in the third period. Over three years, 43 projects were implemented, although for the entire period of 14 years the excess costs amounted to NOK 714 million. The weighted values of the expected deviation for the first, second and third samples are 7.9%, 10.3% and 8.2%, respectively.

One possible explanation for large cost overrun for small projects is the *magnitude of tendering*, which means tender competition is more common for medium and larger projects, because NPRA tends to directly purchase services for smaller projects (Odeck, 2014a, p. 76).

The conclusion can be twofold: on the one hand it can observe an effective system for cost estimation, on the other hand, overestimation of costs and budgeting more resources than needed can be perceived as negative tendency since it retracts resources from another potentially profitable or meaningful project (Flyvbjerg, et al., 2003a). In any case, this contrasts with the opinion of some authors that large infrastructure projects are statistically more prone to cost underestimation (Flyvbjerg, 2007a, p. 581). However, this can also be explained by the excessive risk premium that is pawned into the project at the design and development stage and may be associated with marked uncertainty and desire to insure against all possible risks (Welde, 2017, p. 30), but this assumption is more relevant to an innovative projects, where the risk premiums are much more significant and effect of optimism bias is much more crucial (Siemiatycki, 2015).

The Table 3 is compiled from the data of the study by Trym Kristian Økland. It covers 1987 projects for the period 1993-2015. More recent data provides a new look on a cost overrun problem.

*Table 3. The modern researches of cost overrun problem in Norway.*

| Source | Type/ Size | Group (ml of units) | Sample structure | Mean overrun | Standard deviation |
|---|---|---|---|---|---|
| **Økland, 2017 (1993-2015)** | Roads | 1987 | 100% | 11,5% | 35.4% |
| | Small | <30 NOK | 65,9% | 13,0% | 40.0% |
| | Medium | 30-200 NOK | 24,8% | 9,9% | 26.0% |
| | Large | >200 NOK | 9,3% | 4,9% | 17.2% |
| | Roads/time | 1987* | 100% | 17,0% | 71.0% |
| | Small | <30 NOK | 65,9% | 21,3% | 84.6% |
| | Medium | 30-200 NOK | 24,8% | 10,3% | 32.0% |
| | Large | >200 NOK | 9,2% | 3,9% | 27.4% |
| **Økland, 2017 (2004-2015)** | Roads | 1187* | 100% | 12,4%* | - |
| | Small | <30 NOK | 65,9% | 14,6% | - |
| | Medium | 30-200 NOK | 24,8% | 10,2% | - |
| | Large | >200 NOK | 9,3% | 2,2% | - |
| | Roads/time | 1187* | 100% | 21,8%* | - |
| | Small | 751 | 63,3% | 28,3% | - |
| | Medium | 318 | 26,8% | 14,0% | - |
| | Large | 118 | 9,9% | 1,5% | - |

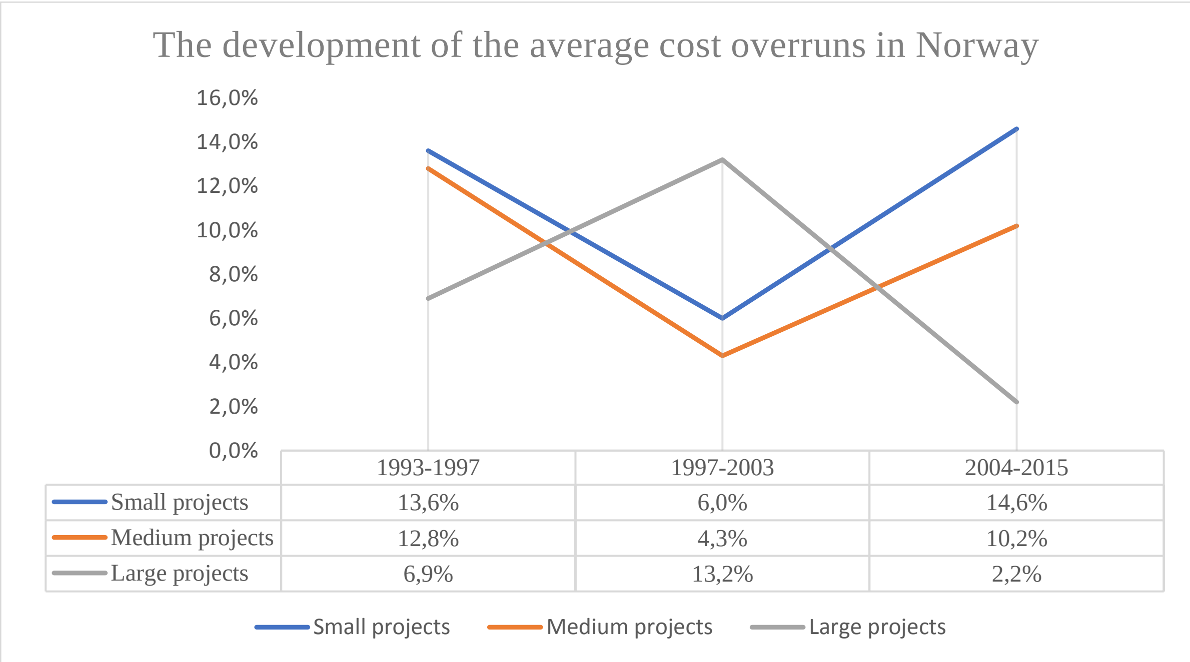
** The numbers are calculated based on empirical data from the study. Some discrepancies are possible due to rounding of data*

The table shows two data blocks. The first block covers statistical information for all three periods of 1993-2015. The second block covers only the period of free competition. Data on time overruns for each size group and general values of the indices calculated according to the formula of the weighted average.

In general, the structure is more similar to the previous studies from Odeck. The share of smaller projects is also dominant and is between 63-66% of total number of the projects. About 25% account on medium-sized projects and 10% on larger projects. The mean value of cost overrun for the small projects is the largest and is 13% on average and 14.6% for the period of full competition.

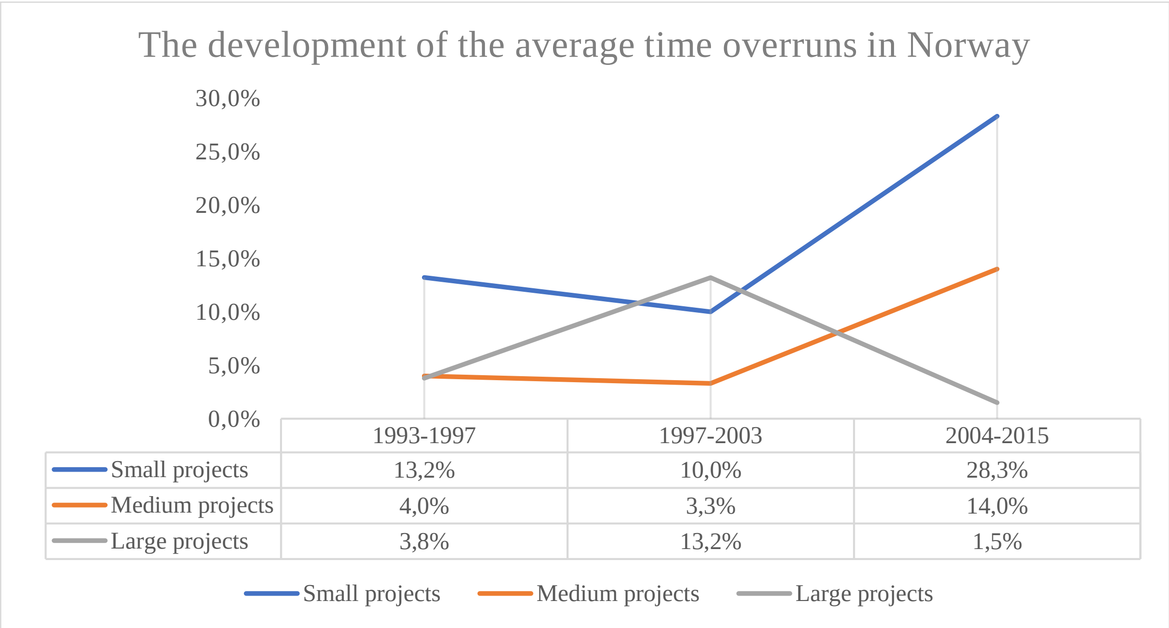
Medium projects have a mean cost overrun of 10%. The smallest cost overrun have projects over 200 million at 4.9% and 2.2%, which generally repeats the results from previous studies — large projects have the lowest cost overrun. Average cost overrun for the whole sample provided by Økland is 11.5% for three periods and 12.4% for 2004-2015.

*Figure 2. The development of the average cost overruns in Norway (Økland, 2017)*




If one look at the dynamics, in the second period, semi-monopolistic period the cost overrun for small and medium projects decreased from 13.6% to 6% and from 12.8% to 4.3%. However, at large projects, this was reflected sharply negatively and overrun increased from 7% to 13.2%. The reform in 2004 led to a reverse picture. The deviation from the plan for small projects was 14.6%, and for the medium-sized 10.2%, larger projects were calculated much more accurately, and the overrun on average was only 2.2%. Thus, the transition from a monopoly system to a bipolar one had a good effect on small projects, but for large ones the effect turned out to be inverse. After the transition to free competition, the situation changed to directly opposite. Given the importance of large infrastructure projects and their significant share in the economy, we can conclude that the reform was more than justified and effective. However, an interesting situation arises, according to Odeck, 2014b, (pp. 14-15) the magnitude of costs for all cost groups decreased, and for major projects after all reforms overrun was replaced by underrun, which is confirmed by the study for 41 major infrastructure projects presented in Table 1 by (Welde, 2017).

*Figure 3. The development of the average time overruns in Norway (Økland, 2017)*




Time overruns have an even more contrasting results. Delay in time in small projects on average for all three periods is 21.3% and 28.3% in the last period. The explanation for this is that small projects have a short lead time and therefore delays more significantly affect statistical data (Økland, 2017, p. 31). However, this explanation is not suitable for medium-sized projects, moreover, in the previous two periods time overrun was 4.0% and 3.3%. Growth to 14.0% in the third period can thus only be explained in part and not for all projects. For large projects, the situation is repeated, as is the case with cost overruns. The decrease due to transition to full competition decline in time overrun was 11.7 p.p and reached an absolute minimum of 1.5%.

According to the Økland's study, in 31.6% of small projects cost overrun does not exceed the threshold of 10%, the same value is 35.6% for medium-sized projects and 47% for large projects. The magnitude is much more uncertain for small projects, where over 40% of projects exceed the 25% mark. The situation is similar for medium-sized projects, where a cost overrun of 25% or more was observed in 33.6%, at the same time one tenth of all projects' overruns were above 50%. This is much better than in the case of small projects, where a little less than one fifth of the projects exceeded the 50% mark. The best magnitude for cost overrun is observed for larger projects where overrun only in 4% of cases exceeded 50%, and a solid 30% remained within 10-25%.

