Cost Escalation in Road Construction Contracts

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Abstract

This paper presents a study of cost escalation in unit price road construction contracts. The aim is to investigate why the final cost of contracts differs from the agreed contract cost following tendering, both to identify causes of observed discrepancies and to suggest measures that could improve the planning and delivery of future projects. Road projects often consist of several contracts and as they account for the biggest costs of the projects, cost escalation in the contracts may increase the risk of project cost overrun. Even if contract cost performance is an important indicator of project success, it may be too simplistic to equate this with project success. It is quite possible to deliver a project within budget even if contract costs escalate, as long as the project cost contingency is adequate to cover such escalations. However, escalations in contracts increase the risk of project overrun and may lead to other problems such as conflicts and delays. The results show that most of the studied contracts experienced cost escalation. The main cause of the escalation was change orders to the scope that were not covered by the original contract. In addition, the results indicate that complexity represented by contract size, duration, and urban location increases the risk and size of cost overrun. Based on these findings, the paper presents some recommendations on how contract delivery can be improved as well as some implications for future research.

The construction industry accounts for a large share of gross domestic product and employs many people in all developed countries. The industry's size suggests that its efficiency is important to the overall performance of the economy. Thus, both client organizations and contractors should work to reduce wasteful practices.

The literature on cost overruns is extensive, and perhaps especially so in the transport industry. However, beyond demonstrating poor cost performance, many of the studies are repetitive and often demonstrate a lack of insight into how large and complex projects are organized (*1*). Most of the research to date has been on project cost overruns, leaving the exploration of contract overruns largely unexamined.

A road project may consist of a single contract awarded to a contractor, or it may consist of many contracts awarded to several contractors. The cost of the contracts will affect the performance of a project. As contracts normally account for the biggest costs in projects, the cost performance in contracts is important for successful project delivery. If contracts are not delivered on time and according to agreed costs, both the client's value for money and the contractor's profits are affected.

Traditionally, project success has been measured against targets for time, cost, and quality. In recent decades, the academic literature has recognized that a wider range of criteria is needed for measuring project success, but efficient project management to convert resources into results still remains at the heart of project-based organizations (*2*). Although certain changes to the scope of a project may be expected, major changes to a contract can indicate poor project management. Additions through change orders often result in cost escalations in contracts and may ultimately cause cost overruns at the project level.

Cost escalations in contracts can have different causes. They can be a result of wrong assumptions in the description of the works, which in turn may result in changes and additions to what was originally agreed (*3*). Cost escalations may also be a result of unforeseen external circumstances that need to be considered and budgeted for, or when the client requires changes to the agreed scope to achieve an intended function. Cost estimation is not an exact science. Therefore, contingency is needed so that, for example, changes to the scope do not automatically

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result in cost overruns (*4*). By adding contingency, cost overruns in contracts may be absorbed so that project overruns are avoided.

It is possible that the final cost of contracts will be higher than originally agreed and that an acceptable result at the project level still will be achieved. However, knowledge of past contract cost performance may be useful when estimating the costs of projects and in particular the necessary contingency that is needed to cover inaccuracies in estimates or unforeseen events.

The purpose of this paper is to investigate the extent to which original agreed contract prices differ from the final cost in construction contracts. This in turn enables an exploration of some of the causes of the observed escalations and suggests measures that could lead to improvements in the planning and delivery of future projects.

The paper is organized as follows. Section 2 reviews some previous studies of cost escalation in construction contracts. Section 3 briefly describes some crucial elements for managing and delivering construction contracts and projects. Section 4 describes the data and methodology used in the paper, and Section 5 reports the results. Section 6 presents some conclusions.

Previous Studies

Many studies have documented that cost overruns in projects are a challenge in most countries and in most industries. The reasons for the overruns vary, and different authors seem to have completely different theories as to why projects exceed their budgets. Flyvbjerg et al. (*5*) argued that overruns are because of deliberate underestimation, fraud, and optimism bias. According to Siemiatycki (*6*), Flyvbjerg et al. received much attention for their sensational accusations at the time, but their work has since received a lot of criticism for relying on secondary data sources and for comparing estimates prepared at different stages of project development. Other authors, such as Love et al. (*7*) and Love and Ahiaga-Dagbui (*8*), have therefore claimed that project-internal issues such as changes in scope, ground conditions, and weak project management are the main reasons for overruns.

