Do cost overruns of road projects improve after reorganization? Empirical evidence from Norway

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Abstract

Reorganizations of authorities in charge of road-planning and construction projects are frequently conducted as a means of reducing cost overruns which are prevalent in transportation projects, yet the transportation literature has seldom investigated the impact of such reorganizations. This paper addresses this question using data from Norway, where the Public Roads Administration charged with the planning and building of roads was reorganized three times in the period 1993 - 2003 with the aim of reducing cost overruns. In the first period, roads were planned and built by the government; in the second period, the roads were planned and built by the government but the building and planning were separated from each other and the building department was accountable to the planning division; in the third period, the construction unit was privatized while the planning department remained a public procurer. The dataset is large and comprises 1,045 road projects, which are classified according to estimated costs. A statistical comparison of cost overruns across these organizational forms reveals several key observations: (1) the magnitudes of cost overruns reduced significantly after road building was outsourced from the government; (2) over the years, cost overruns of larger projects have been reduced while those of smaller projects have increased; and (3) delays in construction time impacts overruns negatively and have been persistent across all periods. Our conclusion is that the government now needs to focus on overruns of smaller projects and on controlling delays in construction.

Keywords: Road construction; Cost estimates; Actual costs; Cost overrun; reorganization

1. Introduction

Cost overruns in public projects have been a pervasive problem that has raised concerns in the media and among policy makers over the years; see, for instance, Edwards (2009). The underlying problem of cost overruns is economic in nature; faulty cost estimates may lead decision makers to implement inefficient policies.. Take the case of a single proposed project where underestimated costs are presented to the decision makers. Assume further that the net present value of this project is positive given the underestimated costs. The decision makers may decide to implement the project. However, had they known the actual costs, they may have instead chosen among the following alternatives: (1) not to implement the project at all, (2) to implement the project in another more viable form, or (3) to implement other more viable projects. What this means is that accurate cost estimates lead to more appropriate uses of public funds, or rather, it saves the taxpayers money. Cost underruns are no less of a problem; had accurate estimates been known, the excess resources marked for certain projects but that were not used could have been used earlier on other profitable undertakings. The underlying rationale for also avoiding cost underruns from an economic point of view is that a dollar of benefits is worth more now rather than in the future.

In the transportation sector, which is the concern of this paper, cost overruns have been shown to be prevalent; see, for instance, Skamris and Flyvbjerg (1996 and 1997), Flyvbjerg et al. (2002 and 2004) and Odeck (2004), for some recent studies. These studies have shown that the causes of overruns seem to be connected not only to factors that are hard to predict and manage, but also to poor management and control of projects at every stage, from planning to completion. In response to criticism that has been raised, governments over the years have looked for ways to curb overruns. A common practice is to reorganize and/or restructure the governmental departments or agencies charged with planning and construction of public works in the hope that this will reduce the average magnitudes of overruns. One of the arguments for reorganization is that the line of command in governments is often not clear and that there is lack of robust and accountable framework in the organizations, which frequently leads to expensive mistakes, e.g., costs are underestimated and are not discovered in time; see, for instance, TPA (2007).

Whereas there is an extensive literature on cost overrun of transportation projects, virtually none have studied how measures taken by governments to reduce overruns, such as reorganization of government departments, helps in reducing the magnitudes of cost overruns. Therefore, it is natural to ask whether the objectives of reorganizations are met, i.e., do the magnitudes of overruns reduce after such reorganizations? This question is the subject matter of this paper. We use data from the Norwegian Public Roads Administration (NPRA), the agency charged with planning and construction of road projects, which was reorganized three times in the period 1993-2003 as means of reducing cost overrun in road projects. Hence, this paper is a contribution to the transportation literature as it is the first to investigate how reorganizations impact cost overruns.

Several questions are therefore asked: (1) how prevalent and how large are cost overruns among Norwegian projects, (2) did the prevalence and magnitude of cost overruns improve after the reorganizations, (3) do the magnitudes of overruns differ according to the sizes of projects and project types, and (4) how do factors such as the construction time and construction delays affect cost overruns?

This paper proceeds as follows. To set up the case to be analyzed, Section 2 gives a brief account of the reorganizations that took place within the Norwegian road sector aimed at reducing cost overruns. Section 3 is a literature review of cost overruns in the road sector.