In the case of schedule overruns for medium and large projects, the situation is generally similar. The only the exception is group of small projects whereas the chances of a time overrun are lower, but the magnitude shifts to a maximum exceeding the 50% —small projects take less time, as mentioned above. The dynamics for three periods is primarily positive — the risk of exceeding costs by 50% or more in 1993-1996 was 15% in 2004-2015 only 2%, which by 7 p.p. lower than on average (Økland, 2017, pp. 5-9).

## 4.2 Sweden

Sweden from all European countries in this study is the most closely geographically to Norway. Regions share similar natural and climatic conditions and are generally close in terms of economic and social development. Sweden in this study is represented by a sample of 102 road and 65 railway projects based on the data of the Swedish Transport Administration by Mattias Lundberg and his colleagues. Projects, like in the case of Norway, are grouped by type and size. Also, the study has links to the reports of the Swedish National Audit Office and the sample for comparison of the author himself, which are also reflected in the table below.

*Table 4. Summary of cost overrun quantitative studies for Sweden.*

| Source | Type/ Size | Projects total | Mean overrun | Standard deviation | Min | Max |
|---|---|---|---|---|---|---|
| **Lundberg, 2011 (1997-2009)** | Roads | 102 | 11.1% | 24.6% | -46.6% | 134.4% |
| | Rail | 65 | 21.1% | 50.5% | -54.2% | 250.0% |
| | Total | 167 | 15.0% | 37.1% | -54.2% | 250.0% |
| **Lundberg, 2011 - World** | Sample/Road | 3988 | 8.1% | - | - | - |
| | Sample/Rail | 300 | 45.7% | - | - | - |
| **Riksrevisionen, 2010-2011**** | Roads | 35 | | - | 8.0% | 18.0% |

| | Rail | 28 | 55.0% | - | - | - |
|---|---|---|---|---|---|---|

**sample presented in the study*
***as cited in (Lundberg, et al., 2011, p. 3)*

Analysis of 102 infrastructure projects demonstrates a mean overrun of 11.1%, which is broadly close to the Norwegian results, where mean overrun is 11.5%. The standard deviation is lower than calculated for Norway by 10 p.p., which means that the distribution of inaccuracy is closer to the expected value and uncertainties are not so significant. The largest share of the costs overruns remains within 25% providing the magnitude for cost overruns similar to Norway (Lundberg, et al., 2011, p. 7). Unfortunately, the detailed data is not given. For Norway, depending on the size of the project, about 59.3- 77% of projects with cost overrun remains within margin of 25% (Økland, 2017, pp. 6-9).

*Table 5. Cost overrun in Sweden by project size.*

| Source | Type/ Size | Group | Sample structure | Mean overrun | Standard deviation | Share of sum overrun |
|---|---|---|---|---|---|---|
| **Lundberg, 2011 (1997-2009)** | Roads | 102 | 100% | 11.1% | 24.6% | 100.0% |
| | Very small | <100 SEK | 30.4% | 29.1% | 34.0% | 27.4% |
| | Small | 100-500 SEK | 52.9% | 2.8% | 14.3% | 20.1% |
| | Medium | 500-1000 SEK | 9.8% | 3.1% | 8.4% | 16.3% |
| | Large | >1000 SEK | 6.9% | 6.3% | 8.6% | 36.2% |

Before the comparison, it is necessary to pay attention to the fact that small projects are SEK 500 million or approximately €50 million. In 2010, the approximate ratio of the Swedish krone to the Norwegian one was about 0.84 to 1, which indicates that very small projects in this study are projects up to NOK 80 million, and small to NOK 400 million, while in the Norwegian sampling, these projects are considered as large, therefore directly projects on the size cannot be compared. Despite this, similar trends are emerging. In particular, very small projects have a much greater mean cost overrun and standard deviation than larger ones.

A "tremendous" decrease in mean cost overrun can be observed for all projects above SEK 100 million from 29.1% to 2.8-6.3% depending on the size of the project. The share of small and very small projects is 30.4% and 52.9%, respectively. At the same time, each of these accounts for 27.4% and 20.1% of the total overruns for road projects, respectively. Similar information can be found in Odeck, (2014a), where the main amount of cost overrun also observed mainly among small and very small projects. At the same a significant underrun in large projects the resulted in mean overrun below zero. Here the share of costs of 10 medium and large 7 projects over SEK 500 ml in absolute value is more than 52.5% of the total amount of total cost overrun in the given sample.

## 4.3 The Netherlands

The Netherlands is the next European country that is of interest to this study. Geographically, the country is in more southern latitudes and geography is quite different from the Scandinavia, this includes flatter terrain and higher dependence on water ways and large share of fixed links projects. The Netherlands is characterized as a country with high economic development and refers to developed countries. An organization that deals with infrastructure projects — the department of the Ministry of Transport, Public Works and Water Management (Rijkswaterstaat) “has responsibility for design, construction, manage and maintain infrastructure networks in the Netherlands, including roads, waterways and water systems” (Rijkswaterstaat, 2018).

The Chantal C. Cantarelli studies from 2011 and 2012 includes 78 infrastructure projects, including 37 road projects, 26 railway and 7 bridges and 8 tunnels. The information is presented in the table below and includes a sample of 459 infrastructure projects implemented in Eastern Europe and includes: Switzerland, Germany, Denmark, France, Norway, Sweden, United Kingdom and Hungary.

*Table 6. Summary of cost overrun quantitative studies for The Netherlands.*

| Source | Type/ Size | Projects total | Projects with overrun | Freq. overrun | Mean overrun | Standard deviation |
|---|---|---|---|---|---|---|
| **Cantarelli, 2012a (The Netherlands 1980-2010)** | Total | 78 | 43 | 55.1% | 16.5% | 40.0 |
| | Roads | 37 | 23 | 62.2% | 18.6% | 38.9 |
| | Rail | 26 | 13 | 50.0% | 10.6% | 32.2 |
| | Fixed Links | 15 | 7 | 46.7% | 21.7% | 54.5 |
| **Cantarelli, 2012a (NW Europe)** | Total | 459 | - | - | 22.7% | 33.8 |
| | Roads | 315 | - | - | 20.9% | 30.2 |
| | Rail | 90 | - | - | 22.3% | 34.9 |
| | Fixed Links | 54 | - | - | 31.5% | 48.6 |

62.2% of Dutch road projects have average mean cost overrun of 18.6%, the spread of the values is very large. The high standard deviation means that the projects deviate significantly from the expected value, which in turn affects the accuracy of the estimates. Fixed links however have the largest mean overrun of 21.7% and the maximum standard deviation of 54.5. The average cost overrun for railway projects is the best in the sample and is 10.6% with a standard deviation of 32.2. The table also presents the international sample of the author, where mean cost overrun is 20.9% for road projects, 22.3% and 31.5% for railways and fixed links. Cost performance based on project sizes is presented in the table 7. The data includes railway projects, so it should be taken into account when comparing.

*Table 7. Cost overrun in the Netherlands by project size*

| Source | Type/ Size | Group | Sample structure | Mean overrun % | Standard deviation | Share of sum overrun |
|---|---|---|---|---|---|---|
| **Cantarelli, 2012b (The Netherlands 1980-2010) *** | Total | 78 | 100% | 18.6% | 40.0 | 100.0% |
| | Small | < €50 | 30.8% | 18.5% | 40.5 | 6.3% |
| | Medium | €50-112.5 | 28.2% | 23.2% | 53.2 | 35.0% |
| | Large | €112.5-225 | 16.7% | 7.0% | 29.3 | 9.0% |
| | Very Large | > €225 | 21.8% | 10.9% | 26.7 | 49.7% |

**including the railway construction projects*

Unfortunately, it is not possible to exclude railway projects from the sample due to a lack of complete data about sample, but it can be assumed that the effect of the group of railway projects on cost performance gives a positive effect and reduces the average deviation, as the data in Table 6 concerning railways have better mean overrun than other types of projects.

Small projects in the study are projects worth less than € 50 million, which makes it difficult to compare the basis data with those presented in Table 7, since this amount is equivalent, roughly, to NOK 400 million at the 2011 exchange rate, which includes both small and large projects from the study of Økland. The share of small projects is 30.8%, which is 6.3% of the total cost overrun. The mean deviation, at the same time, is 18.5% with a wide spread of values of 40.5. The share of medium projects, according to Cantarelli estimates, is 28.2% with a cost overrun of 23.2% and an even larger standard deviation. Medium projects account for 35% of the total cost overrun. Large and very large projects have overrun of 7.0% and 10.9%, respectively, with a smaller standard deviation, and each group accounts for 9% and 49.7% of total cost overrun respectively. Thus, large and very large projects account for about 60% of total excess costs, and their share in the sample is 40%.

Cantarelli (2011), also carried out a quantitative analysis of cost performance for different stages of the project, the results are presented in Table 8.

*Table 8. Cost performance for different project stages.*

| **Source** | **Projects** | | **Cost overrun(CO)/ underrun(CU) in preconstruction phase** | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | **Mean** | **SD** | **Freq. CU** | **CU %** | **Freq. CO** | **CO %** |
| **Cantarelli, 2011** | Total | 37 | 19.7% | 32.6 | 29.7% | 6.5% | 70.3% | 30.8% |
| | Road | 23 | 17.6% | 33.5 | 21.7% | 12.4% | 78.3% | 26.0% |
| | Rail | 11 | 21.5% | 33.1 | 45.5% | 2.0% | 54.5% | 41.0% |
| | Fixed links | 3 | 29.0% | 33.7 | 33.3% | 0.0% | 66.7% | 43.5% |
| | **Projects** | | **Cost overrun(CO)/ underrun(CU) in construction phase** | | | | | |
| | | | **Mean** | **SD** | **Freq. CU** | **CU %** | **Freq. CO** | **CO %** |
| | Total | 37 | -4.5% | 14.4 | 62.3% | 13.1% | 37.8% | 9.5% |
| | Road | 23 | -2.9% | 15.2 | 5.2% | 13.7% | 47.8% | 8.9% |
| | Rail | 11 | -6.9% | 1.2 | 81.8% | 12.0% | 18.2% | 16.0% |
| | Fixed links | 3 | -8.5% | 10.1 | 66.7% | 14.1% | 33.3% | 2.7% |

Dutch infrastructure projects have high mean cost overrun in preconstruction phases such as design and project planning. The frequency of cost overrun for pre-construction phase is significant. The study shows that for road projects, mean overrun is 17.6% at an early stage and -2.9 in the construction phase. For railway projects, the difference is even larger and amounts to 21.5% in the early phase and -6.9% in the construction phase. Bridges and tunnels also have a big difference in the indicator and are 29.0% in the first phase and -8.5% in the second, respectively. In addition, the cost overrun frequency increases and is 70.3% for the planning and design phase and 37.8% for the construction phase. In addition, in the first phase, the standard deviation for all projects is 32.6, and for the second phase, the spread is half that amount and is 15.2 for roads, 1.2% for railways and 10.1 for bridges and tunnels.

