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REFERENCE CLASS FORECASTING IN ICELANDIC TRANSPORT INFRASTRUCTURE PROJECTS

Summary. Previous studies have indicated that the majority of infrastructure projects have cost overruns. The root causes are traced to political, technical and psychological reasons at the initial stage of the project. The consequence is either unintentional overoptimistic forecasting of perceived results or calculated interpretation of facts in favour of personal and political interests. These phenomena are called planning fallacies and strategic misrepresentation, respectively. A step-wise procedure to avoid planning fallacies and strategic misrepresentation is called the *outside view.* The outside view bypasses human biases by using past experience and empirical data from past projects. It has evolved into a professional practice through a method called *reference class forecasting* which has been shown to provide improved cost forecasting accuracy in the initial stage of a project. The study reported in this paper examined reference class forecasting as a means of improving cost forecasting in the planning stage of the project lifecycle. Data from the Icelandic Road Administration (ICERA) were assembled in a cost forecasting model to determine if it might be possible to improve forecasting accuracy. The results proved inconclusive; however, a comparison with findings from similar projects in the UK showed that although cost overruns followed a similar curve, the chance of occurrence is significantly lower at the planning stage after the decision to proceed has been taken.

REFERENZKLASSE VORHERSAGE IN ICELANDIC INFRASTRUKTUR PROJEKTS

Zusammenfassung. Frühere Studien haben gezeigt, dass die Mehrheit der Infrastrukturprojekte Kostenüberschreitungen haben. Die Ursachen sind verfolgt zu politischen, technischen und psychologischen Gründen in der Anfangsphase des Projekts. Die Folgen sind entweder unbeabsichtigt zu optimistischen Prognosen der empfundenen Ergebnisse oder berechneten Interpretation von Fakten zugunsten von persönlichen und politischen Interessen. Diese Phänomene werden als Planungs Täuschungen und strategische Täuschung sind. Eine stufenweise Vorgehensweise zu vermeiden Planung Täuschungen und strategische Täuschung ist die Außenansicht aufgerufen. Die Außenansicht umgeht menschliche Vorurteile durch Erfahrungen aus der Vergangenheit und empirischen Daten von früheren Projekten verwendet wird. Es hat sich zu einem professionellen Praxis durch ein Verfahren namens Referenzklasse Prognosen entwickelt, die eine verbesserte Kostenprognosegenauigkeit in der Anfangsphase eines Projekts zu schaffen gezeigt wurde. Die Studie, die in dieser Veröffentlichung untersuchten Referenzklasse Prognose als Mittel zur Kostenprognosen in der Planungsphase des

Projektlebenszyklus zu verbessern. Die Daten der isländischen Straßenverwaltung (Iceras) wurden in einem Kostenprognosemodell zusammengebaut, um zu bestimmen, ob es möglich sein könnte, Prognosegenauigkeit zu verbessern. Die Ergebnisse bewiesen nicht schlüssig; aber ein Vergleich mit den Ergebnissen aus ähnlichen Projekten in Großbritannien zeigten, dass, obwohl Kostenüberschreitungen eine ähnliche Kurve gefolgt, die Möglichkeit des Auftretens ist deutlich niedriger in der Planungsphase, nachdem die Entscheidung getroffen wurde, um fortzufahren.

1. INTRODUCTION

Certain types of project are notoriously prone to inaccurate cost forecasts. Flyvbjerg et al. [8] reviewed 258 projects and found that nine out of ten suffered from a cost overrun. When Jennings [10] investigated the cost estimates for the London 2012 Olympics over a five-year period, the project's cost had escalated from an original estimate of £1.8 billion to more than £9.3 billion when the budget was formally reviewed.

Jennings [10, p. 458] identifies three underlying factors as contributing to the underestimation of costs for large-scale projects. The first is how risk and uncertainties are downgraded in the political and bureaucratic context. Second is the problem of decision-making under uncertainty leading to systematic biases. Third is the complex technical challenges inherent in large-scale projects, resulting in difficulties in management and administration. This is a variable that can influence monetary cost or income for industry and government over the following decade.