Section 4 describes the data and describes the methodology to be used. Section 5 presents the results and Section 6 provides some concluding remarks.

2. Reorganization of the NPRA to reduce cost overrun

In the late 1980s, the Norwegian media broadcast the magnitudes of cost overruns among Norwegian road projects following an investigation by the Auditor General, hereafter the AG. The AG stated that the project costs were out of control, particularly among larger projects and that, unless the NPRA did something about these, they would continue to escalate, which is tantamount to deception and misuse of public funds. The AG argued that because the NPRA was both the procurer and builder, it did not have an appropriate incentive to control cost overruns for a large majority of projects, even though about 40% of the building was on tenders. The major problem, as observed by the AG, was that procurement and building were within the same division at the NPRA, hence accountability was lacking. Following these tough remarks from the AG, the Ministry of Transport and Communication requested that the NPRA reconsider its organization to be in accordance with the remarks of the AG. . Consequently, in the early 1990s, the NPRA came up with a suggestion on how its procurement and building could be reorganized to reduce overruns, which was accepted by the Ministry of Transport and Communication and implemented for projects to be built beginning in 1997. The reorganization split procurement and building functions into two distinct divisions within the NPRA, where the building division was accountable to the procurement similar to how competition works among private developers. Further, the building division competed for tenders on the same terms as other private entrepreneurs. For the purpose of the analyses to follow, we dub this period as the *semi-monopoly*; the building division remained under the NPRA and the NPRA could favor it in the provision of tenders.

The situation before this is dubbed *full monopoly*, as both procurement and building were concentrated in one department at the NPRA, and, hence, the NPRA had a full monopoly on the provision of tenders.

In the mid 1990s, another study by the AG was conducted, which concluded that there was no reason for the government, such as represented the NPRA, to sit on both sides of the table, both procuring and building some of the projects, observing that the NPRA would favor its own projects. This would be inefficient from an economic point of view as it deters competition, which, all other things being equal, increases efficiency; often resulting in cost reductions. Again, the NPRA was asked to reconsider its position. As a consequence, the building unit was privatized as its own company; however, it remained partially owned by the government (50% of shares) and henceforth could compete with other entrepreneurs on tenders and equal terms. This suggestion was accepted by the Ministry of Transport and was implemented for new projects beginning in 2003. We dub this situation *full competition*.

The reorganizations that took place can be summarized as follows. Period 1 is the *full monopoly* situation in which the procurer was also the builder, is observed in our data set from 1993-1996. Period 2 is the *semi-monopoly* situation when, although both procurement and building were two distinct divisions and the building division competed for tenders and was accountable to the planning division, they both were still under the NPRA. This period is observed in our data from 1997 – 2002. Finally, period 3 is the *full competition* situation where the building unit was privatized and the NPRA became only a procurer, whereas all building occurred on tenders and by competition. This period in the data set ranges from 2003 to 2007. There is one additional change that took place beginning in 2003 that may have significantly impacted cost overruns. After that year, all large projects with estimated costs above 500 million NOK were subjected to quality assurance. This requirement meant that external consultants, commissioned by the Ministry of Finance, scrutinized every such cost estimate. Therefore, we also study the impact of this quality assurance on cost overruns of large projects. Incidentally, the quality assurance of large projects occurred at the same time full competition was instituted. Thus, in the analysis, the quality assurance period exactly matches the full competition period with respect to large projects. The procedure for estimating the cost of roads projects that this study deals with is worth mentioning. The procedure in use, the so-called *judgmental forecasting*, has been the same since the mid 1980s*;* see, for instance, Odeck (2004) for further elaboration.

3. Literature review

The literature on cost overruns of transportation projects is growing. Several authors over the decades have compared forecasted costs and actual costs for large groups of road infrastructure projects.