One reason why both the size of the overruns and the supposed causes vary so much between different studies is that the basis for comparison varies. Some studies compare final costs with the first estimate, most studies compare final costs with the formal budget, and others compare final costs with the contract cost agreed with the contractor. Consequently, different comparisons can cause huge variations in reported results. Surprisingly, professional associations such as the Project Management Institute and the Association for Project Management do

not provide clear definition of cost overruns (*9*). Probably the most common definition of cost overruns is the one used by Flyvbjerg et al. (*5*), namely the difference between final costs and the cost estimate at the time of the decision to build. Flyvbjerg et al. (*10*) argued that this is the most relevant point of departure for comparisons of cost performance because it measures the accuracy of the information that was available to decision makers and how well-informed they were when they made their investment decision. If, instead, one was to compare the final cost with estimates produced while projects were in the earliest stages of project development, when the uncertainty about scope and design is large, the deviation might range from tens of percent (*11*) to several hundreds of percent (*12*). Siemiatycki (*13*) reviewed 13 studies conducted by researchers and auditors and found that one-third of the studies compared final costs with contracts, whereas the other two-thirds compared costs with the budget.

Different cost estimates are prepared throughout the development of a project. The expected accuracy of estimates varies according to, among many things, the extent of project definition and the degree of effort made to prepare the estimate. AACE International provides a classification of estimate classes from concept screening (Class 5) through to estimates for bid/tender (Class 1). Through the stages, the expected accuracy range decreases from $-50\%/+100\%$ to $-10\%/+15\%$ (*14*). Thus, any evaluation of cost estimates should consider the stage at which the estimate has been prepared.

Changes in the contract scope is a source of uncertainty in most projects. If the client requests changes and additions beyond the agreed scope of the contract, the contractor will normally require compensation for carrying out such work. If contractors speculate on change orders for profits, this may give unfortunate incentives to contractors to produce unrealistically low tenders (*15*). Burnett and Wampler (*16*) argued that in tenders in which the lowest bid is crucial to winning, such as in unit price contracts, the contractor must not only calculate the cost of carrying out the specified works according to the client's description but also estimate likely changes to the contract that could increase their profit margins.

Although most studies of cost overruns compare the project's costs with the budget, some studies have investigated cost escalation at contract level. Thurgood et al. (*17*) studied 499 road construction contracts in Utah from 1980 to 1989 and found that the average deviation between final cost and agreed contract price ranged from 0% to 10%. Hinze et al. (*18*) reviewed 468 unit price contracts in projects undertaken in the state of Washington between 1985 and 1989 and found that the average escalation was 5.1%. Ellis et al. (*19*) studied 3,130 road projects in Florida and examined whether unit price contracts were more vulnerable to escalations than other

forms of contracts. They found that there was a difference, although small: unit price contracts were on average 9% more expensive than the agreed contract price, whereas the corresponding figure for other types of contracts was 8%. The North Carolina Department of Transportation found similar results: in 390 road projects, the payment to the contractors averaged 7% over the original contract price (20).

The identified causes of escalations in the above-discussed studies in the United States varied, but in all cases the authors pointed to changes in contract volume as an important source of uncertainty and escalations. Furthermore, strong competition and price pressure, insufficiencies in the contract documents, and poor capacity and competence in the client organization were considered important reasons for escalations. These findings are similar to those of Williams et al. (21), who suggested that cost escalations in contracts in the United States and the United Kingdom were caused by unrealistically low bids, poor project management, deficient design requiring change orders, design difficulties, and unforeseen external events.

Cost escalation in contracts has also been studied in Australia. In a study of 67 construction contracts, Love et al. (3) found that the deviation between the agreed contract price and the final cost was on average 23.8%. They did not find any connection between deviations and project size, type of project, or type of contract. The main reasons for the deviations were changes in the agreed project scope.

Furthermore, escalation in contracts is linked to the wider issue of disputes between contractors and clients, which is a global problem that causes significant costs and may lead to industry inefficiencies. Sabri et al. (22) investigated conflicts in the Norwegian construction industry and found that tender specifications and differences in understandings of contracts were among the main reasons why the conflicts occurred.