## 4.4 Germany

A Cross-sectoral Analysis provided by Genia Kostka and Niklas Anzinger analyses 170 projects with a total cost of € 141 billion between includes a sample of 51 single projects including the transport sector. Among them, 20 completed road projects are of greatest interest. The data are presented in Table 9

*Table 9. Cost overruns in Germany*

| Source | Type/ Size | Projects total | Overrun (%) | Min (%) | Max (%) |
|---|---|---|---|---|---|
| **Kostka & Anzinger, 2015 (1960-2014)** | Total | 30 | 30% | -23% | 364% |
| | Road | 20 | 30% | -23% | 125% |
| | Rail | 6 | 34% | -9% | 59% |
| | Fixed links | 4 | 27% | 11% | 364% |

A sample represents major infrastructure projects including roads, rail and fixed links. For roads, the cost ranges from € 480 million, to € 1.6 billion, for railway projects from € 4 billion and for tunnels and bridges from € 15 million to € 5 billion (Kostka & Anzinger, 2015, pp. 6-10). For transport projects, mean cost overrun is 30%. Road projects have mean cost overrun of 30%, the railways have mean overrun of 34% and bridges and tunnels have lowest overrun of 27%. Other data in the study represents the unfinished projects, where costs overrun os 17% for roads and 27% for railways. However, the projects listed in Table 8 are of primary interest. Although the statistical data is narrow, the study provides a lot of information for discussion which can be found in Chapter 4.

## 4.5 Major international studies

International studies provide a universal basis for comparing individual national studies. Major international samples are the most important tool for benchmarking in terms of cost performance for smaller isolated studies and for the certain regions.

There are not many international studies concerning cost overrun. The most significant and large have already been presented in this paper. The first sample belongs to (Flyvbjerg, et al., 2002) and includes 258 major infrastructure projects, of which 181 are projects from Europe. The second group of studies belongs to Cantarelli, which includes a sample of 806 projects from around the world, including the Dutch projects, as well as 459 projects from Europe

(Cantarelli, et al., 2012a, p. 7) The most recent sample is made by Bent Flyvbjerg and his colleagues and includes data on 2,062 projects from all over the world (Flyvbjerg, 2016). The information is presented in Table 9. The table includes data on large road infrastructure projects, railways, tunnels and bridges.

*Table 10. Cost performance. International data.*

| Source | Project type | Sample | Mean overrun* | Standard deviation** |
|---|---|---|---|---|
| **Flyvbjerg, 2002 (World)** | Total | 258 | 27.6% | 38.7 |
| | Roads | 167 | 20.4% | 29.9 |
| | Rail | 58 | 44.7% | 38.4 |
| | Fixed links | 33 | 33.8% | 64.4 |
| **Flyvbjerg, 2002 (Europe)** | Total | 181 | 25.7% | 28.7 |
| | Roads | 143 | 22.4% | 24.9 |
| | Rail | 23 | 34.2% | 25.1 |
| | Fixed links | 15 | 43.4% | 52.0 |
| **Cantarelli, 2012a (World)** | Total | 806 | 24.5% | 37.8 |
| | Roads | 537 | 19.8% | 31.4 |
| | Rail | 195 | 34.1% | 43.5 |
| | Fixed links | 74 | 32.8% | 58.2 |
| **Cantarelli, 2012a (NW Europe)** | Total | 459 | 22.7% | 33.8 |
| | Roads | 315 | 20.9% | 30.2 |
| | Rail | 90 | 22.3% | 34.9 |
| | Fixed Links | 54 | 31.5% | 48.6 |
| **Flyvbjerg, 2016*** (World)** | Total | 1895 | 15.6% | - |
| | Roads | 1401 | 13.4% | - |
| | Rail | 338 | 23.8% | - |
| | Fixed links | 146 | 18.9% | - |
| **Lundberg, 2011** | Road | 3988 | 8.1% | - |
| **(World)** | Rail | 300 | 45.7% | - |

**Certain mean overruns are calculated based on data provided by the researchers using the weighted average (pooled average for standard deviation) if values were not presented in the original studies*

***Standard deviations are given in "millions of euros" as in original studies*

****The sample from the table includes only bridges, tunnels, roads and railroads, without dams, power plants. BRT projects are combined with road projects. Mean overrun is recalculated.*

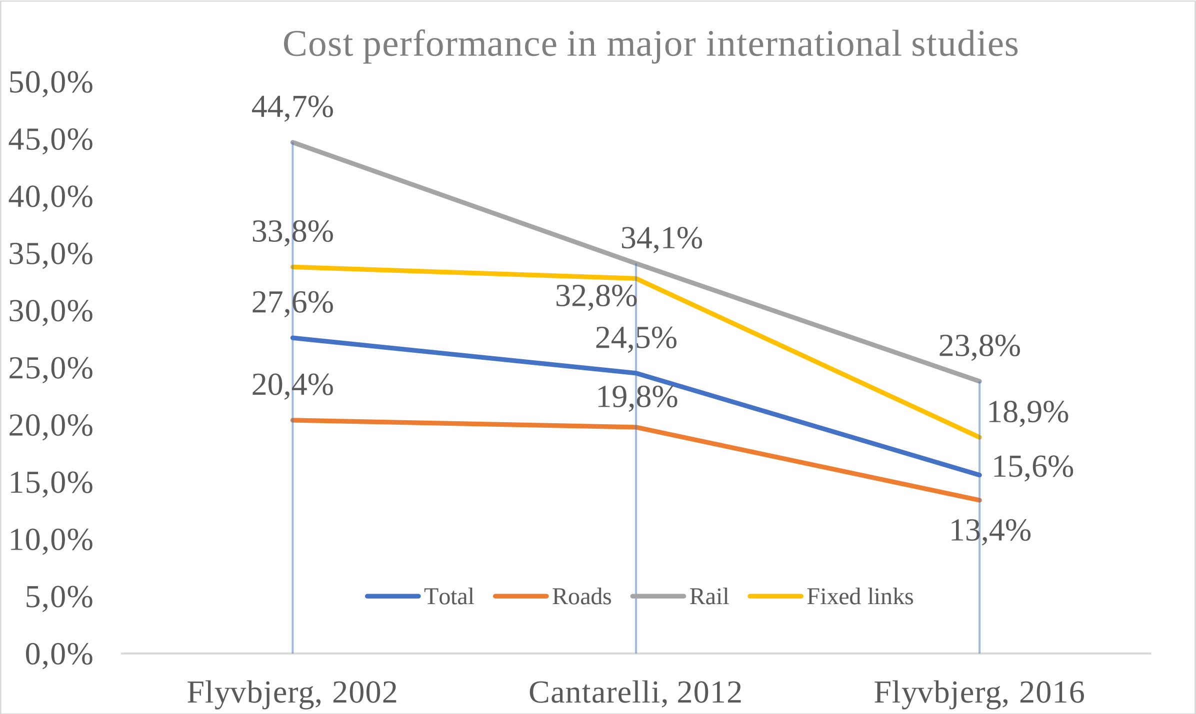
Unlike the national studies presented in this paper, international studies differ in the larger sizes of samples with statistical data for different project types. Original study Flyvbjerg, et al., (2002) is included in all subsequent samples presented in the table. Cantarelli in Cantarelli, (2011); Cantarelli, et al., (2012a; 2012b) also enlarged the sample inserted more projects into the basis for comparison. The largest share of submitted projects falls on the regions of Northern and Eastern Europe.

*Table 11. Latest international studies (Flyvbjerg, 2016)*

| Source | Projects | Sample | With CO | Mean | Freq. CU | CU % | Freq. CO | CO % |
|---|---|---|---|---|---|---|---|---|
| **Flyvbjerg, 2016** | Total | 1885 | 1230 | 15.7% | 34.7% | 7.9% | 65.3% | 28.2% |
| | Road | 1401 | 869 | 13.4% | 38.0% | 4.0% | 62.0% | 24.0% |
| | Rail | 338 | 264 | 23.8% | 21.9% | 34.0% | 78.1% | 40.0% |
| | Fixed links | 146 | 97 | 18.9% | 33.6% | 11.0% | 66.4% | 34.0% |

Detailed data of the latest study from 2016 is presented in Table 10. Mean cost overrun for sampling from 1885 projects is 15.7%. Cost underrun is observed in 34.7% of the total projects and on average is 7.9%, however share with cost overrun is 65,3% with a significant average overrun of 28.2%. Cost performance for rail construction projects is the worst among give three project types. Cost overrun is observed in 78.1% and on average is 40%. In this case, in the rare case of cost underrun, the expected deviation is also large and amounts to 34.0%. For tunnels and bridges, the frequency of the cost overrun is the same as for roads, but in general the mean overrun is higher and makes up 18.9% on average. Dynamics of the cost performance with increasing sample size is presented in the Figure 3.

*Figure 4. Cost performance in major international studies. Effect of large samples.*



The main trend, as can be seen from Table 9 and Figure 3, is that with the inclusion of new projects to the original sample and expanding the basis, mean cost overrun decreases from study to study. For example, the mean cost overrun in the original Flyvbjerg study is 20.4% for roads and 33.8% for fixed links, when in the most recent collection of Bent Flyvbjerg and colleagues of more than two thousand projects, mean cost overrun is 13.4% and 18.9% for roads and fixed links respectively.

In order to correctly draw conclusions and compare data from international and Norwegian researchers, it is necessary to correctly process the sampling data. There needs to exclude railway projects, since the case of national studies in Norway will not give us enough data for comparison. However, the sample of construction projects for bridges and tunnels is also handled by NPRA and must be included in the research basis. Table 11 shows the corrected data for all samples from Table 9.