Pickrell (1990) carried out a study for the US Department of Transportation covering US rail transit projects with a total value of $15.5 billion. The total capital cost overrun for eight of the projects was calculated to be 61%, with individual project cost overruns ranging from 21% to 106%. Another study by the Auditor General of Sweden (1994) covering 15 road and rail projects revealed that the average cost overrun of eight road projects was 86%. The range for road projects was from -2 to 182%, whereas the average overrun for the seven rail projects was 17%, ranging from -14 to 74%. Two thirds of the projects were still under construction and it was concluded that final costs could turn out to be even higher. Another study carried out by Fouracre et al. (1990) for the UK Transport and Road Research Laboratory (TRRL) covered 21 metro systems in developing countries. The results showed that 6 metros had cost overruns above 50%, two of these in the range 100 - 500%. Three had overruns in the range 20–50%, and the remaining four ranged from -10 to 20%.

Odeck and Skjeseth (1995) assessed Norwegian toll roads to reveal whether planning procedure shortcomings experienced by Norwegian road agencies had resulted in poorer-than-projected financial performances for some of the toll roads. They found overestimation of traffic forecasts and underestimation of construction costs. In their small sample of 12 toll projects, they found an average cost overrun of about 5%, but the interval was large at -210 to 170%. They claimed that the uncertainties inherent in cost estimates are never brought to the attention of the decision makers. A study by Skamris and Flyvbjerg (1996, 1997) compared the accuracy of traffic forecasts and cost estimates on large transportation projects in Denmark. The study considered cost estimates of seven bridges and tunnels dating from just before the decision was made to build and actual costs after completion. For the non-completed projects, current developments in forecast were compared to the original forecasts. Their main conclusion was that cost overruns of 50–100% are common for larger transportation infrastructures and that overruns above 100% are not unusual. Further, they claim that the differences between forecasts and actual costs (and traffic) that they find cannot be explained primarily by the inherent difficulty in predicting the future. Hecht and Niemeier (2002) compared transportation-project development efficiencies. In particular, they examined time and cost of project development efficiencies between voter or legislatively approved projects and projects with standard scope. Their data are based on interviews conducted with project managers recently involved in the development of large transportation projects. They did not find significant evidence that state highway projects, with highly defined voter or legislatively approved project scopes, time or costs, were any more likely to have lower development costs or times than projects that are non-voter approved.

One of the studies that sparked renewed interest in the magnitudes and causes of cost overruns among transportation projects was Flybjerg et al. (2002). Based on a sample of 258 transportation infrastructure projects worth US$90 billion and representing different projects worldwide and across historical periods, they found overwhelming statistical significance that cost estimates used to decide whether such projects should be built are highly and systematically misleading. They conclude that the underestimations observed cannot be explained by error and are best explained by a strategic interpretation, which is tantamount to lying. They thus warn legislators, administrators and those who value honest numbers not to trust cost estimates and benefit-cost analyses produced by project promoters

For Norway in particular, Odeck (2004) investigated the statistical relationship between actual and estimated costs among Norwegian road projects completed in the period 1992-1995, comprised of 620 projects. As in previous studies elsewhere, he confirmed that the magnitudes of overruns were large and predominant with one additional new finding: the largest overruns were among the many smaller projects as measured by construction costs. His conclusions were that the greatest potential for cost saving lies in exerting pressure on smaller projects such that costs can be reduced. Magnussen and Olsson (2005) studied cost overrun of 31 major projects in Norway. They analyzed the impact of mandatory quality assurance. Their results showed the magnitude of cost overrun reduced after a mandatory quality assurance was introduced.

The literature clearly shows that cost overruns are formidable among road projects. However, apart from the study by Magnussen and Olsson (2005), the literature does not reveal much about whether measures implemented by governments help in reducing the magnitudes of such overruns. The impact of reorganizing government agencies charged with planning and building of roads on cost overruns is virtually nonexistent in the literature. In this respect, this paper is a contribution to the literature of transport policy, economics and planning; it is the first empirical study to address how reorganizations impact cost overruns.

4. The data

As described in section 2, the Norwegian Public Roads Administration (NPRA) was reorganized three times during the period 1993-2003. The primary data that we use in the subsequent analyses capture both estimated costs and actual costs. These cost elements were retrieved from a database containing planning data, including estimated costs and a database that reports completed projects with actual costs; both of the databases are monitored by the NPRA. These databases were merged, making the calculation of overruns possible. However, it should be stressed here that data for 1997, 1998 and 1999 could not be retrieved as the records were not available. Although this is a drawback, the number of years in each period being studied is the same at 4 years; period 1 consists of years 1993-1996, period 2 consists of years 2000-2003 (excluding the period 1997-1999) and period 3 consists of years 2004-2007.

