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Over time or on time? A study of delays in large government projects

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Abstract

This paper investigates the extent of delays in large government investment projects in Norway. We use a data set consisting of 112 road, railway, building, defence and ICT projects. All projects have been planned and implemented within a standardised governance framework. This ensures a more robust assessment of causation compared to studies that use data from disparate projects around the world. The results have shown that about half of the projects are completed on or before time, there are a large proportion of projects that are severely delayed. Defence projects are particularly prone to problems during their delivery. This is in accordance with findings from other countries. The paper shows that there has been a slight improvement in time, that is, the extent of delays seems to have been reduced over the last 20 years. Counter to expectations, projects that are delayed do not seem to be more at risk to overrun their costs.

Keywords: Schedule delay; overruns.

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1. Introduction

Effective project management is about converting resources into results in a cost- and purpose-efficient way. Even if realising user benefits and societal goals are the most important reasons for carrying out projects, traditional parameters such as time, cost and quality, are still important success criteria for evaluating projects.

Along with increasing use of projects to organise and implement policies and strategies in the private and public sector, both the academic literature and the media have investigated whether projects in different sectors have been able to deliver their agreed objectives. The results of various studies have largely been negative. Internationally, there is an impression that schedules, cost estimates and cost-benefit analyses (CBAs) have been overoptimistic [1].

The Norwegian results with regards to cost performance and the accuracy of benefit estimates have been more positive that what some international studies have reported. Welde [2] showed that a majority of large government projects were completed within budget. Odeck and Kjerkreit [3] reviewed 27 ex post cost benefit analyses of road projects and found that the net present value had been underestimated by an average of 50 per cent.

For one of the classic criteria for project success, however, we have less knowledge. There are no systematic studies of large projects' ability to deliver their results on time. Our knowledge of the extent of project delays are very limited; we do not know why delays occur; nor do we know which consequences delays may have to other project success criteria such as costs or benefits.

Delays may cause social benefits from projects to occur later than planned. CBAs are based on discounting effects over several decades. Since the construction or implementation costs of projects often are large, it is important that the benefits start to flow as quickly as possible. Due to discounting, deferred benefits could have a significant impact on net present value. The same, of course, applies to projects in the private sector that depend on a positive cash flow to repay the investment as quickly as possible. For loan-financed projects, delays can have major negative consequences. In the private sector, however, time is money and it can provide a stronger incentive for effective project implementation than in the public sector.

Delays may also be associated with project implementation as they can occur as a consequence of or be a cause of other challenges. The level of conflict in the construction industry has increased in recent years. Although the contracts in most cases contain an obligation for the contractor to continue the work even if the contractor and the client disagree on payment settlement, it is documented that the opening of several new roads has been delayed due to disagreement between client and contractor. When contracts are terminated due to disagreements about contractual obligations, delays may occur because the client must procure another contractor to take over the work.

It is not only the client who suffers due to delays. Delays are also resource-consuming for contractors. Errors and omissions in the design, disagreement about contract understanding, client-initiated change orders, can lead to the contractor not being able to carry out the work in line with the agreed schedule and lead to a loss of profitability.

This study examines whether large government projects in Norway completed from 2005 to 2019 have been completed in accordance with the agreed time for completion when the projects were formally approved by the Parliament. We examine the extent of delays, whether there are systematic differences between project types or sectors, what the reasons for any delays may be, and whether there is any connection between cost overruns and delays.

The paper is organised as follows. Section 2 discusses some previous studies of delays in projects, Section 3 describes the data and methodology used in the paper, Section 4 presents the results and in Section 5 we provide some concluding remarks.

2. Previous studies of delays in projects

A number of historical examples from the world of project management gives the impression that delays in projects are widespread and causes major problems for project implementation.