There is no simple explanation for under-performance in cost forecasting but, at the most basic level, it can be grouped into three categories: the technical, the psychological and the political [4, 5]. Technical explanations cover inaccuracy in terms of *project uncertainty, unreliable or outdated data and the use of inappropriate forecasting models* [14]. These are often typical explanations, used by management, for under-performance against forecasts. Psychological explanations describe inaccuracy in terms of *optimism bias*. Optimism bias is defined as *"the demonstrated systematic tendency for appraisers to be over-optimistic about key project parameters"* [9, p. 84]. Circumstances are interpreted in favour of taking risks if the decision-maker is convinced that the rewards exceed the cost. In so doing, it provides decision-makers with an attractive argument to explain failed projects, i.e. they were taking reasonable risks. In other words, optimism bias occurs when planners fall into the trap that psychologists call *the planning fallacy* [13]. Political explanations cover inaccuracy in terms of *strategic misrepresentation*, which occurs when forecasters and managers deliberately and strategically over-estimate the benefits and under-estimate the costs of a project in order to increase the probability of approval for funding [3, 4].

Planners may see themselves in two distinct roles that are in contradiction with each other. On the one hand, planners are scientists who analyse data to provide the best solution for a problem. Conversely, planners are advocates who use data, models and methods to prove that a certain outcome is the best choice in a given situation. In the *AICP Code of Ethics and Professional Conduct* [1], one can see the conflict. The code says in the same article, for example, that planners must exercise independent professional judgment but must also accept the decision of the client concerning the objectives and nature of a professional service. Planners, politicians and managers have the ability to choose how they decide to interpret the outcome of a forecast and how they present it to others [15, 16].

The situation when a planner is primarily focusing on the present project only often results in extremely optimistic plans. This is called the *inside view* and the alternative is called the *outside view* [13]. The outside view completely ignores the present project and instead examines past experiences on similar projects. The resulting forecast is usually much more accurate as the outside view bypasses cognitive and political biases, such as over-optimism and strategic misrepresentation, and cuts directly to the outcomes [13]. The outside view is also known as *reference class forecasting*. The outside view

does not assess explicit risk factors but indicates the overall financial risk based on empirical evidence of past projects with similar attributes.

Reference class forecasting (RCF) is a method for systematically taking an outside view when planning projects by basing forecasts on actual performance of comparable projects rather than focusing only on the project in hand. Originally, RCF was developed to compensate for the cognitive bias that Kahneman and Tversky [11, 12] discovered in their work on planning and decision-making under uncertainty. In short, their work demonstrated that human judgement is generally optimistic and overconfident with a tendency to under-estimate cost, completion times, and risk of planned actions, whilst over-estimating benefits. Flyvbjerg has since expanded the use of RCF to improve control and due diligence evaluation of project front-end preparation [6].

The RCF method has been recommended by The American Planning Association (APA), which *"encourages planners to use reference class forecasting in addition to traditional methods as a way to improve accuracy"* [2]. The concept, which has also been adopted by HM Treasury, requires that all budget estimates in investment appraisals be adjusted for optimism bias by means of RFC [9, p. 85].

The work [7] on procedures for dealing with optimism bias in transport planning is primarily focused on the use of RCF in the initial stage of a public project when the decision for *go/no-go* is under review. The research reported in this paper differs as it focuses on the application of RCF to the planning stage following the decision to implement the project. The subject of the research is the work of the Icelandic Road Administration (ICERA). The question that the research aimed to answer was: *"Could ICERA improve its cost forecasting by using reference class forecasting at the planning stage of a transportation project?"* With this aim in mind, this paper centres on the building of a reference class forecasting model which has been used with data provided by ICERA to evaluate the risk of cost overrun on transportation projects in Iceland. The forecasting model evaluates how much extra cost has to be added to a reference class of similar projects in order to cover the risk of cost overrun: this is known as the *optimism bias uplift.* The consequence of adding optimism bias uplift is that it should be possible to avoid (or substantially reduce) situations where costs exceed budgets since the latter are set at more realistic levels.

2. RESEARCH METHODS

The research is quantitative and covers all accessible ICERA projects at the time of the study. The method adopted to construct the model is comparable to the procedure originally used by the UK government (Department of Transport) under the supervision of Flyvbjerg and COWI [7]. The research method is based on analysing empirical data of completed projects to establish statistical information on the differences between the actual cost at project completion and the forecasted cost at the beginning of the project [13]. The following three key steps were defined.