Because the planning process takes several years and several estimates are available, one must be careful with the choice of the appropriate cost estimate to compare with the actual cost to derive the magnitude of overruns. In Norway, as in many other European countries and the US, there are up to several cost estimates for each road project. For Norway, these different estimates can be classified as follows: (1) feasibility study estimates with confidence intervals of ±40%, (2) corridor plan estimates with confidence intervals of ±25%, and (3) the detailed plan estimates, i.e., the stage at which design, specifications and final estimates are made, with confidence intervals of ±5%. The detailed plan estimates are the estimates that are presented to decision makers (members of the Norwegian parliament) in conjunction with the national budget, normally a year before the commencement of construction.

There is no accepted standard concerning which of these cost estimates should be used to access the magnitudes of cost overruns. However, the most logical to use are the final cost estimates that are presented to the decision makers at the time of decision making, which in our case means the estimates at the detailed plan level. We use these estimates in our analyses and conform to the suggestions in literature, as in, e.g., Flyvbjerg et al. (2002).

The database, in addition to estimated and actual costs, contains information such as completion time, delays in completion, project size, project type, etc., and includes a total of 1,045 projects. The set of variables available in the data set is provided in Table 1.

Table 1: List of variables in data set

No.	Variable	Measure	Explanation
1	Year	Numerical	Year of project completion(1993 -2007)
2	Region	Categorical	Region where project is situated(Five regions in all)
3	Type of project	Categorical	Project type i.e.,either road, tunnel, bridge etc(9 classes in all)
4	Period of organization	Categorical	Either 1993 -1996, 1997 -2003 or 2004-2007
5	Project size	Categorical	Size of project as measured by class of estimated cost(less than 50 mill NOK, 51 -100 mill NOK and greater than 100 mill NOK)
6	Estimated cost	Numerical	Estimated cost in mill. NOK(2008)
7	Actual cost	Numerical	Actual cost in mill NOK(2008)
8	Planned completion time	Date	Date for planned completion time
9	Actual completion time	Date	Date for actual completion time
10	Delay in completion time	Months	Dsscrepancy between planned and actual completion time in months
11	Actual construction start	Date	Actual date for construction start
12	Actual construction completion	Date	Actual date for completion of construction
13	Actual construction time	Months	The difference between actual construction start and completion date

The summary statistics of the projects involved, categorized by project size versus number of projects in each category, estimated cost and share of total cost, are provided in Table 2. Several interesting observations emerge. Consider first the number of projects in each cost category according to the periods being studied, as shown in the upper part of Table 2. A great majority of projects irrespective of period under consideration belong to the cost category “small projects” with an estimated cost of less than 50 million NOK. The next largest category is the number of larger projects greater than 100 million NOK. Overall, it is seen that the number of smaller projects has reduced over the years, whereas the number of larger projects has increased. This is also confirmed by figures in the lower part of the table, where the share of total budget for smaller projects has decreased, whereas it has increased for larger projects. Overall, the number of projects in each cost group and period is large enough to warrant a statistical test of differences in cost overruns between the different periods.

Table 2: Summary data on the distribution of overruns by project size

	Number of projects			
	1993-1996	1997-2003	2004-2007	Total
Small(less 50 mill. NOK)	383	279	220	882
Medium(50-100 mill. NOK)	22	19	25	66
Large(greater than 100 Mill. NOK)	29	25	43	97
Total	434	323	288	1045

	Estimated costs in mill. NOK(2008)			
	1993-1996	1997-2003	2004-2007	Total
Small(less 50 mill. NOK)	3121	2645	3201	8967
Medium(50-100 mill. NOK)	1494	1311	1775	4580
Large(greater than 100 Mill. NOK)	6314	10091	17039	33444
Total	10929	14047	22015	46991

	Share of total costs			
	1993-1996	1997-2003	2004-2007	Total
Small(less 50 mill. NOK)	0.29	0.19	0.15	0.19
Medium(50-100 mill. NOK)	0.14	0.09	0.08	0.10
Large(greater than 100 Mill. NOK)	0.58	0.72	0.77	0.71
Total	1.00	1.00	1.00	1.00

5. Methodology

Any assessment of cost overruns starts with an assessment of the forecast error, i.e., the discrepancy between the actual cost and the forecasted cost. If Y_i is the actual observation of cost for project i and F_i is the forecast for the same project, then the forecast error, e_i, is defined as

$$e_i = Y_i - F_i. \qquad (1.1)$$

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If e_i is positive, then underestimation has occurred, and the opposite applies if e_i is negative; e_i =0 implies that actual costs exactly matches forecasts, i.e., cost estimates have been accurate.