The tunnel under downtown Boston, "the Big Dig", was nine years late when it opened in 2007. The railway tunnel through Hallandsåsen in southern Sweden took 19 years longer and cost 12 times more than planned. The 8.7-kilometer long railway tunnel opened in 2015. Berlin Brandenburg Airport opened in 2020, eight years later than planned. The Edinburgh light rail took six years longer to build than planned, costing twice as much, and when it opened in 2014, it was only half of the line originally planned. The new Crossrail railway line from Reading west of

London to Shenfield east of London was due to open in 2018. After a series of overruns and technical challenges, the opening has been postponed to 2022. The Catholic Basilica Sagrada Família in Barcelona is perhaps the world's most long-lasting project. Construction began in 1882 and is still ongoing. According to the plan, it will be completed in 2026.

Delays in mega-projects can give the responsible actors headaches and entertaining media reports for the rest of us. In other cases, delays can be a matter of life and death. In the roll-out of COVID-19 vaccines in the winter and spring of 2021, progress was crucial for the possibility of avoiding death and serious illness, as well as for reopening countries increasingly affected by unemployment and stagnation. More than 200 years ago, Napoleon Bonaparte's campaign in Russia experienced the consequences of an overoptimistic timetable. When his army crossed the border in June 1812, he estimated that the war would be over within 20-30 days and brought supplies accordingly. When he was forced to retreat five months later, hundreds of thousands of soldiers and most of the horses had lost their lives due to lack of food and equipment. More than a hundred years later, Adolf Hitler made the same mistake and with the same disastrous result. His opponent in the west, Britain, did much the same in the Battle of France in the spring of 1940. Despite being just over 20 years since the last war, it was estimated that Germany's professional and well-equipped army and air force would be defeated within weeks. When the British were chased to sea just over a month later, they had lost 68,000 soldiers and most of most of their equipment.

There are, in other words, no lack of anecdotal and entertaining examples from projects and plans that have gone horribly wrong, but bad news sells better than good ones. Neither of the projects referred to above, were average projects. In order to draw general conclusions regarding the extent and magnitude of delays in different sectors, we need to consult the academic literature.

Many countries have an auditor general with a mandate to scrutinise government investments and political decisions. In Australia, the Australian National Audit Office (ANAO) reviews projects from various sectors. In a review of 26 defence projects [4], they concluded that the progress in these projects was a continuous challenge. A majority of the projects were delayed, and the average delay was 32.9 months.

Saïd Business School in Oxford have a database of 12,000 projects from around the world and according to Budzier [5] it shows that almost all project categories experience overruns and delays: Only 8 per cent of the projects in the database were completed within budget and on time. The proportion of delayed projects varied between sectors: 8 out of 10 roads, 6 out of 10 railways, 6 out of 10 buildings, and 8 out of 10 defence projects were delayed

Bordat et al. [6] reviewed contracts in 2,668 construction and maintenance projects for which the transportation authorities in Indiana, USA, were responsible during the years 1996 to 2001. They found that 12 per cent of the contracts experienced delays and that these amounted to 115 days on average. Based on regression analysis, the authors concluded that low bids (winners curse) and inadequate description of works in the contracts were the main causes of the problems.

Plummer Braeckman et al. [7] studied project implementation in 191 hydropower plants, of which 60 were collected by the authors themselves and the others from other studies of the same topic. They found that the average delay was 32 per cent, corresponding to about 18 months. There had been an improvement over time as projects completed after the turn of the millennium had significantly fewer delays than previous projects. The authors also found a significant effect of size. Large projects had larger delays than small ones.

Ansar et al. [8] found worse results in their study of 239 dams (both hydropower plants and for other purposes). Eight out of ten dams were delayed with an average of 44 per cent or 2.3 years (median 27 per cent; 1.7 years). The authors claimed that planners of hydropower plants and irrigation systems had not learned anything between 1934 and 2007, the period when their data set was from.

Wind power is another energy source where the developers have strong incentives for commercial operation as soon as possible. In a study of wind power plants in Brazil, however, Bayer et al. [9] found that only 17 per cent of the licenses granted in the first ten auction rounds (with a total of 397 projects) came into operation within the deadline. They referred to similar results from other countries in Latin America and pointed in particular to two external factors as important reasons for the delays: Lack of access to the transmission network for power and late delivery of wind turbines.