*Table 12. Cost overruns for road and fixed links projects compared by regions*

| Source | Region | Sample | Mean overrun** |
|---|---|---|---|
| **Flyvbjerg, 2002** | World | 200 | 17.5% |
| **Lundberg, 2011 *** ** | World | 3988 | 8.1% |
| **Cantarelli, 2012a** | World | 611 | 16.2% |
| **Flyvbjerg, 2016** | World | 1557 | 11.4% |
| **Flyvbjerg, 2002** | Europe | 158 | 21.3% |
| **Cantarelli, 2012a** | NW Europe | 369 | 18.0% |
| **Updated sample NW Europe** | NW Europe | 2164 | 11.7% (16.3%)* |
| **Lundberg, 2011** | Sweden | 102 | 11.1% |
| **Cantarelli, 2012a** | The Netherlands | 51 | 13.0% |
| **Kostka & Anzinger, 2015** | Germany | 24 | 29.5% |
| **Økland, 2017** | Norway | 1987 | 11.5% |

**Calculated using weighted average (simple average.*

***Railway projects excluded for better comparison with NPRA results. Mean overrun is recalculated based on lesser samples.*

****Sample is given in the study, however there is no detailed information provided about what studies were included among all presented in the first chapter of (Lundberg, et al., 2011).*

As can be seen from the adjusted data, the smallest mean cost overrun is for two Scandinavian countries: Sweden - 11.1% and Norway - 11.5%. These two parameters are the smallest among the submitted national studies, the Netherlands with 13.0% is in third place. Germany has the lowest cost efficiency among studies from the Northern and Eastern Europe, and mean cost overrun is estimated as 29.5%

Among the national studies, the majority of projects are Norwegian projects. Due to the fact that 9 out of 10 projects in the region are Norwegian projects, the estimation of the region cost performance using the weighted average can be strongly influenced by Norwegian sample. For this case Table 11 also includes data calculated based on the simple average and estimated as 16.3%. Data for the entire region for four studies are 2164 projects and mean cost overrun is 11.7%.

According to Table 11 and to the most recent data from Flyvbjerg, (2016), the mean cost overrun for infrastructure projects is 11.4%, which is significantly lower than the data from previous studies (Cantarelli, et al., 2012a), where the overall value for mean cost overrun was 16.2%, and from earlier (Flyvbjerg, et al., 2002), where cost overrun for two project types estimated as 17.5%. However, sample of researchers provided by Mattias Lundberg includes studies from over 3988 projects from various national studies and found out mean cost overrun for road projects around 8.1% which is significantly lower than all studies presented in the current research. However aside from the total mean overrun the study lacks information about regional distribution within the sample in contrast to other known international studies presented in the table.

One can also observe a contrast with the results of early European studies with a smaller sample sizes, where mean cost overrun is estimated at 21.3% for Europe and 18.0% for Northern and Eastern Europe, where cost overrun the excess is 7 p.p. in comparison with the data from Scandinavia

# Chapter 5. Discussion

## 5.1 Norwegian case

All the studies presented together give a detailed and complete picture of how NPRA manages cost overruns in the road construction projects.

Every second major project experiences excessive costs and for every fourth the cost remains within 10%. This differs from small and medium-sized projects. In 3 out of 5 smaller projects cost overrun occurs and the chance that the total overrun will be 10, 25, 50% are almost equally probable.  For medium projects, however, a mean overrun of 25% or more occurs a little less frequently, although it is still relatively high. The dynamics in this case is in the direction of reducing the likelihood of high cost overrun and time overrun for large projects. The average data for the three periods almost completely repeat the data of the period 2004-2007.

As the project scale increases, the mean cost overrun decreases and the accuracy of the project estimate becomes higher, which is confirmed by the data of all the studies in Tables 2 and 3. The researchers underline that government tends to prioritize the larger projects  when enhancing the control over the projects (Welde, 2017) In general, this concentration on large projects is advisable, since their share is more than 70-77% of total cost overrun for construction projects and they have a longer fulfilment time (Odeck, 2014b), (Økland, 2017). Although later studies found no strong interdependence between time overruns and cost overruns (Økland, 2017, p. 24), nor between cost overruns and project duration (Welde, 2017, p.58), but one cannot discard the earlier studies and ignore the influence of time overruns on project cost (Flyvbjerg, et al., 2004b), (Odeck, 2004). The effectiveness of reforms for large construction projects is confirmed by later studies (Welde, 2017). However, the analysed data relate only to the period 2001-2009 and priority should be given to larger studies from tables 2 and 3.

There arises a natural question, about what values to choose for the basis of research. The sample in 1987 of the projects by Trym Kristian Økland seems to be the most preferable in terms of coverage of statistical data and includes samples of other authors, but his studies do not take into account the absolute magnitude of each group where the largest budget impact is from large projects as we know from the study provided by Peter Odeck. The second question is which periods, taking into account all the reforms, should be included in the basis for comparative evaluation with other countries. Given that the data of the third period of full competition are extremely close to average data in terms of mean values and structure, therefore it is possible to use only data from 2004-2015. The average mean cost overrun is 11.5%, and for the third period 12.4%, the average time overrun is 17.0% and 21.8%, sample sizes are 1987 and approximately 1187 respectively. The main argument is the favour of the using the overall average is that most of the studies cover the period before 2010, in addition the sample is twice as large. This provides statistically more reliable conclusions and therefore is more appropriate for the purposes of this study. Thus, for Norway, the data from Table 3 will be selected as a basis for comparison.

For the same reason of low representativeness, including the seven railway projects into sample hardly affect the total results for the whole sample. The studies found do not provide sufficient statistical information for reasonable conclusions. In the presence of a large number of studies in the field of road construction, other important infrastructure projects are poorly described by the researchers. The data from Table 1 presents a certain information, but for meaningful conclusions this sample of 7 projects is not enough. Now, more and more studies are underway that are being conducted by External Quality Assurance (KS-ordningen) so the basis for railroad projects will be enlarged over the next few years (Welde, 2017), (Volden & Samset, 2017).

## 5.2 Swedish case

Comparing the statistical data of the two research groups, it is necessary to take into account the scale of the projects. Mean deviation in both cases decreases with larger investment. For example, in the list of 15 major road construction projects, the cost of projects is between

NOK 4 billion and 16.8 billion (Ovale, 2015) and it is possible that the situation with cost underrun in large projects may change over time. However, according to research from the two countries, we can conclude that, on average, Norway and Sweden are about equally good at estimating costs.

For selected periods after 1993, mean overrun for Norway and Sweden is 11.5% and 11.1%, respectively, subject to a high standard deviation of 36.9% and 24.6% for each country respectively. Both countries are proficient at managing large projects while keeping overrun at a minimum. Norway has been able to achieve an average mean overrun of 3.9%, while the same parameter remains also within 3-6.3% for Sweden.

Despite the proximity of the results, cost performance for megaprojects is lower with 6.9% mean cost overrun, which, given a similar cost structure and the existence of equally large mega-projects in Norway, allows us to conclude that Sweden is somewhat inferior in controlling costs for the largest projects. This conclusion is confirmed by the latest analysis of Welde Morten, where for 41 large-scale projects. In this study the mean overrun amounted to -6.7% and with a standard deviation was lower — this all indicates greater accuracy and cost control for megaprojects with largest possible scale.

This conclusion suggests itself, if you pay attention to mean overrun for very small Swedish projects and small and medium-sized projects in Norway. In the Swedish group, mean overrun is 29.1%, far exceeding mean overrun for similar NPRA projects, where the overrun was 13% -14.6% for small and 10% for medium-sized projects to NOK 200 million.

Although the authors of the Norwegian studies criticize the NPRA for not paying much attention to small and medium-sized projects, saying that the reforms affected positively mainly on the accuracy of the assessment of large infrastructure projects (Odeck, 2014b), (Økland, 2017), but it cannot be denied that reforms have shown their effectiveness in long run. In particular, the author of the Swedish study himself stresses the necessity of developing the practice of cost assessment and control for small projects (Lundberg, et al., 2011, p. 14) and the introduction of control by several external organizations (Lundberg, et al., 2011, p. 15), which has earlier been implemented in Norway with the reforms of 2004-2008 and the opening of tender competition (Welde, 2017).

Other researchers in an attempt to explain the situation with cost overrun in the practice of the Swedish Transport Administration provided the survey of project managers and senior personal in contractor and consulting. The study showed that a significant part of managers involved into project evaluation agrees that the cost overrun takes its place in the planning phase and refers to changes in the original design. They also confirmed the negative influence of competence and optimism bias on cost performance (Brunes & Lind, 2014, p. 34), agreeing with hypotheses of Flyvbjerg. Given the similarity of many points in both groups of studies in Norway and Sweden, it can be concluded that Norway is more proficient in concept and design researchers. Potential explanation can be that large projects go through many stages of approval and evaluation before the implementation phase begins, and overall process has a relatively higher transparency and external control (Welde, 2017).

## 5.3 Dutch case.

For comparison with Norway, there needs to take into consideration that building of fixed links includes the bridges and tunnels with both are managed by the NPRA. The samples are not fully comparable in size and Cantarelli's sample of Dutch projects may not be representative enough, however this is the only and most comprehensive study available among European countries.

The Dutch case provides an interesting look at how cost performance changes depending of the project phase (Cantarelli, 2011) , size (Cantarelli, et al., 2012b) and project type(Cantarelli, et al., 2012a).

In the Cantarelli's sample, small projects share is 30% of all projects and represents 6.3% of the total cost overrun. Megaprojects account for exactly half of all the cost overrun of the sample, which is explained by a fairly high mean overrun of 10.9% for large projects which is twice higher than compared to 4.9% for NPRA. Norway has also significantly bigger share of 70-80% for larger projects over NOK 200 million.

Small projects have a huge cost overrun of 30.8%, which is also true for Norway, but on a smaller scale, where the expected mean overrun for projects below NOK 200 million estimated as 10-13% for the same standard deviation value. If one take Odeck (2014) for 1993-2007 as a data basis, then the Cantarelli' sample will differ only in terms of the mean cost overrun and scale, but overall cost performance will be proportional.

In addition to the above, the author found another common trend for European countries, which is that infrastructure projects in urban areas have worse cost performance (Cantarelli, 2011, p. 121). This statement is seemed correct for the Norway (Welde, 2017, p. 9), although Swedish studies do not confirm that urbanized projects are better managed in terms of cost performance and indicators are higher than for most other types of projects (Lundberg, et al., 2011, p. 9).

Cantarelli's studies emphasize that most cost overruns are observed at the early project stages, which is supported by quantitative data from table 8. Both Norwegian (Welde, 2017, p. 19) and Swedish (Brunes & Lind, 2014) support his findings and agree that cost performance is worse in design and planning phase than in construction phase. This difference can be explained both by the pathogenic effect of poor project cost management (Love, et al., 2016), and by problems associated with project administration and a complexity of planning and preparation phase, which often leads to changes in project design, goals and scope or with other words strategic misrepresentation (Cantarelli, 2011).