If there are observations and forecasts for n projects, there will be n errors and some form of aggregation is required to measure the overall error across projects. The following standard statistical measures can be defined (see, for instance, Makridakis et.al, 1998):

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$$\begin{aligned} ME &= \frac{1}{n}\sum_{i=1}^{n} e_i \\ MAE &= \frac{1}{n}\sum_{i=1}^{n} \left| e_i \right| \\ MSE &= \frac{1}{n}\sum_{i=1}^{n} e_i^{\,2}. \end{aligned} \qquad (1.2)$$

ME is the mean error across all projects, MAE is the mean absolute error and MSE is the mean squared error. These measures tell different stories depending on what one intends to measure. ME tends to be small because negative and positive values will tend to offset one another; it only shows whether there are systematic under- or over forecasting, generally termed forecast bias. Because it considers the absolute values, MAE reveals the absolute size of forecast error, i.e., bias irrespective of direction. It thus gives an indication of the magnitudes of forecast biases. MSE gives more weight to larger values as compared to smaller values; it is similar to MAE in that all values will be positive.

When comparing forecast accuracy across different time periods, however, the measures above do not facilitate adequate comparison, as their size depends on the scale of the data. To make such comparisons, even though equation (1) will give an indication of the magnitude of error for each of the periods, one needs relative or percentage error measures that are independent of the scale of data. A relative or percentage error (pe_i) is defined as

$$pe_i = \left(\frac{Y_i - F_i}{Y_i} \right) \times 100. \tag{1.3}$$

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Note that other authors have used forecasted cost in the denominator, e.g., Flybjerg et al. (2004). They have thus measured error as a percentage of the forecast. We have instead taken the position that error is measured as a percentage of actual cost, i.e., how large errors are in relation to actual costs. This conforms to the literature of forecasting (see for instance Makridakis (1998)).

From equation (3), the following two relative measures that are frequently used in the literature can be derived:

$$\begin{aligned} MPE &= \frac{1}{n} \sum_{i=1}^{n} pe_i \\ MAPE &= \frac{1}{n} \sum_{i=1}^{n} \left| pe_i \right| \end{aligned} \tag{1.4}$$

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MPE is the mean percentage error and MAPE is the mean absolute percentage error. Like ME and MAE, the MPE is likely to be small because negative and positive values tend to offset each other, and MAPE is defined by taking the absolute value of MPE so as to gain knowledge of the absolute size of the bias. Thus, in this study, the ME and MAE are computed to gain insight on the magnitudes of overruns in the periods being studied, whereas

MPE and MAPE are computed to gain insight into the overrun differences between the periods being studied.

When there are several periods to be compared, a question readily addressed is whether the results obtained are significantly different across periods. To test for significant differences between groups, non-parametric tests such as the Median and the Kruskal-Wallis test can be used with respect to the different measures, i.e., MAE and MAPE.

To infer the impact of other variables such as delay in construction time on the overruns, a regression analysis can be performed. In our case, the regression equation, similar to that used by Odeck (2005) and Flybjerg et al. (2006), is as follows:

$$e_i = \alpha + \beta_i x_i + \delta_i D_i + \varepsilon_i \qquad (1.5)$$

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where e_i is the overrun for project i, x_i are the continuous variables of interest and D_i are the dummy variables. The parameters to be estimated are α, β and δ.

6. Empirical results

The objectives of this paper are to (i) investigate the magnitude of cost overrun among the Norwegian road projects in period 1993 -2007; (ii) explore whether the different organizational forms (pure monopoly in the period 1993-1996, semi-monopoly in the period 1997-2003 and competition from 2004-2007) impacted cost overruns; and (iii) how delay in construction time impacted cost overruns. The results below are presented in that order.