Nuclear power plants are characterized by the fact that the investments are very large and complex, and the waste from the incineration must be stored for hundreds of years afterwards. In a study of the nuclear power industry, Budzier et al. [10] found that among 177 nuclear power plants built from the 1960s until today, the median delay was 40

percent. The median delay for storage of the waste was at a similar level. Considering that the average construction time for new reactors is usually 5-6 years, such a percentage delay can have significant consequences.

In Norway, the petroleum industry is the country's largest industry. Its efficiency is important for value creation and GDP. In a study of 66 projects approved for delivery on of the Norwegian continental shelf during the years 2007-2018, the Petroleum Directorate [11] demonstrated that over 80 per cent of the projects were completed below budget and that the mean delay was only some 3.5 months.

We have by no means carried out a full literature review, but the overall impression from studies of time-use and delays is that a majority of projects are delayed to a greater or lesser degree. There is a clear skewed distribution where a large number of projects are carried out on time, some very few before time, while many projects are significantly delayed. In other words, it is far more likely that a project will be significantly delayed than that it will be completed much earlier than planned.

However, we cannot rule out publication bias, that studies may have been based on projects that already have challenges, and that there will therefore be a higher incidence of studies with negative results. It is demanding to find studies with large and representative samples.

There is no universal root cause for delays, and the causes may vary from country to country and between sectors, but from the literature we can try to group the causes as in Table 1.

Table 1. Causes of delays in projects (from the literature)

Group	**Issues that increases the risk of delays**
Reasons related to the planning of projects	• Poor front-end loading and immature business case • Overoptimism
Reasons related to the project's characteristics	• Small projects with a short implementation time • Large and complex projects • Development projects (not off-the-shelf) • Complex constructions
Reasons related to project governance / organisation	• Change of personnel • Lack of follow-up and clarifications from the project owner • Lack of experience/evaluation reports from the project organisations as a basis for experience transfer • Lack of a superior body for effective coordination and decision-making
Project internal reasons	• Lack of resources • High turnover of personnel • Lack of competence, capacity and continuity in the project organisation
Reasons related to the contract strategy and the contract award	• Lack of assessment of suppliers' ability to deliver • Choice of supplier without production experience • Contracts with weak incentives for the supplier to meet its obligations • Lowest price as award criterion • Defects in the description of works
Reasons related to the supplier	• Missing clarifications / answers from the supplier • Failure to deliver material • Over-optimistic supplier • Poor customer-supplier collaboration

3. Empirical strategy

The paper makes use of data collected by the research programme Concept at the Norwegian University of Science and Technology. The projects in the sample have all subjected to a governance scheme where the business case have been scrutinised by external consultants before parliament approval. They are planned and adopted in the same way, and within each sector the implementation model is relatively similar. This ensures a more robust assessment of causation compared to studies that use data from disparate projects around the world.

In Norway, all large government projects (> ≈ EUR 100 million) are subjected to a mandatory quality-at-entry scheme. The scheme was introduced in the year 2000 after a series of large cost overruns, delays and poor benefit-cost efficiency and requires that all project appraisals and business cases must be scrutinized by external consultants before parliament can approve funding and delivery [12]. The QA-scheme has contributed to improved cost performance [13] and annual ex post evaluations have demonstrated that projects subjected to the scheme largely are successful in achieving their goals [14]. Until now, there have, however, been np studies that explicitly have dealt with the issue of projects delays and how projects perform in this respect.

In this chapter, we briefly describe the dataset, research questions and which methods we use in this paper (the full study will be comprehensively presented in a report by Welde and Bukkestein [15] that is due for publication later this year).

3.1. Data

The sample for the study is made up of 112 road, railway, building, defence and ICT projects planned and implemented from 1999 to 2021. Figure 1 describes the distribution of projects between sectors.