Managing and Delivering Construction Contracts and Projects

The contract strategy is an important element in a construction project. The contract strategy should describe how to ensure appropriate competition in the selection phase, how to allocate tasks, responsibilities and uncertainties, and which contractual instruments should be established to support governance during the implementation phase. Most large client organizations have a general, overall strategy for contracts, which in turn provides the premises for the contract strategy for the individual projects. The purpose of the contract strategy is to achieve the best possible value for money in the contracts, considering the market situation, the characteristics of the contract, and the maturity of the plans, as well as the client's expertise and capacity. The contract strategy can have major impacts on the timescale and cost of projects (23, 24), and therefore the choice of contract is important when making investment decisions.

The costs of carrying out a project are made up of different elements, depending on the contract strategy of the client organization. Traditionally, the most common contracts in the construction industry have been design–bid–build unit price contracts. This type of contract is based on estimated quantities of items and unit prices (e.g., hourly rates, rate per unit work volume) set out by the client in the tendering documents. As such, the risk of inaccurate estimation of quantities has been removed from the contractor. In general, the contractor's overhead and profit are included in the rate. Consequently, some contractors may submit an "unbalanced bid" when they discover large discrepancies between their own estimates of quantities and the owner's estimates. Depending on the contractor's own estimates and risk propensity, the contractor may slightly raise the unit prices on the underestimated tasks and lower the unit prices on other tasks. If the contractor is correct in its assessment, it can increase its profit substantially as the payment is made on the actual quantities of tasks; if the reverse is the case, the contractor can lose on this basis (25).

The final price of the project depends on the actual quantities needed to carry out and complete the work. Contracts allow the client flexibility in that the scope can be changed to accommodate for changes in needs and unforeseen circumstances. They also provide transparency, particularly when the client is trying to procure the contractor with the lowest bid. The difference between estimated and actual quantities represents a risk to both owners and contractors and may affect a client's costs and a contractor's profit (26). Thus, unit price contracts are best suited for projects with well-known elements but unknown quantities.

A shortcoming in traditional contract arrangements is that contractors who carry out the contracts are not involved in developing them, even in cases when contractors may have better construction knowledge and experience than the clients or designers (27). This may increase the risk of changes to the agreed contract scope, which may come at an additional cost to the client. Molenaar et al. (28) claimed that unit price contracts and similar traditional practices have led to diminished trust between clients and contractors, inhibited innovation and efficiency, and contributed to cost and schedule overruns.

A budget in a construction project may consist of several elements (Figure 1). In Norway, where costs are estimated by stochastic cost estimation, the budget in large projects is normally set at the P85 level, meaning that the risk of overrun should be no more than 15%.
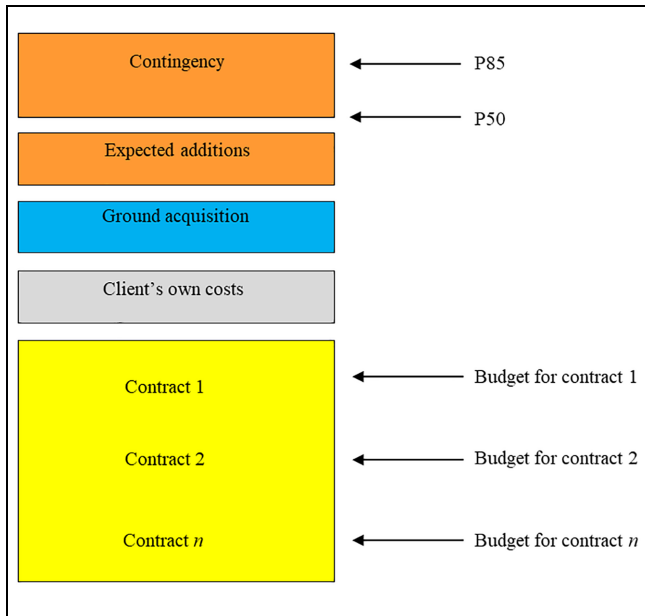
Figure 1. Traditional organization of a construction project.

Construction projects in Norway include a contingency for uncertainty and for "known-unknowns", the client's own costs of organizing and managing the project, the costs of ground acquisition, and the costs of the different contracts needed to deliver the project. The contingency is reserved at project manager or project owner level. The cost of the contracts is estimated by deterministic methods with no contingency for unforeseen events outside the agreed contract scope. The agreed contract cost with the contractor may differ from the client's own contract estimate and the final cost depends on the completion of the works.