1. *Identification of a relevant reference class of past projects.* It was important that the class was broad enough to be statistically meaningful, yet narrow enough to be comparable with the specific project at hand.
2. *Establishing a probability distribution for the selected reference class.* This required access to reliable data on cost overrun for a sufficient number of projects within the reference class to make a statistically meaningful conclusion (normally, at least 10).
3. *Comparison of the specific project with the reference class distribution.* The most likely outcome for the specific project was established.

Step 1

The main issue when identifying a relevant reference class of past projects is how the classification should be determined. Reference classes cannot be too narrow; e.g. transportation projects cannot be divided into too many categories because it could be difficult to establish valid optimism bias uplift as each category would be too small. Similarly, reference classes cannot be too wide, because some

projects within each reference class are unlikely to be comparable [7]. Each reference class should reveal the risk of cost overrun based on statistical analysis, benchmarking and other forms of analysis. Uplift refers to the amount of additional funding that is needed to raise the cost estimate so that there is an equal chance of the outturn cost being above or below the planned cost. In other words, it produces the 50:50 or 50% cost estimate.

Step 2

Once the reference classes had been built, an accurate probability distribution for overrun was found for each class. Cost overruns in percentiles were defined according to equation (1), where I = Cost overrun in %, T_a = Actual cost of a project and T_f = Forecasted cost of a project. Actual cost is defined as real, accounted cost determined at the time of completing a project, and forecasted cost is defined as the cost at the time the decision is made to implement the project.

$$I = \frac{(T_a - T_f)}{T_f}$$ (1)

In order to ensure comparability, it was important that the definition of forecasted and actual cost was identical for all projects. The distribution for each reference class was used to establish the optimism bias uplifts—see step 3.

A particular concern was the representativeness of the data sample. A number of issues were considered in the light of Flyvbjerg and COWI [7].

1. It could be argued that projects that are well-managed regarding data availability are also likely to be well-managed in terms of other factors which result in better than average performance.

2. Managers of projects that have large over-expenditure are likely to be less interested in making cost data available, while more successful project managers might well be interested in making cost data available. This leads to under-representation of *bad* projects, and over-representation of *good* projects in the sample.

3. Even when managers have made cost data available, they might have decided to provide data that present their projects as favourably as possible. Often, there are several forecasts of cost and several estimates of actual cost to choose from. There might, therefore, be a temptation for managers to choose the combination of forecasted cost and actual cost that make their projects look good on paper.

4. There might be a difference in the representation of different sub-samples; e.g. in a reference class that is supposed to be comparable for both bridges and tunnels, 85% of the projects might be bridges and only 15% tunnels.

Step 3

Once a probability distribution for cost overrun has been found for each reference class, it is possible to determine the required optimism bias uplift. Required uplifts are established as a function of the level of risk one is willing to take. A lower level of acceptable risk results in a higher required uplift [7].

If the project being examined is regarded as average then it should be expected that, on average, the final cost will exceed the forecasted cost by the average budget increase. For example, if in a single reference class the average cost overrun is, say, 10%, then to have a 50% chance of being under or over forecasted cost, 10% uplift should be added to the project being compared to the reference class. If it is unacceptable to have a 50% chance of cost overrun, then the uplift needs to be higher than the average budget increase.

For ICERA, which had, and which continues to implement, a large portfolio of projects, the total realised budget increase across all projects can be expected to be close to the expected average. ICERA might have to decide if the 50% chance of the actual cost exceeding the budget is an acceptable risk or not. If not, ICERA should add an uplift to the budget relative to the frequency of the empirical data of past projects in the reference class.

The uplifts refer to cost overrun calculated in constant prices. The lower the acceptable risk for cost overrun, the higher the uplift. For instance, if the willingness to accept a 50% risk for cost overrun in a project in a given reference class is only 10%, ICERA must add as an uplift the cost overrun of 90% of projects in the reference class. If ICERA accepts 20% chance of cost overrun, it must add 80% of the cost overrun in the reference class and so on.

A database of projects over a five-year period was obtained directly from ICERA covering projects completed between 2007 and 2011. The database contained 80 projects, 11 of which had been completed in 2007, 24 in 2008, 22 in 2009, 15 in 2010 and 8 in 2011. As each project can comprise different project segments, i.e. a single project can consist of bridges, roads and tunnels, some projects had to be split. For that reason, the database contained 110 projects (project segments) in all, 14 of which were completed in 2007, 39 in 2008, 23 in 2009, 23 in 2010 and 11 in 2011. All projects for which cost data were available were initially included in the sample.