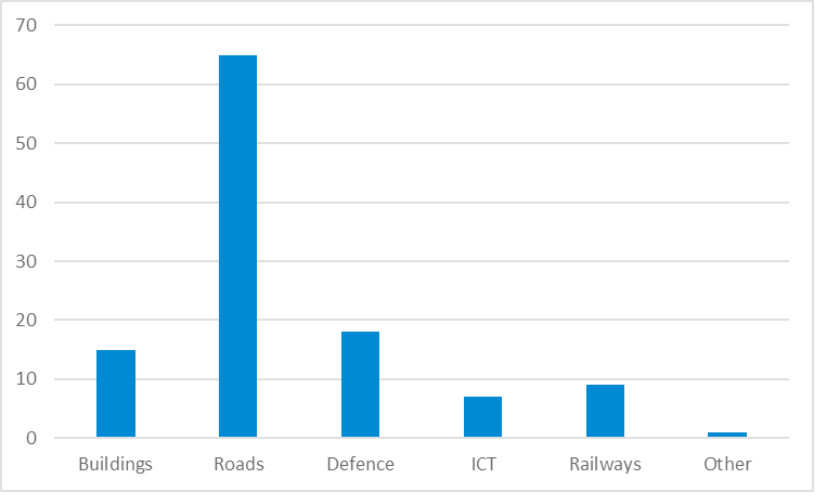

Figure 1. Project categories in the sample

The majority of the projects in the sample were carried out by the roads administration (65), followed by the armed forces (18), Statsbygg – the government's building commissioner (15), the railway administration (9) and various other government agencies (8). The estimated cost at the time of the decision to build was typically in the range of EUR 100-150 million.

3.2. Research questions

We look at both deviation (in months) between the planned and actual time of completion. We also investigate some potential causes for the delays. For the purpose of this paper, we answer the following research questions:

- What is the extent of delays in Norwegian government projects?
- Are there any differences between sectors?
- What is the impact of time?
- What is the relationship between cost overrun and delay?

4. Results

In this section, we present the answers to the research questions formulated in Section 3. We start with descriptive statistics that summarizes the main results per sector and for the whole sample, before we urn to the concrete research questions.

4.1. Descriptive statistics

Table 2. Delays in Norwegian government projects (months)

Sector	Roads	Railways	Buildings	Defence	ICT	Other	Total
N	65	9	15	17	5	1	112
Mean delay	4	8	3	30	40	32	10
Median	0	0	0	37	14	32	2
Standard deviation	9	13	7	33	48	-	21
Minimum value	-15	0	-8	-35	0	32	-35
Maximum value	47	36	22	97	105	32	105
Share of projects with delays	45%	45%	13%	88%	80%	100%	53%

Table 2 shows that the average delay in large Norwegian government projects is 10 months. There is a considerable right skew as the mean is much larger than the median delay that just 1.5 months. The results are very dispersed with a standard deviation of 21 months. The mode is 0, that is a typical government experience no delays. In fact, in our sample 42 projects or 38% are completed according to the agreed schedule.

Comparing the results of different sectors reveal some interesting differences. Roads, railways and buildings have similar results as their median completion time is equal to the planned time for completion. However, among both roads and railways, over half the projects experience delays. The large majority of buildings are completed on time, but the average delay is still positive, indicating that hardly any are completed earlier than planned. Defence and ICT project display particularly negative results as only 12 and 20% of the projects from the two sectors are completed on time. Their mean delay is 30-40 months, years behind schedule.

Table 3. Results for projects with and without delays

	With delays (n=59)	Without delays (n=53)
Mean	21	-2
Median	11	0
Standard deviation	24	7
Minimum	1	-35
Maximum	105	0

Table 3 shows the results for projects with and without delays. Among the projects with delays, the average delay is 21 months, almost two years. The most delayed project in our sample is the TETRA (Terrestrial Trunked Radio) projects which is a mobile radio system for emergency and public safety agencies. The projects was implemented in two stages and there was considerable delay between stage one and two due to political discussions on the choice of technology.

Figure 2 shows the distribution of the delays. There is a large number of projects that are finished on time, some are finished before time, but also a considerable number with large delays.