Some projects are based on just one contract with one large contractor, whereas others are based on many contracts with several small contractors. As shown in Figure 1, even if the total cost of the project is made up of the costs of the individual contracts, escalations in the individual contracts may not result in project overrun if project contingencies are adequate to cover contract cost uncertainties. In a large project, a client may also diversify risk between different contracts so that escalations in one contract are offset by decreases in others.

However, large changes to a contract may indicate that the descriptions of works have been poor, and that the management of the project and the costs have been inadequate. In addition, major changes may pose challenges to staffing, progress, and costs for both the client and the contractor. This may result in lower cost-efficiency, and there is a broad agreement in the industry that this should be avoided (22).

Projects are delivered differently throughout the construction industry, but with the growth of increasingly more complex projects there has been a development toward early contractor involvement and toward transferring a larger proportion of the risks to contractors. In such situations, contractors may be forced to factor in the risk of changes and additions in their bids, which will lead to greater cost certainty for clients, but may require a risk premium.

Figure 1 shows a project organized through traditional design–bid–build contracts. The client awards contracts to separate companies for the design and construction. The project consists of different elements that need to be managed to ensure successful project delivery. If the sum of the cost of all elements in Figure 1 exceeds the budget, the project will overrun its budget.

Data and Methodology

This paper is based on data from the Norwegian Public Roads Administration (NPRA) and a study of 712 different contracts tendered between 2009 and 2014 and completed between 2012 and 2016 (29). The contract prices varied from USD 35,000 to USD 195 million and covered typical highway engineering works such as tunnels, bridges, groundworks, and water drainage.

The contracts were all unit price contracts. The NPRA is increasingly using contract strategies whereby contractors are responsible for the design and in some cases the maintenance of the road over a specified time, but the initial dataset only contained a handful of such projects, so they were omitted for purposes of data consistency.

To gain an overview of the cost performance of the contracts, first the main features of the data were summarized through descriptive statistics. Traditional statistical measures such as average escalation, the median, standard deviation, and min and max were used. To measure cost escalation, both the size and probability of escalation were examined.

The escalation from agreed contract to final cost was defined as:

$$Escalation = \left(\sum Adjustable\,items + \sum Change\,orders \right) - Agreed\,contract$$

The total cost in a unit price contract is normally made up of non-adjustable items such as items that are easy to specify, adjustable items that are difficult to specify and for which quantities can be adjusted at an agreed price, and change orders beyond the description of works and at a higher price. Lump sum/non-adjustable items made up a very small proportion of the total cost in the study data and therefore their costs were merged with the adjustable items.

Ideally, the deviation between agreed contract and final cost should be zero, but as the purpose of unit price

contracts is flexibility, some degree of cost deviation should be expected. Errors in the description of work can occur and changes to the description can add value to the contract even if this results in a cost escalation.

An escalation beyond the agreed contract does not have to be above the client's own estimate. Hinze et al. (*18*) found that even when the contracts in their sample overran by an average of 4.68%, the total cost of the contracts was close to the engineer's own estimate, as bids were usually below this.

Nevertheless, final costs in contracts should be reasonably close to the agreed contract. AACE International expects the accuracy of estimates prepared for the bid/tender stage to be within the range from −10% to + 15% (*14*). Although the agreed contract might differ from the (unknown) client's own estimate, this was used as a proxy for target accuracy.

Additionally, the data were used to develop a best-fit cumulative distribution function (CDF) to determine the probability of escalation. A CDF $F(x)$ is a mathematical equation that describes the probability that a random variable X is less than or equal to x:

$$F(x) = P(X \leqslant x)$$

The probability density function can be determined from the CDF by differentiation:

$$f(x) = \frac{dF(x)}{dx}$$

The CDF can be expressed as an integral of its probability density function:

$$F(x) = \int_{\infty}^{x} f(t)dt$$

The distribution can be tested for best fit, for example, by using the chi-squared statistic (χ^2):

$$\chi^2 = \sum_{i=1}^{k} \frac{(N_i - E_i)}{E_i}$$

where N is the observed frequency for bin i and E is the expected frequency for bin i (*30*).

The CDF is useful when historical data are accessible. If past results are considered likely to be representative of future events, the CDF can be used to estimate the necessary ranges around estimates of different cost elements, so that the total project cost necessary at different levels of probability can be estimated.