The problem of cost performance for small projects is relevant in the case of the Netherlands, but medium projects also have a high mean overrun compared to NPRA data. For the Netherlands, the indicators of small projects on average have a mean cost overrun of 18.5% and 23.2% for the average, while larger projects have an average mean deviation of 7 and 10.9%, respectively. The average cost overrun for Norway is 11.5%, the situation is also changes based on project scale and larger projects perform better. Based on the data presented in both studies, it can be concluded that Norwegian projects have on average better cost performance than Dutch ones, cost overrun values for all groups of projects are lower, which indicates a higher accuracy of cost estimation.

## 5.4 German case

Despite the small number of samples, the projects represent large infrastructure projects with a total cost of € 36 billion or taking into account the costs of unfinished projects — the study includes 25% of total costs for the research period (Kostka & Anzinger, 2015, p. 8). The high cost overrun of 30% is explained by particular poor management of infrastructure projects. Among the main factors of high cost overrun are also: technical factors — strong geographical differences between regions and "governance factors — high ambitions in terms of project realization" (Kostka & Anzinger, 2015) or, as defined in major studies, "optimism biases" (Flyvbjerg, 2007a). Compared with the average values for Norway at 11.5%, German cost performance looks much worse, even taking into account the size of the samples.

On the example of Germany, we can see how much cost overruns are affected by public pressure and how the involvement of private capital improves the accuracy of the cost estimates.

In the presented selection of 24 road projects, 18 projects were implemented without involvement of private capital (PPP - Public-private partnerships), the average cost overrun was 34%, for 6 others, where private capital and external control took place, cost overrun was only 9 %. This is consistent with the experience of Norway, where most of the projects have a tender basis and the cost overrun is significantly lower (Odeck, 2014b), correlates with recommendations found in the major studies such as Flyvbjerg, (2007b), Love, et al., (2016), Siemiatycki, (2015). In other words, attracting private capital contributes to improving cost performance and in practice, this is confirmed by the example of countries in this study and not only in case of Germany.

The negative impact of public protests on the project efficiency occurs when the infrastructure project affects the interests of residents, when it is negatively reflected in the media, when it is perceived as an inefficient use of budget funds by public in general (Kostka & Anzinger, 2015, p. 15), or when the decision makers ignore important requirements, for example, environmental protection (Cantarelli, et al., 2012b, p. 9). The costs associated with making changes to the project will not be limited to technical modifications. The social pressure alone can affect the project's efficiency. Decisions are linked to the rhetoric around the project and therefore can lead to additional costs that can be explained by political reasons (Flyvbjerg, 2009, p. 350). According to a German case, such costs can almost a half times increase the costs of the project, as well as adversely affect the project schedule (Kostka & Anzinger, 2015, pp. 15-16).

Other explanation of the situation, according to researchers, is innovative nature of the projects. Similar examples can be found in Norway, for example, Norway High Speed Rail studies initiated in 2010 (Railway Gazette, 2010). The cost models for such projects include a fairly strong risk premium of 17-29%, where the key risks are the risks associated with changes in prices for resources and materials, as well as risks associated with design (innovativeness), as well as optimism bias, which is estimated to be twice as high as other risks for innovative projects (Bane NOR, 2012) .

## 5.5 Case of international studies

Among all the European studies presented in the chapter the most complete data is provided by the Norwegian researchers. The sample of almost two thousand projects, gives a detailed and most accurate representation of the national experience of managing the productivity of costs for a specific region in the context of road infrastructure projects. Sample Information from Odeck, (2014b) and Økland, (2017), includes data classified by project size, regions, by weight in the cost structure, and from the historical perspective.

National studies from North and West Europe, however are not that representative in term of the sample sizes and statistical information.

With studies from other countries, the situation is somewhat worse. The a relatively small sample size of projects that does not allow to make a completely statistically valid conclusion about cost performance in a particular region, in other words, the presented samples can describe relatively poorly the selected regions, which in turn can refute certain hypotheses about cost performance in individual regions. For example, according to Peter Love, studies of (Terrill, et al., 2016) and 836 projects in Australia disregards Flyvbjerg's contention that 9 out of 10 projects exceed the budget, as cost overrun was observed in only 34% of projects (Love, et al., 2017). However, in the absence of such large-scale studies as in Norway, the main argument in favour of the representativity of presented national studies is that almost all of them cover large state infrastructure projects. The total cost represents billions of euros and that is accounted for by the small number of projects (Odeck, 2014b), (Kostka & Anzinger, 2015),(Lundberg, et al., 2011).

At the same time, comparison of results with international samples for example with Flyvbjerg, et al., (2002), Cantarelli, (2011), Flyvbjerg, (2016), or with samples from other regions e.g. Terrill, et al., (2016), Bordat, et al., ( 2004), Ansar, et al., (2016) may not be entirely correct due to the major differences from the regions included in the study. This problem is noticed also in Love, et al., (2017) and Flyvbjerg, (2016), therefore the need for constant expansion of international research in this area emphasizes by both authors. These studies may be in the process of elaboration (Local Transport Today, 2018).

# Chapter 6. Findings

## 6.1 Sample sizes and national studies

One of the problems associated with international studies is that they are based on a sample of data from large national studies that can differ qualitatively and quantitatively from each other, for which Flyvbjerg was criticized after publishing his first study few years later The main counterargument was that the study covers many regions and time periods, but at the same has a relatively small sample resulting in low representativeness  (Osland & Strand, 2010). Also, the methods of assessment and data collection differ, because different organizations have varying requirements for the evaluation of infrastructure projects, for example, Norway takes into account the probability of exceeding costs by a certain percentage (Welde, 2017). The methods also improve over time, which leads to the comparison of empirical data obtained by various and different methods (Love, et al., 2016), in particular, there are significant differences between the technologies for creating models for data analysis and cost estimating estimate (Ahiaga-Dagbui & Smith, 2014a; 2014b). It can be argued that in general this does not affect only the accuracy of the estimate, since the cost estimate and, in fact, the project data are secured in the initiation documents. However, using the more and more technologically advanced methods of cost estimation, the general picture becomes distorted This happens due to fact that studies include outdated statistical data from distanced in time projects (Love, et al., 2017),. For example, the circumstances and of assessment in the 1940s and in 2018 are very different, and in turn, the accuracy of the assessment in later years has dramatically increased which can be seen in data from the Norwegian case. Even estimating models from the same decade are different from another for example flat and curve reference class forecasting models (Love, et al., 2016). Again, scientific research methods raise requirements for the reliability of data, otherwise any conclusions can be questioned, especially in case if organizations that conduct research has its own interest (Siemiatycki, 2015). In addition, the researchers can also misinterpret data in the light of various causes, for example "high political and organizational pressure [...] by non-intentional technical error or optimism bias" (Flyvbjerg, 2009).

When design the international samples, its representativeness is very important. For example, if one take the previous Norwegian study of 1557 projects with a mean cost overrun of 11.5% and add this sample to the database from the USA with 2669 road projects from Indiana alone, where the cost overrun was about 5% (Bordat, et al., 2004) and 3969 projects from Florida with 7% % (The Office of Program Policy Analysis and Government Accountability, 1996) how one can determine how much such a sample of data will characterize the world cost performance for infrastructure construction projects, if four of the five projects are from the USA? In the case of this study, 9 out of 10 submitted projects are from Norway, which further exacerbates the problem of estimating cost performance for European region only. One possible solution is to use a simple average in order to generalize the data from the international sample, but this causes a major misrepresentation in terms of actual statistical data. Another possible solution is expanding regional samples through national researchers to eliminate the size differences and increase the representability (Flyvbjerg, 2016). However, this does not solve the problem that national studies may include a small number of projects even considering their total cost. In the same region, country development and geographical conditions may vary significantly, and conclusion based exclusively on statistical data can be unreliable (Osland & Strand, 2010). Norway and the Netherlands where the latter is below sea level and first one is covered with mountains share different conditions and therefore different groups if risks must be considered during the design and implementation phase. A simple statement of the fact that a cost overrun has occurred and its deviation as a percentage of the expected estimate can be greatly distorted by the influence of a large number of small projects with a low total cost overrun (Odeck, 2014b), while large projects have a stronger impact on the economy (Flyvbjerg, 2009).

Comparison of national studies of different regions, in view of the above-mentioned reasons, is also problematic, but the averages allow one to draw conclusions and characterize the cost performance of different regions. This also allows one to draw conclusions based on statistical analysis. For example, it is possible to compare overall cost performance for monopolistic state organizations in China with 30% (Ansar, et al., 2016) with procurers under free marked competition such as NPRA with 11.5% (Odeck, 2014b). The mean cost overrun is significantly different in this case, so it is possible to draw certain conclusions on the effectiveness of one or another model for state agency organization. This also allows one to compare measures for reducing the cost overrun in the geographically different regions and provided argument explanation for cost performance (Flyvbjerg, et al., 2002), (Siemiatycki, 2015) и (Terrill, et al., 2016).

## 6.2 Common features

The four European countries represented in this paper are characterized by the fact that with a small number of large and megaprojects, they are accounted for by the major share of total cost overruns. In the overall structure of cost overruns, these projects account for over 70% of costs, which forces government agencies to pay more attention to large projects. Small projects, in turn, are get less attention and mean cost overrun is higher here than for other types of projects. This is true for Norway and for the three other European countries represented in the study. It should be noted that the difference between small and megaprojects in the expected deviation is significant, as for example to Norwegian projects cost NOK 100 million have an average mean cost overrun of 13.3%, while for large projects expected value is 4.9%. If one takes another example, the in Sweden, projects up to SEK 100 million have an expected deviation of 29.1% while more expensive ones have 2.8-6.1%. In the Netherlands, the difference is not so significant, but the overall trend is absolutely the same - small projects are evaluated worse than large ones.

The second common feature is the relatively low frequency of cost overrun for infrastructure projects, for example in Norway 59% projects have cost overrun, in the Netherlands, the figure is 55%. These data disprove Flyvbjerg statement that 86% of large projects have cost underestimation, as the European experience provides the opposite picture. For example, in Norway, only 37% of major projects have cost overrun, in the Netherlands, only 62.2% of road projects. In other words, the frequency of cost overrun is different for geographically close regions but remain much low then in the known international studies (Flyvbjerg, 2009).

## 6.3 Causes and explanations

All authors agree that cost overrun is a complex problem. The main cause is weak project management and a large number of changes in the planning and design phase (Cantarelli, 2011), (Kostka & Anzinger, 2015) . In particular, this is related to imperfect methods for estimating costs, lack of reliable models for calculations, geographical differences, a long planning phase, in other words, due to technical reasons (Siemiatycki, 2015).