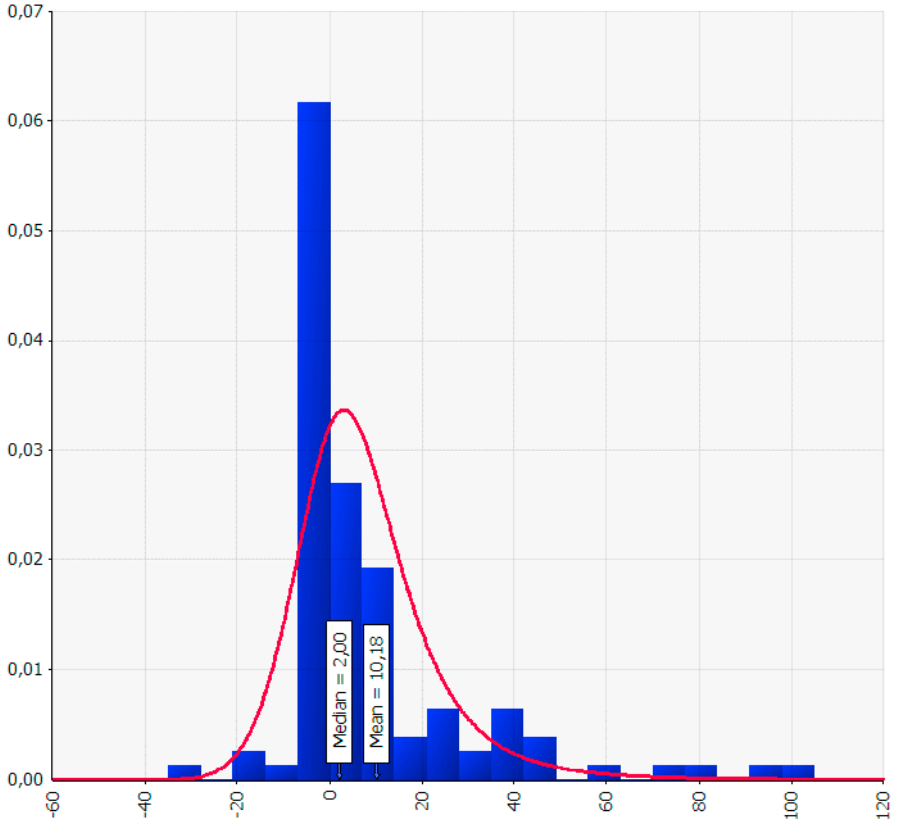

Figure 2. Distribution of delays

4.2. The impact of time

Learning is an essential part of all organizations, and especially capital-intensive organizations where the actions of individuals can have huge financial implications. The link from individual learning to group and organizational learning is, however, often weak and complex. Individual learning itself does not guarantee organizational learning. That means that even if an organization carries out a lot of projects per year, there is no guarantee that good practice in one project benefits the others.

Figure 3 shows the relationship between the year of the investment decision and project delay. The plot shows a declining relationship which indicates that the responsible agencies seem to have become better at completing projects on time.

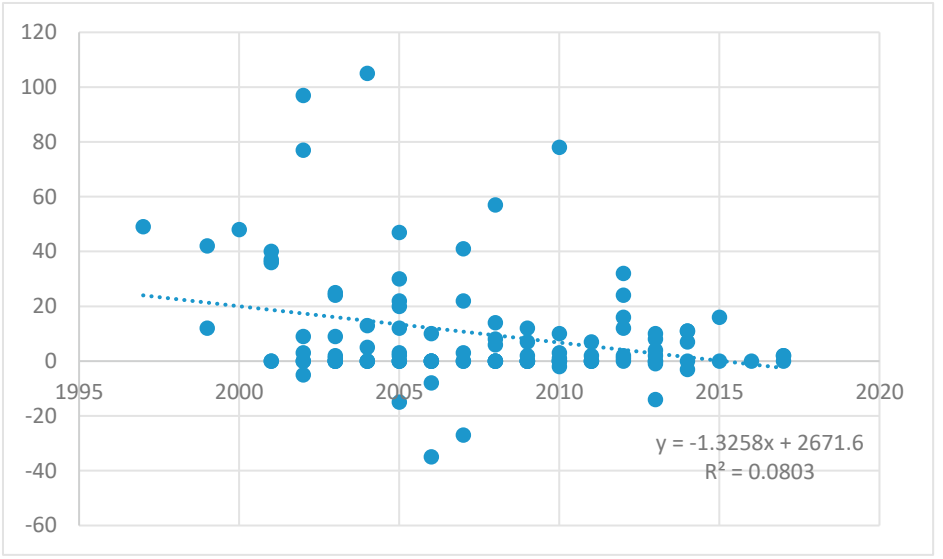

Figure 3. Development of delays over time (n = 112)

For every year, delays have been reduced by some 1.3 months. The relationship is significant at 99 per cent level ($t(111) = 2.99$, $p = 0.003$).