The 110 projects in the database covered the following types of work: roads, entrance ramps, traffic roundabouts, intersections, bridges, underpasses, drainage, waterside protection, road lighting and electrical installations, fences, conduits and wiring systems, ditches, poles and utilities. Project information included the following.
1. Primary cost plan, both from ICERA and from the contractor who was awarded the main contract.
2. Secondary cost plan, both from ICERA and from the contractor.
3. Actual cost of the project.

Cost data were provided in two categories: forecasted cost (primary cost plan) and actual cost (including additional cost items). The information was not, however, completely reliable, as closer examination showed that items that should have been recorded as additional cost were, in some instances, recorded as forecasted cost and vice versa[1]. Correcting these anomalies ensured that the forecasted cost, as shown in the primary cost plan, and actual cost were comparable.

After identifying the transportation projects included in the database, it was decided to make two reference classes similar to those classified in the UK for the same kind of project. After discussing this proposal with the directors of ICERA, it transpired that it was not possible to say if traffic roundabouts, entrance ramps and intersections should be placed in the same group as roads in general or if they should be treated as statistically similar; much depended on the nature of the project[2]. Eventually, it was decided to classify transportation projects into roads and fixed links.

Table 1

Classification of Icelandic transportation projects

Category	Types of projects	Source of optimism bias uplifts
Roads	Main roads	Reference class of 65 road projects
	Connecting roads	
	Region roads	
Fixed Links	Bridges	Reference class of 11 bridge and underpass projects
	Underpasses	

For all possible cost overruns, the frequency of a project having a given cost overrun or higher value was counted. The number of projects with a given maximum cost overrun was determined. The probability distribution with cost overrun on the *x-axis* and the share of projects with a given maximum cost overrun on the *y-axis* were determined.

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[1] Interview with R. Gunnarsson and S. Gudmundsson, ICERA Construction Department, on 10 May 2012.
[2] Interview with S. Gudmundsson, ICERA Construction Department, on 11 June 2012.

Since the database contained both the primary cost plan of ICERA and the primary cost plan of the contractor awarded the project, it was decided to find the uplift for both. Key statistics about each reference class are summarised in tables 2 and 3.

Table 2

Key statistics on Reference Class 1 – Roads

Reference Class 1 – Roads		
	ICERA	Contractors
N	65	65
Average overrun	6%	27%
Standard deviation	0.237	0.213
Variance	0.056	0.045
Maximum overrun	118%	97%
Minimum overrun	-36%	-7%

Table 3

Key statistics on Reference Class 2 – Fixed Links

Reference Class 2 – Fixed Links		
	ICERA	Contractors
N	11	11
Average overrun	7%	19%
Standard deviation	0.207	0.199
Variance	0.043	0.04
Maximum overrun	34%	63%
Minimum overrun	-24%	1%

In ICERA's Reference Class 1 (Roads), the project with the second highest overrun had a cost overrun of 53%, but the project with the highest overrun had a cost overrun of 118%. If this project, with the highest cost overrun, had been left out of the reference class, the difference between the maximum and minimum overruns would have decreased substantially. However, it was decided to include this project in the reference class, as there was nothing to indicate that the data on this project were unreliable. Projects were excluded from the reference class only if there was a belief that the data might be erroneous.

The practical application of this model is that when a new project is scheduled a primary cost plan is prepared as normal. With a primary cost plan, it is necessary to choose an acceptable risk level. It is then possible to add an appropriate uplift to the primary cost plan as risk capital. The 50% percentile should only be used in instances where it is accepted there is a high risk that cost overrun will occur and in situations where investors are funding a large number of projects and cost savings on one project may be used to cover the costs of overruns on other projects. The 80-90% percentile (20-10% acceptable chance of cost overrun) should be used when it is agreed that overrun must not occur on a particular project.