6.1. The magnitude of cost overruns

Table 3 presents the mean, mean absolute and mean percentage errors for each period, by size category and for all periods being assessed. Consider first the mean errors (ME) as shown in the upper part of the table. Recall that if these figures are positive it implies that underestimation has occurred and the opposite applies if figures are negative. Further, these figures are in million NOK; they show the mean overruns measured in NOK (2008). First, as expected, the mean errors for smaller projects are smaller than for medium-sized and larger projects. Comparing overruns across periods, we note the interesting result that the mean errors for the medium and large projects reduced tremendously in the final period of 2004-2007; this is the period of full competition when building was privatized. Nevertheless, the mean errors for large projects were negative, implying that the actual costs were less than estimated; underruns occurred with a mean value of -18.7 million NOK, down from an overrun of 55.4 million NOK in the previous period of semi-monopoly. The medium-sized projects also showed a reduction in overruns from 12.8 to 8.4 million NOK, but overruns still persisted. For smaller projects, there was an increase in mean overruns from the second to the final period. If all projects are considered, the results are that the magnitude of overruns increased from the first period to the second and then dropped tremendously in the final period of 2004-2007, ending with an underrun of 1.55 million NOK. This indicates that the competition that came to force in that final period of 2004-2007 helped reduced overruns significantly,, whereas overrun reduction in the semi-monopoly period was no better than in the full monopoly period.

Consider next the mean absolute errors (MAE), which are only of interest if overruns are considered to be equally as bad as underruns. It is seen that mean absolute overruns have increased throughout the periods being studied. These results should be interpreted with care because they do not reveal anything about the direction of development in over/underruns across the periods of interest.

As discussed in the introduction section, percentage overruns are the most appropriate statistics to consider when comparing different periods, as percentage overruns are scale invariant. The mean percentage error and the mean absolute percentage errors are presented in the bottom of Table 3. The results of the mean percentage error (MPE) analysis confirm the results observed with respect to mean absolute percentage errors; overruns increased from the full monopoly period to the semi-monopoly of period and then dropped tremendously in the full competition period. Much of this development, once again, is explained by the improved accuracy of larger projects, which dropped from 11% to -7%! Consider finally the mean absolute percentage error (MAPE), which measures the percentages irrespective of the direction of overrun (or underrun). The results are interesting in relation to the question being addressed, which is as follows: did the reorganizations impact the magnitude of overruns? The overall results indicate that absolute overruns decreased systematically, from the full-monopoly period, via the semi-monopoly period, to the full competition period, from 18 to 15%, and much of the decrease can be explained by the improved estimation accuracy of larger projects.

Table 3: Mean, mean absolute and mean percentage errors

Mean error(ME)				
	1993-1996	1997-2003	2004-2007	Whole period
Small(less 50 mill. NOK)	1.07	0.40	1.09	0.86
Medium(50-100 mill. NOK)	0.95	7.36	5.34	4.39
Large(greater than 100 Mill. NOK)	4.56	55.40	-18.69	7.36
All projects	1.30	5.06	-1.55	1.68

Mean absolute error(MAE)				
	1993-1996	1997-2003	2004-2007	Whole period
Small(less 50 mill. NOK)	1.80	1.28	2.64	1.84
Medium(50-100 mill. NOK)	9.05	12.79	8.40	9.85
Large(greater than 100 Mill. NOK)	21.15	57.84	48.56	42.76
All projects	3.45	6.29	10.01	6.13

Mean Percentage error(MPE)				
	1993-1996	1997-2003	2004-2007	Whole period
Small(less 50 mill. NOK)	0.03	0.01	0.05	0.03
Medium(50-100 mill. NOK)	0.00	0.05	0.06	0.03
Large(greater than 100 Mill. NOK)	0.03	0.11	-0.07	0.00
All projects	0.03	0.02	0.04	0.03

Mean absloute ercentage error(MAPE)				
	1993-1996	1997-2003	2004-2007	Whole period
Small(less 50 mill. NOK)	0.19	0.17	0.16	0.18
Medium(50-100 mill. NOK)	0.13	0.13	0.11	0.12
Large(greater than 100 Mill. NOK)	0.10	0.12	0.14	0.12
All projects	0.18	0.16	0.15	0.17