Designing the cost models is primary task for a number of the researchers e.g. Odeck, (2014b), Love, et al., (2016), Lundberg, et al., (2011), Terrill, et al., (2016), Cantarelli, (2011). These studies provide the new instruments and models for cost estimation. The more advanced techniques provide a higher level of cost performance. This also relates to the proficiency of the researchers and accuracy in forecasting the project costs by lowing the risk of technical mistakes (Siemiatycki, 2015).

At the same time, the major differences between regions enforces different magnitude of cost overrun across the country, the difference in the accuracy of estimates can be up to 33% according to Cantarelli, (2011), for Norway this difference is lower, but it is equally significant and reaches 13% (Økland, 2017).

The second important problem is overoptimism — underestimation of risks and overestimation of potential benefits. This is a common explanation (Flyvbjerg, et al., 2002) than is found in most of the studies e.g. in Welde, (2017), Kostka & Anzinger, (2015), Lundberg, et al., (2011), Cantarelli, et al., (2012a). Early attempts to reduce the impact of this factor were proposed in Flyvbjerg & COWI, (2004), following by practices of including the additional risk premiums, increasing the transparency of the design process, establishing the external controls, involving private capital, which in turn explains the good performance indicators for the European region according to the studies of four countries and outside the region (Bordat, et al., 2004), (Flyvbjerg & COWI, 2004), (Siemiatycki, 2015).

## 6.4 Explaining the Norwegian high cost performance

### 6.4.1 High level of transparency

On the basis of the information provided, it can be concluded that Norway and Sweden have better cost performance precisely because of the widespread *inclusion of external control* during the design, planning and implementation phases. In many respects this relates to reforms aimed at increasing the cost control for the entire implementation process (Welde, 2017), including in the early stages of the project lifecycle where cost overrun is most possible and threatening (Cantarelli, 2011). However, earlier conclusions indicate that in Norway a significant part of infrastructure projects, especially small local projects, is not taken into account, which may create a situation with high cost overrun for small projects where performers take responsibility for controlling function (Welde, 2014, p. 6). In turn, the large projects can also overrun significantly the established cost framework, so the problem remains wicked (Welde, 2017, p. 17), even taking into account the results in the period 2004-2015 with best cost performance for large projects. Involvement of external organizations for independent evaluation also proved effective measure (Welde, 2017, p. 67), as well as the inclusion of multiple risk types at the design and planning stage to reduce the total information uncertainty associated with the implementation of the project. These measures include analysis of the market situation, control of costs at the state level in different phases of the project, as well as individual research for each project, as well as comparison of economic and social expectations associated with the project (Welde, 2017, pp. 68-69).

### 6.4.2 Technical proficiency

Norway and Sweden have similar reform experience and a final increase in cost performance for large projects, but researchers associate this with the development of *methods for estimating costs* and creating *calculation models* that are successfully *applied* in practice. Examples of these successful calculations can be found both in Lundberg, et al., (2011) and in Odeck, (2014b). In many respects the development of methods for estimating costs was promoted by works on Reference Class Forecasting emphasized and partly implemented in Flyvbjerg & COWI, (2004) and also modern methods referred as “data mining” in Ahiaga-

Dagbui & Smith, (2014b). The increase in cost performance as a result of the improvement of the methods of evaluation was mentioned also in the original study Flyvbjerg, et al., (2002), which is confirmed in present time (Ahiaga-Dagbui & Smith, 2014b, p. 17). Importantly, support for national studies allows the adaptation of known models and tools to the conditions of a particular region for example Odeck, (2014b), where it is possible to find a multitude of complex cost performance studies and the best indicators for Norway in general. Examples can be found for the Netherlands in Cantarelli, et al., (2012a), for Australia in Terrill, et al., (2016), and for the United States in Bordat, et al., (2004). The more research conducted in this area, the better the results show the national researches and the higher overall cost performance, since more and more factors can be included in the model модель (Lundberg, et al., 2011). At the present time, Norwegian researches are the most complete in terms of sample size and number of studies across the region of interest. At the same time NOK 3.2 billion are spent on consultant services in order to secure high level on competency (Bordal, 2014).

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### 6.4.3 Prioritizing the social benefits

It is important to *take into account public opinion, safety and environmental criteria* while developing and designing the projects. An attempt to reduce costs "on paper" in order to quickly initiate the project lead not only to financial losses, but also simply a threat to the health and well-being of the citizens (Flyvbjerg, 2007a). In turn, this can lead to serious social pressure from people whose interests were affected. From a study in Germany, we know that protest movements can influence the actual cost of the project and increase the cost overrun by almost a half.

The example given in Flyvbjerg, et al., (2003a) describes the importance of this factor. Among many problems, the Danish government tried to ignore environmental requirements in the construction of the Great Belt, as a result of the restrictions were taken under public pressure and the cost of the project increased significantly by 7% or by DKK 1.5 billion, and subsequently to DKK 2.9 billion. Enhancing of construction standards more often leads to decreasing social and environmental risk associated with infrastructure projects. For example, the key difference between the Norwegian National Transport Plan from 2014 and 2018, aside from budget size, is that how much attention is given to the measures for reducing of hazardous impacts on the environment (Norwegian Ministry of Transport and

Communications, 2012; 2016). *Taking the socially meaningful risks into consideration* during the design phase pays off by reducing the risks of project scope changes during the implementation phase and the risk of additional costs associated with the public pressure (Kostka & Anzinger, 2015).

### 6.4.4 Free competition and involvement of private capital

*Competition with private organizations* in turn led to increased control by other market participants, which is consistent with the recommendations of almost all researchers of the phenomenon of cost overrun, which have already been discussed in this paper. The same conclusion can be found in Odeck, (2014b) for Norway, where for major projects there has been a sharp decline in mean cost overrun for tenders-based competitions for large projects. However, the summary of the results of two Norwegian studies indicate a decrease in the accuracy and cost performance for small projects (Økland, 2017).

### 6.4.5 Balanced approach is adopted

Managing the optimism bias is detailed in (Flyvbjerg & COWI, 2004), where the main reasons are: *imperfect information, scope changes and poor management.* Flyvbjerg explains optimism bias not only with political and economic reasons, but also with technical explanations for this phenomenon. Although his radical focus on the management of optimism bias has been criticized in recent years, but his works remain the most cited researchers so far. This leaves a strong imprint on the cost assessment system throughout the world, including in Norway. Among the countermeasures he calls: *encouraging realistic budgets, financing projects with local authorities and private capital, establishing formal requirements for risk management and quality control, and establishing an independent external audit of projects* (Flyvbjerg & COWI, 2004, pp. 57-58). How these are implemented in Norway can be found in Odeck, (2014b), Welde, (2017) and Andersen, et al., (2016). The realistic budget is established on the basis of the degree of uncertainty. It is calculated by taking into account a variety of risk factor with extended cost models. The design of the project is constantly in focus during the planning and implementation phase (espessialy for projects over NOK 750 million). The project is evaluated depending on the achieved or not *achieved objectives* and not only based on closing cost performance. Cost control is provided by *independent and often non-profit organizations* wich evaluate projects based on their own practices and models (Andersen, et al., 2016). Another method for project performance evaluation that is commonly used is *benchmarking with similar projects* (Welde, 2017, pp. 44-45). Control measures are also carried out with the involvement of local representatives.

The implementation is also carried out with the *involvement of local suppliers and subcontractors*. The regional projects are also *financed from the municipal budget* (in particular procurement of the small projects) with provides concernment about the project costs. Such an approach supports the interests of business and people living in a certain region and increases their involvement and control over the implementation of the project and overall decision making (Andersen, et al., 2016). The efficiency of this approach can be judged from 78 state large projects, including 41 road projects, where the mean overrun was -6.7%, with an extremely low standard deviation of 10.6% — this indicates an extremely high degree of cost performance for these projects and the effectiveness of such a system in general (Welde, 2017, pp. 52; 65-69). It can be concluded that Norway successfully applies a balanced approach and does not focus only on external causes (Love, et al., 2014b). The internal environment in case of Norwegian agencies also relies on modern research and *improves dynamically* over time (Welde, 2014).

## 6.5 Potential threats to Norwegian cost performance

### 6.5.1 Low cost performance of small projects

The main negative feature for Norway is the relatively high mean cost overrun for small projects. The share of small projects in the total share of the total cost is approximately 15% (8-10% for medium projects up to NOK 50-100 million), with mean cost overrun several times higher than for large projects. Reorganization and transition to free competition have affected cost performance for large projects, but the cost performance of small and medium-sized projects has dropped dramatically. There are several explanations for this phenomenon given in Andersen, et al., (2016). First, *less attention is paid to small projects*, and often the *formal procurement procedure is greatly simplified*, which speeds up the procurement process itself, but reduces its economic efficiency. This happens partly due that fact that small projects require operational decisions and therefore *flexibility in decision-making, often is prioritized over the efficiency*, this applies mainly to small projects up to NOK 25 million the process of choosing a concept is simplified and the project can be accepted in the original form that is proposed. Templates are often used by contractors in addition when calculating the project costs. Project development is based on early projects with incomplete data and without taking into account the features of the new project. This often happens if the initial concept suits to the NPRA's requirements. However, this does not explain the situation with projects over NOK 25 million since they are subject to the same requirements as for large projects (Andersen, et al., 2016, pp. 32-33)

Secondly, there are *different requirements for control*: projects worth up to NOK 100 million are valued by regional controllers, and only projects above NOK 200 million report to Directorate of Public Roads (Vegdirektoratet), and external control is provided for projects above NOK 750 million. Thirdly, *small projects are often offered to regions by groups (packages)* and the *control procedure is complicated and slowed down*, each project is confirmed individually. Projects can also be imposed on regions for political reasons (Andersen, et al., 2016, p. 35).