Figures 1 and 2 show the distribution of cost overrun for each reference class for both ICERA and the contractor.
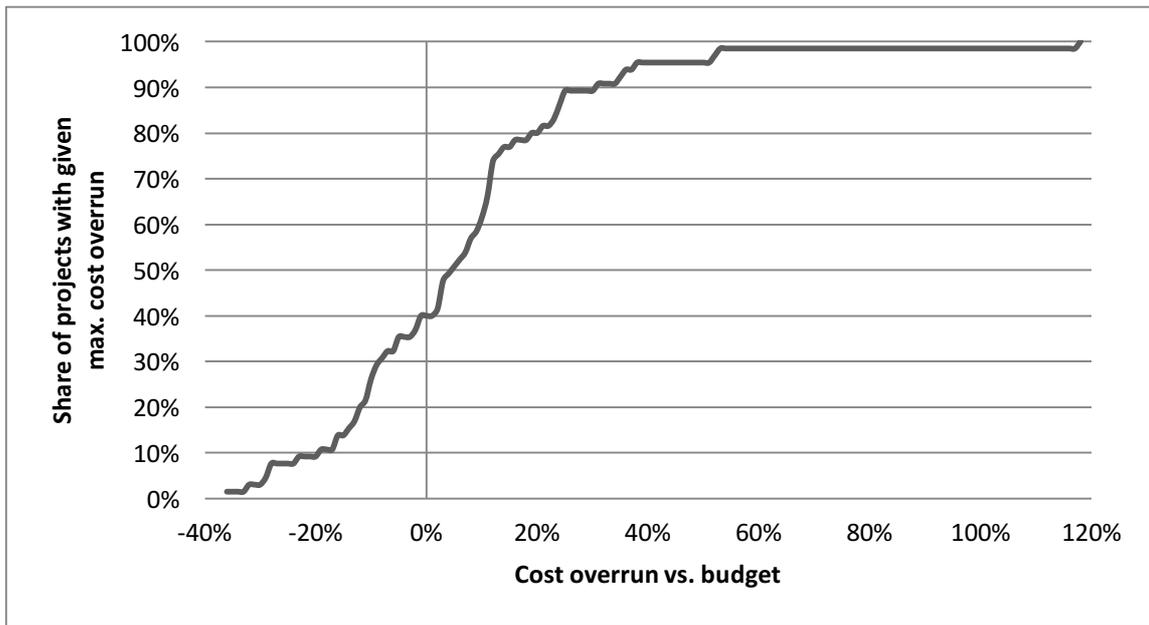
Fig. 1. Probability distribution of cost overrun for Reference Class 1 – Roads, *N*=65 (ICERA)
Abb. 1. Wahrscheinlichkeitsverteilung der Kostenüberschreitung für Referenzklasse 1 – Straßen, N = 65 (ICERA)

Fig. 1 shows the distribution of cost overrun for ICERA's primary cost plan covering road projects. For example, 40% of projects have a maximum cost overrun of between 0% and 80% of projects and a maximum overrun of 19%.
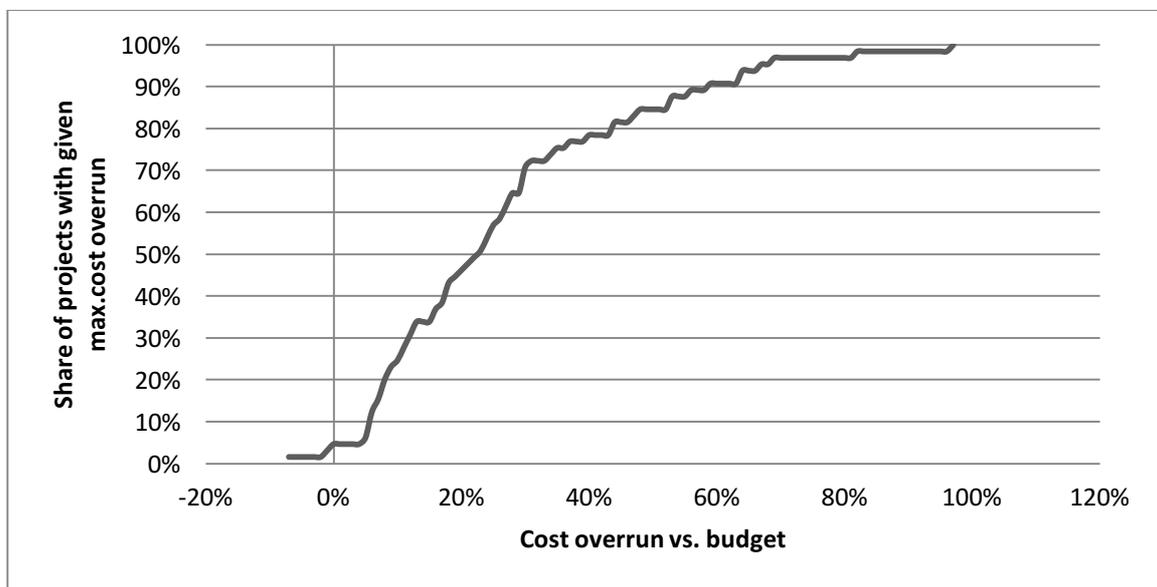