A relevant question to address now is how much the prevalent cost overruns observed for the whole period have been measured in 2008 NOK. Table 4 presents these results. Over time, the cost overruns have resulted in an enormous amount of 1,742 million NOK. We note that the intermediate period of semi-monopoly (1997-2003) had the greatest overruns, whereas the full competition period of 2004-2007 had an aggregate underrun of about -442 million NOK. This suggests that the reorganization into full competition was a real improvement. Thus, a general and tentative conclusion that can be drawn is that the reorganization from monopoly to semi-monopoly led to increased magnitudes of overruns, whereas the reorganization from semi-monopoly to full competition led to a tremendous reduction in cost overruns; in fact, underruns are observed in the full competition period with respect to larger projects. Finally, overruns are still prevalent, especially with respect to small- and medium-sized projects.

Table 4: Actual overrun in mill NOK (2008)

	1993-1996	1997-2003	2004-2007	Whole period
Small	409	113	239	761
Medium	20	125	123	268
large	132	1385	-804	714
All projects	561	1623	-442	1742

(6.2) Statistical significance of differences in overruns between periods

The observations made in section (6.1) above are tentative; we should test whether or not the differences in the magnitudes of cost overruns between periods of organization are statistically significant before any firm conclusions can be drawn. To test for significant differences, non-parametric tests such as the median and the Kruskal-Wallis test can be used to test for differences between overruns in the different periods. The null hypothesis is that there are no differences in cost overruns between the periods being studied. In Table 5, we present the results of the Median and Kruskal-Wallis tests for differences in MAPE between periods being studied. The two tests are used to confirm that the test results conform to each other; otherwise, the results would be sensitive to the test method being used.

Test statistics with high ρ-values indicate that there is reason to suspect that there are differences between cost overruns between periods being studied. Lower values, below 0.01, indicate that there are differences. The results in Table 5 suggest that the null hypothesis of no differences between cost overruns in the periods being studied, irrespective of periods or across projects, should be rejected. Therefore, we conclude that full competition led to a reduction of overruns, whereas overruns increased from the pure monopoly to the semi-monopoly period, as was observed in Tables 2 and 3. Re-call however that the quality assurance discussed in section 1 and which implied that cost estimates of all larger projects were scrutinized by external consultants commenced in the period 2003 -2007. It is therefore likely that this quality assurance explains some of the large reduction observed for this period.

Table 5: The Median and Kruskal-Wallis tests for differences in MAPE across periods

	Median test	Kruskal Wallis test
Across periods		
Chi-square	8.92	11.05
P-value	0.01	0.00
Across project size		
Chi-square	7.02	7.62
P-value	0.04	0.02

(6.3) The impact of delay in construction time on cost overruns

It is now tempting to investigate the impact that delays in construction time had on construction overruns. Thus, overruns were regressed on delays and then delays were regressed on time periods and project sizes. The results showed that neither time period nor project size impacted delays, whereas delays impacted overruns significantly; the derived equation was as follows:

$$e_i = 1.14 + 0.74 \textit{Delay in construction};$$

SD =0.155, t=4.78, p=0.000 and Adj-$R^2 = 0.14$

Thus, we conclude that cost overruns increase with delays in construction and that overruns vary significantly with the periods being studied.

7. Concluding Remarks

This paper has investigated the impact of reorganization on cost overruns in the context of Norway. The reorganizations that took place were a change from a situation where the building and construction were in one governmental department, a separation of building and construction in two different departments with one accountable to the other and, finally, to an outsourcing of the construction department, which became a private company.

The findings show not only the variation in cost overruns across the organizational forms studied but also the overall status of cost overruns in the Norwegian road sector. These findings are summarized as follows:

1. The reorganization encompassing the outsourcing of construction work led to a tremendous improvement of cost estimates to the extent that the magnitudes of overruns decreased. However, the reorganization that separated building and construction into two different departments did not improve overruns.

2. The reduction in overruns has mainly been among larger projects; overruns among smaller projects are still common.

3. The reorganization does not seem to have improved delays in construction, which is found to impact overruns positively.

Our conclusions are that the final reorganization, which implied outsourcing of construction work, improved cost overruns on the whole. The government now needs to exert pressure on smaller projects and to improve delays in construction work. This will reduce overruns even further.

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