4.3. Relationship between overrun and delay

Cost overrun is an indication of problems that can increase the risk of delays. However, the relationship between the two issues is not clear cut. Overruns may cause delays and vice versa. In Figure 4 we have plotted delays against the deviation from the P50 estimate in the projects (where available).

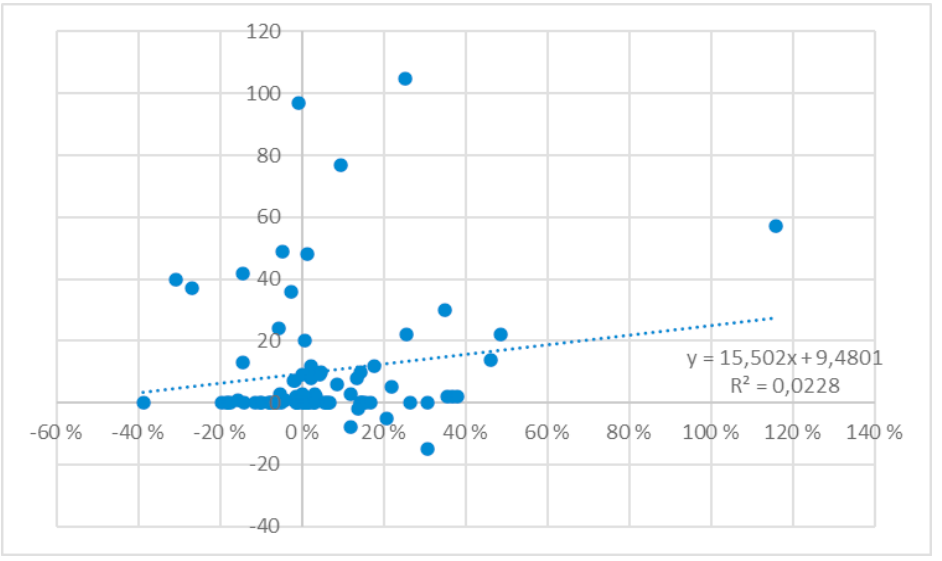

Figure 4. Relationship between delay (y-axis) and cost overrun (x-axis) (n = 80)

Figure 4 indicates that there is no relationship between delay and cost overrun. The slope coefficient is not significant ($t(79) = 1.38$, $p = 0.17$) This is counterintuitive as we might expect projects that experience overruns are more delayed than those that don't. It may seem as if the responsible agencies have been able to complete projects according to the agreed schedule despite problems during projects execution. This may indicate that the reasons for delays lies in external factors such as those of the TETRA project mentioned above.

5. Concluding remarks

This paper has briefly presented some of the results of a study of delays in large government projects in Norway. The projects have all been planned and implemented within a common framework for project appraisal and quality assurance. This ensures a more robust assessment of causation compared to studies that use data from disparate projects around the world. The issue of delays is important as if projects deliver their results later than planned, the social benefits that they were intended to deliver will fall short of intentions. In a world of rapid technological change, delayed results may also lead to reduced relevance and lifespan of products. Delays may also cause several project internal problems such as overruns and disputes with contractors and suppliers. The purpose of the study has been to investigate if delays are a problem in government projects in Norway and to determine if there are any obvious causes that can be mitigated by the organisations responsible for the implementation of the projects.

The results have shown that about half of the projects are completed on or before time, there are a large proportion of projects that are severely delayed. Defence projects are particularly prone to problems during their delivery. This is in accordance with findings from other countries. We have found that there has been a slight improvement in time, that is, the extent of delays seems to have been reduced over the last 20 years. Counter to expectations, projects that are delayed do not seem to be more at risk to overrun their costs.