The data allowed for the testing of several contract features such as the impact of contract size, contract duration, and geographical location (urban versus non-urban). The sources of escalation were also investigated by examining whether the escalations were the results of changes in quantities through adjustable items in the contracts or change orders to the contract scope.

All costs were adjusted to real prices using the construction cost index developed by Statistics Norway (*31*). The contract accounts were made up of three elements: the original contract price, changes in agreed scope (i.e., different quantities), and change orders to the scope. Generally, changes to the scope were priced higher than changes to the agreed scope.

Results

This section presents the results of the research.

Cost Escalation Overview

The cost escalation of the contracts in the study sample is summarized in Table 1. On average, the contracts that the NPRA was responsible for turned out to be about 17% more expensive than the agreed price. The statistical dispersion shown in Table 1 is large, ranging from 46% under the agreed contract price to 185% over. Only 37% of the contracts had deviations within ± 10% of the original contract. There was a relatively large difference between the median (P50) and the mean, which indicated a high number of large escalations.

Half of the contracts experienced escalations of more than 10%. The NPRA factors in the risk of contract escalations through projects' contingencies, but if escalations at the contract level are too large, this can lead to cost overruns at the project level.

The results for contract cost escalation differ from the results for project cost overrun. The average overruns against the P50 estimate in large (>USD 60 million) Norwegian road projects is relatively small, ca. 1%–2% (*32*). Average overruns in all Norwegian road projects, large and small, are somewhat larger. The yearly average overrun for road projects completed between 2007 and 2018 was 5.8% (*33*). The relatively large escalations in contracts, as shown in Table 1, may explain the consistent overruns in projects. If the contracts overrun in a project, a higher contingency will be required to deal with the overruns. The results in Table 1 indicate that the cost performance in contracts may be a source of project risk, for which budgets need to be adjusted.

Distribution Fit

The large sample size (712 projects) of this study enabled the authors to determine the probability of cost escalation expressed as CDF.

Table 1. Summary of Cost Escalations in the Road Construction Contracts Tendered Between 2009 and 2014

Description	Statistic
Number of contracts	712
Mean escalation	17%
Median	10%
Standard deviation	31%
Minimum	−46%
Maximum	185%
P10	−12%
P90	59%
Share of contracts with escalation	72%
Share of contracts with escalation >10%	50%
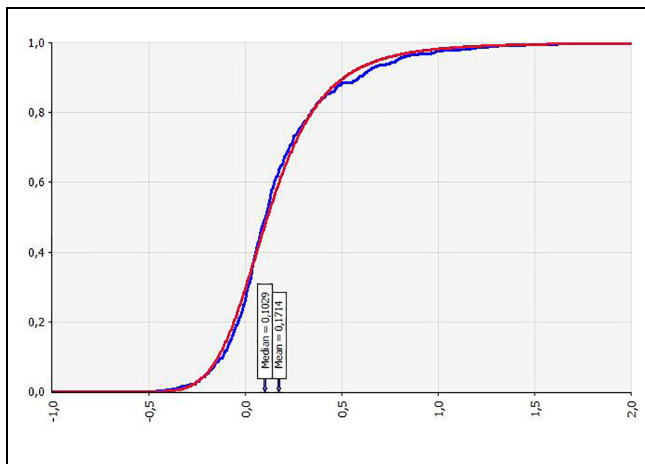
Figure 2. Cumulative distribution function for cost escalation.
Note: Blue line, input data; red line, best fit.

The CDF was produced using the "best fit" command in Palisade's *@Risk* software. The distribution of final costs to the awarded contracts is shown in Figure 2.

The data shown in Figure 2 have a right skew. Based on these historical data, there is strong probability that final costs in construction contracts will be significantly higher than the awarded contract price. For example, the probability of an escalation between 10% and 50% is 40%, whereas the probability of a large escalation (>50%) is 10%.

The best fit for the data is the log-logistic distribution, which is a typical right-skewed distribution with a heavy tail. Ideally, the deviations should follow a normal distribution with a mean of zero, but that was not the case for data relating to road construction contracts.

Cost estimation practices vary between industries and countries, and accounting for risk may vary from a simple uplift to more sophisticated methods aimed at identifying the main risk drivers and quantifying risk in individual projects. Knowledge of past contract performance and their distributions may be useful when applying probability-based cost estimation.