Fig. 2. Probability distribution of cost overrun for Reference Class 1 – Roads, *N*=65 (Contractor)
Abb. 2. Wahrscheinlichkeitsverteilung der Kostenüberschreitung für Referenzklasse 1 - Straßen, N = 65 (Contractor)

Fig. 2 shows the distribution of cost overrun for the contractor's primary cost plan covering road projects. For example, 40% of projects have a maximum cost overrun of 17-18% and 80% of projects have a maximum overrun of 43-44%.
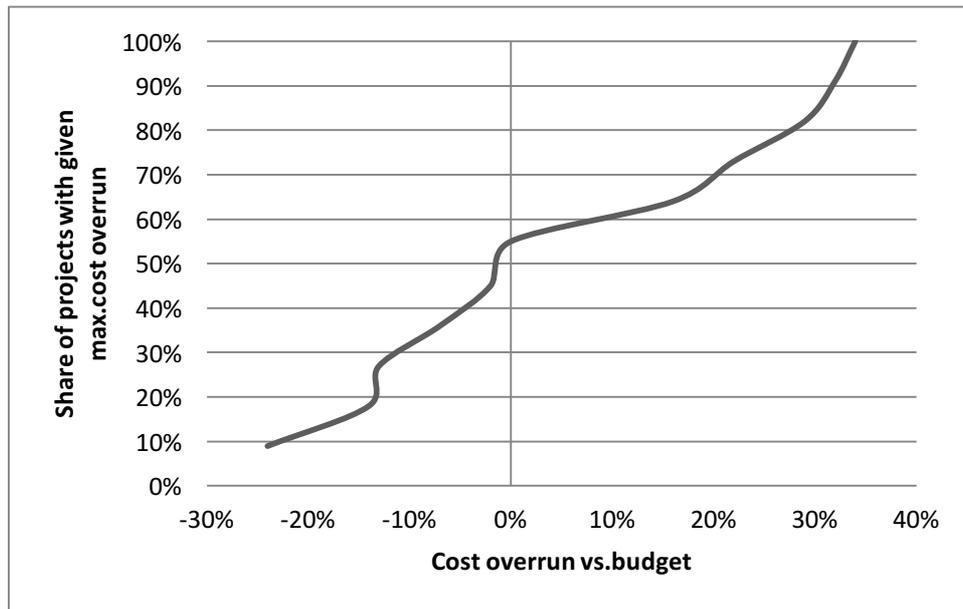
Fig. 3. Probability distribution of cost overrun for Reference Class 2 – Fixed links, *N*=11 (ICERA)
Abb. 3. Wahrscheinlichkeitsverteilung der Kostenüberschreitung für Referenzklasse 2 - Feste Verbindungen, N = 11 (ICERA)

Fig. 3 shows the distribution of cost overrun for ICERA's primary cost plan regarding fixed links projects. For example, 40% of projects have a maximum cost overrun of (-3)-(-2)% and 80% of projects a maximum overrun of 28-29%.

Finally, Fig. 4 shows the distribution of cost overrun for the contractor's primary cost plan covering fixed links projects. For example, 40% of projects have a maximum cost overrun of 10-11% and 80% of projects a maximum overrun of 26-27%.
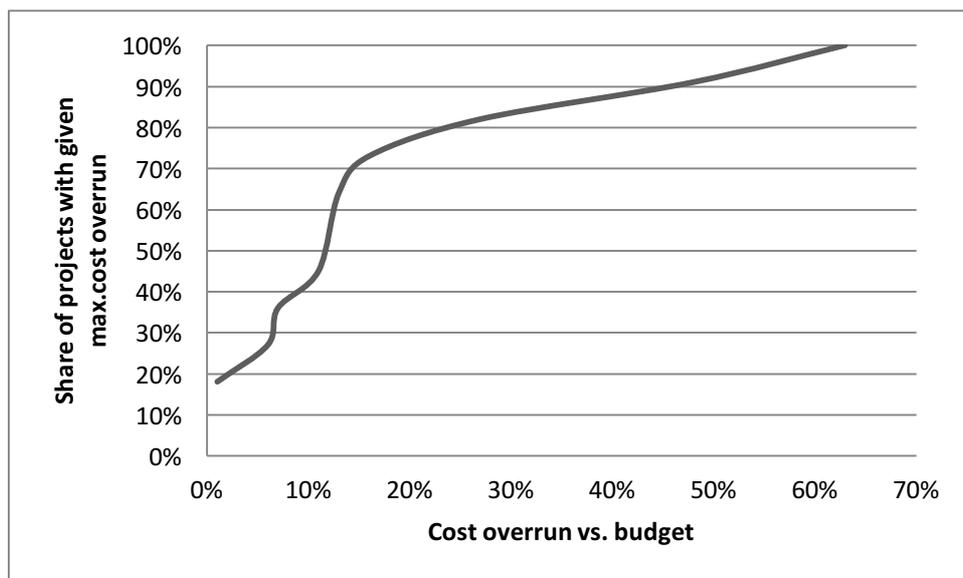