### 6.5.2 Quality uncertainty due to focus on cost performance

The duration of the planning phase is primarily related to costs (Love, et al., 2012) . Over time, external conditions are constantly changing, and uncertainty is growing. For example, prices in the materials and labour market (index) are growing, laws and procedures are changing (Love, et al., 2014b). The solution of the problem and project implementation becomes slowed down by the total length of the delays during the planning phases and scope changes (Cantarelli, 2011). Increased control over costs can lead to the fact that to the projects with a low cost will always be given priority, but this should not imply sacrificing of quality in order to fulfil the certain cost plan (Lundberg, et al., 2011). Infrastructure projects, in particular road projects produce a specific product that is consumed by the citizens over time. Decreased quality can lead to discontent, a threat to health and life, and hazardous impact on the environment (Ansar, et al., 2016, p. 374), as well as the increased cost for maintenance in the future. Economic efficiency in this case should be determined not by high cost performance, but by high quality performance in terms of costs. In other words, the *social benefit should be put on the first place*. At the current moment, the balance is maintained, but this does not mean that with increasing cost control by external and internal actors, the projects will not start to be selected according to the overall cost efficiency or to other secondary benefits (Flyvbjerg, et al., 2004b) . Specificity of reports in the new quality system (Quality Assurance 2) provides for the achievement of the project objectives, and its cost performance (Welde, 2017), however, the same definition have projects that meet the minimum conditions are (Siemiatycki, 2015, p. 6). This was noted by the Statens havarikommisjon for transport (SHT) when criticizing NPRA for "*prioritizing security too low during contractor competitions*"(Statens Havarikommisjon for Transport, 2008). In turn, raising standards, leads to increased costs, and more sophisticated control procedures — to longer project implementation. The main threat is that consequences of the poor-quality results is in the later project stages, or even after its completion causing the *additional cost in form of change orders* (Bordat, et al., 2004).

### 6.5.3 Project overpricing and cost underrun

Studies Økland, (2017) and Welde, (2017) indicate a *trend of cost underrun* for large scale road and fixed links projects. An inaccurate estimate of costs plays both ways. *Ineffective allocation of funds* leads affects the decision makers in way that they will not be able to initiate another project since the funds remain frozen in the budget of the current project (Odeck, 2014b). The cost underrun can be just as negative as overrun if it caused not by increased efficiency of project performers, but due to overevaluation of risks and misrepresentations. This implies both the technical reasons and hidden political motives — *unwillingness to face negative consequences* in case of bad cost performance (Flyvbjerg, et al., 2005, pp. 22-23).

# Chapter 7. Conclusions

## 7.1 Conclusion and answers to research questions

*How historically cost performance in Norway changed over time periods overall and for different types of projects?*

Answers to the research question are detailly provided in chapter 4 and 5.

The overall cost performance in Norway in terms of road and fixed links projects is very high. The mean cost overrun for all projects combines is estimated as 11.5% with relatively moderate standard deviation. The highest efficiency is observed for larger scale projects with 4,9% mean overrun. The reforms for NPRA led to dramatical increase of cost performance for larger projects, but for smaller projects the cost performance remains relatively low and is between 9.9% for projects below NOK 200 million and 13.0% for projects below NOK 25 million.

*How proficient is the Norwegian state organisation in comparison to other countries in the Northern and Western Europe in terms of cost estimation?*

Based on qualitative and quantitative data from the studies, Norway is among best cost performers in the Northern and Western Europe. The international studies show that Norwegian cost performance, especially in between 2004-2015 is overall higher than average cost performance in Europe and World.

*How researchers explain the cost overrun in infrastructure projects in different regions?*

Explanations to the cost performance of other countries can be found in chapter 6.

Norway has the high level of transparency in terms of control of cost estimates. There is high level for research proficiency due to academical researchers and technically advanced method for estimation and control of the cost. Government organisation meet no extra cost due to the social pressure. Free competition positively affects cost performance by providing the additional control measures. There is also adopted balanced approach which allows to manage all groups of potential risk the cost performance.

*What are possible ways to improve the national cost performance for road and fixed links projects?*

The best way is ensuring overall high cost performance is to eliminate the potential threats of cost overruns and enhance the best practice which is already adopted by Norwegian organizations. The cost performance in Norway is high, however the various studies indicates the potential treats that must be taken into consideration by Norwegian Public Road Administration and controlling agencies. The main threats are poor cost management for small infrastructure projects, the additional costs related to the quality losses and overall pessimism in terms of risk evaluation which leads to cost underruns and project overpricing.

## 7.2 Recommendations

The general recommendation is to enhance the balanced approach to the cost problem to ensure the cost performance for all types of infrastructure projects. Overall process is highly well organized and efficient in terms of adopted practises and archived results. The biggest challenge is to enhance best practises on small and medium projects since they represent at least one fourth of the total costs on infrastructure projects. The latest researches of quality assurance practises show the positive trend of project realisation below the cost budget and provides precedent for ensuring these practises for small- and medium-size projects. This should be done without overall quality losses for the industry and thus it a tough challenge for government agencies. Cost underruns should be perceived as a negative feature and main goal is to provide the most accurate cost estimate in order to avoid both the overpricing and the underestimating.

There is also required a research of cost performance in terms of other infrastructure projects, especially for the rail construction projects since they are poorly described in empirical studies. It can be assumed that these studies already exist and are just for intern use. However, the information about time overruns for transport projects is part of practice almost exclusively for Norway and international studies for this case can help to develop the background for future researchers but requires the partnership with organizations from other countries.

## 7.3 Self-criticism

The main criticism toward this paper is narrow study object. The reasons to that are described in chapter 3. The main problem that certain information is not provided by the national agencies through common communication channels. Lack of time and resources for more comprehensive studies leads to lower potential accountability of the findings and conclusions.

Time overruns and more types of construction projects could be also better introduced for analysis and comparison, but they are very poorly presented in the literature. Thus, the information found is not representative enough for comparative study but can be compensated by future researches since more and more information is introduced over time.

The lack of isolated studies for project types in Norway, also led to the recalculations for the original samples which enhances risks of calculation errors. Risk of technical mistakes without more detailed examinations can decrease the accountability of the paper conclusion.

The study method can also be improved using the more complex and advanced techniques for analysis. This relates also to the study problem and object of the research. For example, already named artificial neural networks or complex computer modelling can provide deeper analysis. Therefore, the study could not be limited to the comparative analysis and provide a deeper empirical analysis to the cost overrun problem. This requires more resources and time, but potentially can provide a more valuable results

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# Appendix

## A1 – Criticism from Office of the Auditor General of Norway



Statens vegvesen

Hovedside / Om Statens vegvesen / Presse / Nyheter

### Kritikk fra Riksrevisjonen

**Riksrevisjonen gir Vegvesenet kritikk i sin årlige revisjon av statlig virksomhet. Et av punktene som blir kritisert er styringen av konsulentkontrakter. [16.10.2014]**

- Dette er en kritikk vi må ta på alvor og at dette er noe vi må gjøre noe med. Vi må ha et klart mål om å forbedre oss på dette, sier Jane Bordal, direktør for Veg- og transportavdelingen i Vegdirektoratet.

#### - Må bli flinkere

- Kritikken retter seg mot anskaffelsesprosedyrene våre knyttet til kjøp av konsulenttjenester. I rapporten får vi ikke kritikk for at vi har brukt pengene feil, men vi må erkjenne at styringen vår ikke er god nok, sier Bordal.

Hun mener Vegvesenet blant annet må bli flinkere til å ta høyde for det uforutsette i kontraktene.

- Vi har nå etablert et eget prosjekt der målet er at vi skal bli bedre på å kjøpe inn ekstern kompetanse og kapasitet. En viktig del av prosjektet vil være å avklare når vi skal kjøpe inn tjenester, når vi skal bruke egne ansatte og når vi eventuelt bør ansette nye medarbeidere. Konklusjoner og forslag skal være ferdige og vil bli presentert i løpet av 2014, sier Bordal.

#### Årsakene til overskridelsene

Gjennomsnittlig overskridelse i de 70 kontraktene Riksrevisjonen har gått igjennom er på111 prosent.

- Årsakene til overskridelsene er sammensatte. Ofte dreier det seg om at det er vanskelig å forutsi hvor mange utredninger vi blir pålagt å gjøre blant annet i en planprosess- en prosess som ofte er svært kompleks i utgangspunktet, sier Bordal.

- Når vi for eksempel blir bedt om å utrede en ny trasé som ikke lå inne i den opprinnelige planen, noe som ikke er helt uvanlig, vil det mest effektive ofte være å bruke konsulenter som allerede kjenner det aktuelle prosjektet. Hvis vi må gjennomføre en ny og omfattende anskaffelsesprosess kan det forsinke fremdriften i prosjektet, og til og med fordyre det, fortsetter hun.

#### Bidrar med kapasitet og kompetanse

Bordal sier man i Statens vegvesen erkjenner at anskaffelsesregelverket kan være tungt og komplisert å forholde seg til.

- Men det fritar oss ikke fra at vi må forholde oss lojalt til de reglene som gjelder, sier hun.

Slik forklarer hun at Vegvesenet bruker 3,2 milliarder kroner på kjøp av konsulenttjenester:

- Vegvesenet er pålagt svært mange oppgaver, og oppgavemengden har økt betydelig de siste årene. Vi er rett og slett avhengige av å kjøpe konsulenttjenester for at vi skal få utført oppgavene vi er pålagt. Det er viktig å huske at de bidrar med både kapasitet og kompetanse. De tilbyr ekspertise vi trenger, og noen ganger bidrar de med spesiell kompetanse vi selv ikke har, sier Jane Bordal.

Her er oversikten over kontraktene Riksrevisjonen har gjennomgått:

| Region | Prosjektets navn | Kontraktssum | Sluttkostnad/Oppgitt prognose for ikke avsluttende kontrakter ( Beløp ekskl. mva.) | Overskridelse i beløp | Overskridelse i prosent |
|---|---|---|---|---|---|

| Region | Prosjektets navn | Kontraktssum | Sluttkostnad/Oppgitt prognose for ikke avsluttende kontrakter ( Beløp ekskl. mva.) | Overskridelse i beløp | Overskridelse i prosent |
|---|---|---|---|---|---|
| 1 Region Øst | KVU for hovedvegnettet i Moss og Rygge | kr 424 400 | kr 4 231 791 | kr 3 807 391 | 897 % |
| 1 Region Øst | E16 Sandvika-Skaret | kr 76 540 000 | kr 103 485 000 | kr 26 945 000 | 35 % |
| 1 Region Øst | E16 Sandvika-Skaret | kr 14 467 200 | kr 21 220 000 | kr 6 752 800 | 47 % |
| 1 Region Øst | Urban Lifeguard | kr 500 000 | kr 800 000 | kr 300 000 | 60 % |
| 1 Region Øst | Kløfta-Kongsvinger | kr 58 638 450 | kr 76 279 529 | kr 17 641 079 | 30 % |
| 1 Region Øst | E16 Fønhus-Bagn | kr 360 000 | kr 535 000 | kr 175 000 | 49 % |
| 1 Region Øst | Ikke oppgitt | kr 519 520 | kr 768 339 | kr 248 819 | 48 % |
| 1 Region Øst | E18 Bjørvikaprosjektet | kr 39 950 000 | kr 270 000 000 | kr 230 050 000 | 576 % |
| 1 Region Øst | E18 Sydhavna | kr 12 544 200 | kr 49 600 000 | kr 37 055 800 | 295 % |
| 1 Region Øst | Ikke oppgitt | kr 2 346 535 | Ikke oppgitt | kr - | Ingen overskridelse |
| 1 Region Øst | Rehabilitering av VTS øst | kr 500 000 | kr 1 309 000 | kr 809 000 | 162 % |
| 1 Region Øst | Ikke oppgitt | kr 521 189 | kr 416 951 | kr - | Ingen overskridelse |
| 1 Region Øst | Ikke oppgitt | kr 2 047 500 | kr 2 000 057 | kr - | Ingen overskridelse |
| 1 Region Øst | Kløfta-Kongsvinger | kr 1 371 960 | kr 4 929 392 | kr 3 557 432 | 259 % |
| 1 Region Øst | Innleie av geomatikere | kr 11 452 000 | kr 15 200 000 | kr 3 748 000 | 33 % |
| 1 Region Øst | E16 Vinstra-Sjoa | kr 53 391 699 | kr 93 400 000 | kr 40 008 301 | 75 % |
| 1 Region Øst | E18 Ørje-Vinterbro | kr 20 796 735 | kr 86 759 904 | kr 65 963 169 | 317 % |