Contract Size

The study data allowed to test cost escalations using some contractual characteristics. First, contract size may give an indication of the complexity of the work and thus the likelihood of escalation. At the same time, cost escalation in large contracts may have bigger impact on a project's financial success, as even small escalations may cause considerable monetary cost overruns.

Table 2 provides a summary of the results when considering small contracts (≤ USD 2 million), medium-sized contracts (between USD 2 million and USD 12 million) and large contracts (>USD 12 million). Although most of the contracts were small, the dataset was sufficiently large for a statistical comparison of the categories.

Although the risk of cost escalation increased with contract size (from 66% for small contracts to 86% for large contracts), the escalation percentage was larger for the smaller contracts (17% for small contracts versus 14% for the largest contracts). This was even more evident when only the contracts with a cost escalation were considered: small contracts on average experienced a 32% escalation, whereas large contracts only experienced an 18% escalation on average. These results are similar to those of Odeck (*34*), who found that the mean overrun in small road projects was 10.6% and that large projects experienced a mean underrun of −2.5%.

The effect might be a result of better project management in the larger projects, as cost escalations in large contracts are prioritized in Norway, and damage control, incentives, or both, in the contracts allow for a better outcome when a cost escalation occurs. Furthermore, large projects generally have more client resources at hand, with which to follow up the contractor more closely. Large contracts are also more complex, which is why they have a greater probability of cost escalation compared with smaller contracts.

Contract Duration

Contracts with a long duration may be more vulnerable to escalations than contracts with shorter durations. Time may be an indicator of complexity, and delays may be caused by inefficiencies on the part of the client or the contractor. A total of 44% of the contracts in the dataset had a duration of less than 1 year, 41% had a duration between 1 and 2 years, and 15% had a duration of over 2 years. The differences in escalation between different durations of the contracts are listed in Table 3.

Shorter contracts had on average lower escalations than medium and long contracts, and long contracts had

Table 2. Cost Escalations and Contract Size

Description	Statistic	Small	Medium	Large
Contract size (in USD)	All	≤2 million	≤12 million	>12 million
Number of contracts	712	406	234	72
Average escalation (%)	17	17	18	14
P (cost escalation) (%)	73	66	80	86
Average escalation (for contracts with cost escalation) (%)	28	32	25	18

Table 3. Cost Escalation and Contract Duration

Description	Statistic	Short	Medium	Long
Duration (in months)	All	<12	12–24	>24
Number of contracts	712	310	294	108
Average escalation (%)	17	13	20	21
P (cost escalation) (%)	73	64	77	84
Average escalation (for contracts with cost escalation) (%)	28	27	29	27

Table 4. Selected Projects' Cost Escalation in Relation to Urban and Non-Urban Locations

Description	Statistic	Urban	Non-urban	T-test
Number of contracts	554	50	504	na
Average escalation	16%	25%	15%	0.015
P (cost escalation)	72%	78%	70%	0.169
Average escalation (for contracts with cost escalation)	27%	34%	26%	0.049

Note: na = not applicable.

Table 5. Sources of Cost Escalation

Description	N	Mean (%)	SD (%)	Median (%)	P10 (%)	P90 (%)
Adjustable items	712	−1	25	−3	−26	23
Change orders	712	18	20	12	2	41

Note: SD = standard deviation.

a higher probability of escalation. However, the average escalation was the same, regardless of duration.

Geographical Location

It is widely acknowledged that civil engineering projects in urban areas are high-risk ventures, as demonstrated by, for example, Crossrail in London, Boston's Big Dig, and a range of light rail transit projects worldwide. Welde (*32*) found that large governmental projects in urban areas experienced significantly higher overruns than other projects (which, on average, experienced underruns). Ideally, increased risk should be covered by a higher contingency in the budget, but the estimates for urban projects did not take the increased risk of such projects fully into account, as shown in Table 4.

Among the 554 projects for which the authors were able to distinguish between an urban location and non-urban location, the escalation in urban contracts was significantly higher than in non-urban areas. The probability of escalation also appeared to be higher but was not significant.

Sources of Cost Escalation

Cost escalation in contracts can arise from two sources: changes in quantities through adjustable items in the contract and change orders to the scope beyond the description of works in the contract. The impact of the two sources of changes for cost escalations in the studied road construction contracts is shown in Table 5.