The short paper has not tried to identify the root causes of delays in projects, but the time range of completion times should be a cause for concern for both decision makers and projects organisations alike. This is a source of uncertainty that may not have been identified properly in the appraisal of the projects. The findings of this paper should be a starting point for mitigation of delays in order to improve project efficiency.

References

[1] Flyvbjerg, B. (2017). "Introduction: The Iron Law of Megaproject Management", in Bent Flyvbjerg, (ed.) *The Oxford Handbook of Megaproject Management*, Oxford, Oxford University Press.

[2] Welde, M. (2017). "*Kostnadskontroll i store statlige investeringer underlagt ordningen med ekstern kvalitetssikring*", Concept report no. 51, Trondheim, Ex ante academic publisher.

[3] Odeck, J. and Kjerkreit, A. (2019). "The accuracy of benefit-cost analyses (BCAs) in transportation: An ex-post evaluation of road projects." *Transportation research Part A: Policy and Practice* **120**: 277-294.

[4] Australian National Audit Office (ANAO) (2019). "*2018–19 Major Projects Report"* [online]. Auditor-general report no.19 of 2019–20. Available from: https://www.anao.gov.au/work/major-projects-report/major-projects-report-2018-19

[5] Budzier, A. (2019). "*Changing How Projects Are Delivered Insights from Studying 11,000 Projects"* [online]. Available from: https://projectdataanalytics.uk/wp-content/uploads/2019/04/Alex-Budzier-London-Data-Meetup-v1.pdf

[6] Bordat, C., McCullouch, B.G., Labi, S. and Sinha, K.C. (2004). "*An Analysis of Cost Overruns and Time Delays of INDOT Projects*." Publication FHWA/IN/JTRP-2004/07. Joint Transportation Research Program, Indiana Department of Transportation and Purdue University, West Lafayette, Indiana.

[7] Plummer Braeckman, Disselhoff, T. and Kirchherr, J. (2020). "Cost and schedule overruns in large hydropower dams: an assessment of projects completed since 2000." *International Journal of Water Resources Development* **36** (5): 839-854.

[8] Ansar, A., Flyvbjerg, B., Budzier, A. and Lunn, D. (2017). "Big is Fragile. An Attempt at Theorizing Scale", in Bent Flyvbjerg (ed.), *The Oxford Handbook of Megaproject Management*, Oxford, Oxford University Press.

[9] Bayer, B., Berthold, L., Moreno, B. and de Freitas, R. (2018). "The Brazilian experience with auctions for wind power: An assessment of project delays and potential mitigation measures." *Energy Policy*, **122**: 97-117.

[10] Budzier, A., Flyvbjerg, B., Garavaglia, A. and Leed, A., 2018. "*Quantitative Cost and Schedule Risk Analysis of Nuclear Waste Storage*." Oxford Global Projects.

[11] Norwegian Petroleum Directorate (2020). "*Prosjektgjennomføring på norsk sokkel*". Rapport nr. OD - 02-20.

[12] Volden, G.H. and Samset, K. (2017). "Quality assurance in megaproject management: The Norwegian way", in Bent Flyvbjerg, (ed.) *The Oxford Handbook of Megaproject Management*, Oxford, Oxford University Press.
[13] Odeck, J., Welde, M. and Volden, G.H. (2015). " The Impact of External Quality Assurance of Costs Estimates on Cost Overruns: Empirical Evidence from the Norwegian Road Sector." *European Journal of Transport and Infrastructure Research*, **15**: 286-303.
[14] Welde, M. and Volden, G.H. (2018). "Measuring efficiency and effectiveness through ex-post evaluation: Case studies of Norwegian transport projects". *Research in Transportation Business & Management*, **28**: 33-39.
[15] Welde, M. and Bukkestein, I. (2021). "*Til rett tid? En undersøkelse av forsinkelser i store statlige prosjekter*." Concept report no. 66, Trondheim, Ex ante academic publisher.