| Region | Prosjektets navn | Kontraktssum | Sluttkostnad/Oppgitt prognose for ikke avsluttende kontrakter ( Beløp ekskl. mva.) | Overskridelse i beløp | Overskridelse i prosent |
|---|---|---|---|---|---|
| 1 Region Øst | E6 Arnkven-Moelv | kr 20 227 700 | kr 44 869 000 | kr 24 641 300 | 122 % |
| 1 Region Øst | FP2 Brøhaug-Strandlykkja | kr 48 973 195 | kr 61 469 600 | kr 12 496 405 | 26 % |
| 1 Region Øst | E6 Frya-Vinstra | kr 57 699 999 | kr 108 000 000 | kr 50 300 001 | 87 % |
| 1 Region Øst | Støytiltak E6 Alvim-Solli | kr 1 999 218 | kr 6 050 000 | kr 4 050 782 | 203 % |
| 1 Region Øst | E6 Nord-Fron gr.-Otta | kr 2 620 000 | kr 7 200 000 | kr 4 580 000 | 175 % |
| 1 Region Øst | E18 Ørje-Vinterbro | kr 13 770 000 | kr 68 185 849 | kr 54 415 849 | 395 % |
| 1 Region Øst | Ikke oppgitt | kr 6 198 700 | kr 6 300 000 | kr - | Ingen overskridelse |
| 1 Region Øst | Rv.3 Gita bru-Skjærodden | kr 5 177 600 | kr 11 800 000 | kr 6 622 400 | 128 % |
| 1 Region Øst | FP3 Strandlykkja-Labbdalen | kr 53 540 934 | kr 129 050 000 | kr 75 509 066 | 141 % |
| 2 Region Sør | E134 Damåsen-Saggrenda | kr 8 071 400 | kr 16 800 000 | kr 8 728 600 | 108 % |
| 2 Region Sør | E18 Bommestad-Sky | kr 185 000 | kr 770 362 | kr 585 362 | 316 % |
| 2 Region Sør | E18 Bommestad-Sky | kr 32 553 980 | kr 105 000 000 | kr 72 446 020 | 223 % |
| 2 Region Sør | Rv 23 Dagslet-Linnes | kr 5 498 988 | kr 14 000 000 | kr 8 501 012 | 155 % |
| 2 Region Sør | Rv 7 Sokna-Ørgenvika | kr 20 316 360 | kr 55 000 000 | kr 34 683 640 | 171 % |
| 2 Region Sør | Innleie byggeleder Øvre Buskerud | kr 936 000 | kr 1 994 000 | kr 1 058 000 | 113 % |
| 2 Region Sør | E18 Gulli-Langåker | kr 56 858 000 | kr 112 000 000 | kr 55 142 000 | 97 % |
| 2 Region Sør | Rv 7 Sokna-Ørgenvika | kr 2 378 000 | kr 3 935 000 | kr 1 557 000 | 65 % |

| Region | Prosjektets navn | Kontraktssum | Sluttkostnad/Oppgitt prognose for ikke avsluttende kontrakter ( Beløp ekskl. mva.) | Overskridelse i beløp | Overskridelse i prosent |
|---|---|---|---|---|---|
| 2 Region Sør | E39 Gartnerløkka | kr 23 254 000 | kr 33 600 000 | kr 10 346 000 | 44 % |
| 2 Region Sør | FOU Biologisk mangfold – anskaffelse av konsulent | kr 1 246 000 | kr 1 630 300 | kr 384 300 | 31 % |
| 2 Region Sør | Konsulentoppdrag byggeplan Raveien/Vestfold | kr 3 890 000 | kr 11 500 000 | kr 7 610 000 | 196 % |
| 3 Region Vest | Hardangerbrua | kr 10 730 000 | kr 28 367 406 | kr 17 637 406 | 159 % |
| 3 Region Vest | Rv13 Osbergtunnel, (Kilane – Hålandsosen prosjekt 301612 | kr 300 000 | kr 854 000 | kr 554 000 | 185 % |
| 3 Region Vest | Ferjefri fjordkryssing | kr 500 000 | kr 613 235 | kr 113 235 | 23 % |
| 3 Region Vest | Svegatjørn – Rådal | kr 29 743 000 | kr 87 027 429 | kr 57 284 429 | 193 % |
| 3 Region Vest | E39 Langeland – Moskog | kr 3 528 808 | kr 11 197 927 | kr 7 669 119 | 217 % |
| 3 Region Vest | Bruvedlikehold RV, Hordaland | kr 8 165 299 | kr 8 500 000 | kr 334 701 | 4 % |
| 3 Region Vest | E39 Rogfast-reguleringsplan | kr 22 575 737 | kr 26 080 654 | kr 3 504 917 | 16 % |
| 3 Region Vest | Ringveg vest | kr 8 998 680 | kr 13 200 000 | kr 4 201 320 | 47 % |
| 3 Region Vest | Eiganestunnelen | kr 108 891 526 | kr 162 198 892 | kr 53 307 366 | 49 % |
| 3 Region Vest | Ikke oppgitt | kr 4 369 150 | kr 3 000 000 | kr - | Ingen overskridelse |
| 3 Region Vest | Ikke oppgitt | kr 2 288 700 | kr 1 890 130 | kr - | Ingen overskridelse |
| 3 Region Vest | Ikke oppgitt | kr 1 790 000 | kr 1 437 688 | kr - | Ingen overskridelse |

| Region | Prosjektets navn | Kontraktssum | Sluttkostnad/Oppgitt prognose for ikke avsluttende kontrakter ( Beløp ekskl. mva.) | Overskridelse i beløp | Overskridelse i prosent |
|---|---|---|---|---|---|
| 4 Region Midt | Prosjektering Klett-Sentervegen | kr 29 814 140 | kr 37 900 000 | kr 8 085 860 | 27 % |
| 4 Region Midt | Prosjektering Fv 900 Heimdalsvegen | kr 7 240 000 | kr 7 800 000 | kr 560 000 | 8 % |
| 4 Region Midt | Prosjektering og regulering Skansenbrua | kr 3 572 814 | kr 18 400 000 | kr 14 827 186 | 415 % |
| 4 Region Midt | Værnes-Havnekrysset | kr 5 456 600 | kr 28 500 000 | kr 23 043 400 | 422 % |
| 4 Region Midt | Rv 769 Vemundvik-Sørenget | kr 396 000 | kr 930 000 | kr 534 000 | 135 % |
| 4 Region Midt | Prosjektering E6 Øst parsell Øst | kr 20 000 000 | kr 44 500 000 | kr 24 500 000 | 123 % |
| 4 Region Midt | Astad-Knutset | kr 12 900 000 | kr 16 300 000 | kr 3 400 000 | 26 % |
| 5 Region Nord | Rv 80 Løding-Vikan ,Tverlandet bru | kr 2 997 280 | kr 11 395 882 | kr 8 398 602 | 280 % |
| 5 Region Nord | Rv 80 Hunstadmoen-Thallekrysset | kr 61 332 410 | kr 64 474 586 | kr 3 142 176 | 5 % |
| 5 Region Nord | E6 Hålogalandsbrua | kr 12 185 230 | kr 46 000 000 | kr 33 814 770 | 278 % |
| 5 Region Nord | Rv 80 Hunstadmoen-Thallekrysset | kr 13 127 750 | kr 20 000 000 | kr 6 872 250 | 52 % |
| 5 Region Nord | E8 Riksgrensen-Skibotn | kr 879 100 | kr 2 141 514 | kr 1 262 414 | 144 % |
| 5 Region Nord | E6 Møllnes-Kvenvik-Hjemmeluft | kr 2 389 750 | kr 3 751 326 | kr 1 361 576 | 57 % |
| 5 Region Nord | Ikke oppgitt | kr 299 620 | kr 321 325 | kr 21 705 | 7 % |
| 6 Vegdirektoratet | Geodata-GISLine | kr 3 000 000 | kr 3 955 457 | kr 955 457 | 32 % |

| Region | Prosjektets navn | Kontraktssum | Sluttkostnad/Oppgitt prognose for ikke avsluttende kontrakter ( Beløp ekskl. mva.) | Overskridelse i beløp | Overskridelse i prosent |
|---|---|---|---|---|---|
| 6 Vegdirektoratet | Planlegging Ildhusøya | kr 2 520 250 | kr 8 386 000 | kr 5 865 750 | 233 % |
| 6 Vegdirektoratet | Planlegging almannajuvet | kr 1 548 736 | kr 3 980 134 | kr 2 431 398 | 157 % |
| 6 Vegdirektoratet | Planlegging Trollstigen og Gudbra | kr 1 960 000 | kr 20 700 000 | kr 18 740 000 | 956 % |
| 6 Vegdirektoratet | Planlegging Vøringsfossen | kr 9 500 000 | kr 16 000 000 | kr 6 500 000 | 68 % |
| 6 Vegdirektoratet | Basisutstilling Kvorning | kr 11 022 500 | kr 14 000 000 | kr 2 977 500 | 27 % |
| 6 Vegdirektoratet | Vegvesenets historie | kr 2 800 000 | kr 2 800 000 | kr - | Ingen overskridelse |

KONTAKTPERSON: Jane Bordal, Direktør for Veg- og transportavdelingen i Vegdirektoratet: 2207 3727 eller 901 03 330

**Norges miljø- og biovitenskapelige universitet**
Noregs miljø- og biovitskapelege universitet
Norwegian University of Life Sciences

Postboks 5003
NO-1432 Ås
Norway