The results listed in Table 5 are interesting for the following reasons. All the escalations were caused by change orders to the contracts. Unit price contracts are based on items for which quantities can be adjusted according to an agreed fixed price. In line with the intention of such contracts, the variation with respect to the expected value is normally distributed with a mean close to zero. However, client-initiated change orders account for a significant increase in the cost of the contracts. Just 10% of the contracts had change order costs of 2% or less. The cause of the escalation was work that was not included in the description of works.

Conclusions

This paper studied cost escalation in unit price contracts in the Norwegian road construction industry. There are many studies of project cost overruns in the transport literature, but as argued in this paper, there is a need for more knowledge of the impacts of the cost performance of the contract that make up the project as this will have implications for project performance.

The results of the analyses revealed that contracts for road construction projects tendered between 2009 and 2014 experienced higher escalations than reported in most studies from the United States, where most of the reported escalations have been in the order of 0%–10%.

The average escalation in the dataset was 17%, and the dispersion of the data indicates that there are large risks remaining at the time when contracts are agreed. The results are well beyond the target accuracy range suggested by the AACE International (*14*) and may explain why final costs in Norwegian projects are consistently skewed to the right.

The poor cost predictability and the right skew of the distribution of final costs should be a cause for concern for project managers and project owners, and may ultimately lead to project cost overruns, unless the project cost contingency is large enough to account for these uncertainties. Even if some changes to the scope of works may be necessary to accommodate changing needs and to deliver higher benefits, the volume of escalations may indicate a risk of poor efficiency because of delays, opportunistic behavior, and conflicts.

Our results revealed that some road construction contracts are more at risk of escalations than others. Large and complex contracts have a higher probability of escalation even if their average escalations are lower than for small contracts. The same relationship was found for contracts with a long duration, and therefore project managers are advised to treat such contracts with caution, especially in urban locations where both the probability of escalation and average escalation is higher than in other locations. The main source of escalation was

change orders. This indicates that in many cases the description of works was inadequate.

One can only speculate as to why the results from Norway differ so much from the results from Utah (*17*), Washington (*18*), Florida (*19*), and North Carolina (*20*). The studies in the United States suggest that factors such as project size, the client's staff skills, and a competitive bidding process may affect overruns. The studies also found that change orders were a major source of risk. The suggested causes in those studies are similar to those of the present study; however, as Hinze et al. (*18*) argued, relatively little can be explained from large sample studies that use independent variables that are easily observed. For more specific knowledge, it is probably necessary to conduct in-depth studies of considerable magnitude.

However, and as argued by Williams et al. (*21*), unit price contracts create a competitive environment in which contractors may have a lot to gain by submitting unrealistically low bids and deliberately misinterpreting the contracts, which in turn will lead to costly change orders. Therefore, in a lot of countries there has been a development toward contract arrangements that require closer alignment of the incentives of clients and contractors. The Norwegian experience suggests that Norway, too, may have something to gain from exploring the use of contracts in which the contractors are responsible for parts of the design.

The present study is not without limitations. The dataset was large, but it could not be used to differentiate clearly between the types of work (e.g., rehabilitation, resurfacing, reconstruction, bridges). Most contracts are classed as "mixed." More detailed data could have allowed for further testing of the relationships explored in this paper. Furthermore, the NPRA has not provided information on their own estimate of the contract costs, only the agreed contract price, which may be either below or above their own estimate. In a tender process, bids are often very dispersed and may create incentives for low bidding. Therefore, it may very well be the case, as also suggested by Hinze et al. (*18*), that that the real deviation between final cost and the client's estimate is lower than the observed escalations. Finally, intuitively, contract cost escalation can be expected to correlate with project cost overrun, but that is beyond the scope of this study. In future studies, it would be worth mapping contract performance against project performance. The knowledge gained from such mapping could allow better modeling of cost performance to improve estimation and project delivery in future projects.

Author Contributions

The authors confirm contribution to the paper as follows: study conception and design: M. Welde; data collection: R.E. Dahl

and M. Welde; analysis and interpretation of results: R.E. Dahl and M. Welde; draft manuscript preparation: M. Welde. All authors reviewed the results and approved the final version of the manuscript.

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