Fig. 4. Probability distribution of cost overrun for Reference Class 2 – Fixed links, *N*=11 (Contractor)
Abb. 4. Wahrscheinlichkeitsverteilung der Kostenüberschreitung für Referenzklasse 2 - Feste Verbindungen, N = 11 (Contractor)

Figures 5 and 6 show the required uplift as a function of the maximum acceptable level of risk. These figures apply to Reference Class 1 (Roads) and show the required uplift that should be added to ICERA's and the contractor's cost plans.
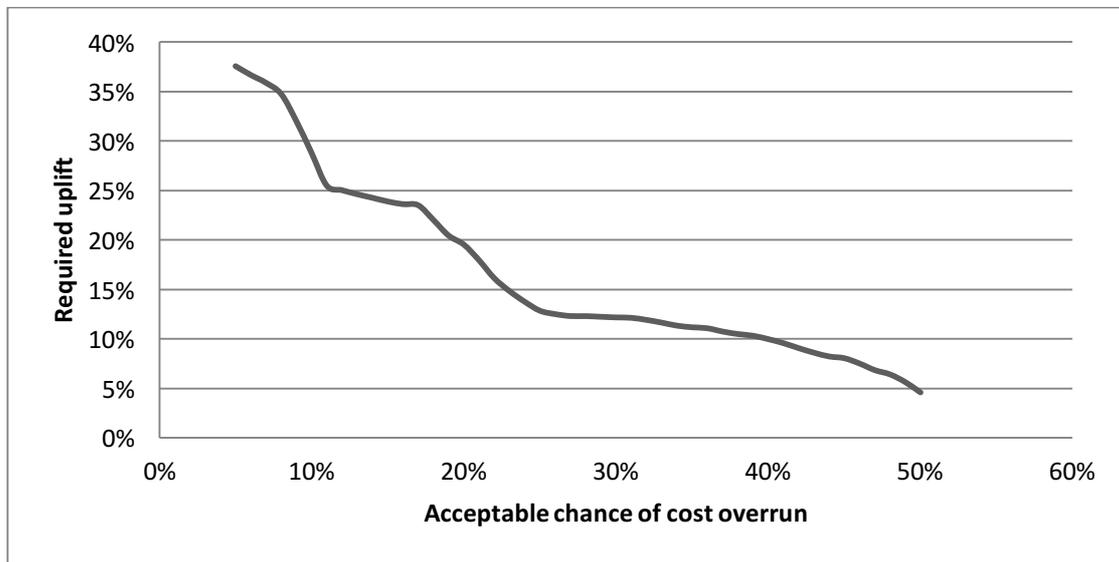

Fig. 5. Required uplift as a function of the maximum acceptable level of risk for cost overrun – Roads (ICERA)
Abb. 5. Erforderliche Auftrieb als Funktion der maximalen akzeptablen Risiko für Kostenüberschreitung – Strassen (ICERA)

Figures 5 and 6 indicate that if it had been decided the risk of cost overrun for a road project should be less than 50% (having a 50% chance to be within budget), it would be necessary to use an uplift of 5% on ICERA's primary cost plan with an uplift of 23% on the contractor's primary cost plan. If it had been decided that the risk of cost overrun should be less than 20% (having an 80% chance to be within budget), then an uplift of 20% should be added to ICERA's primary cost plan with 44% added to the contractor's primary cost plan.
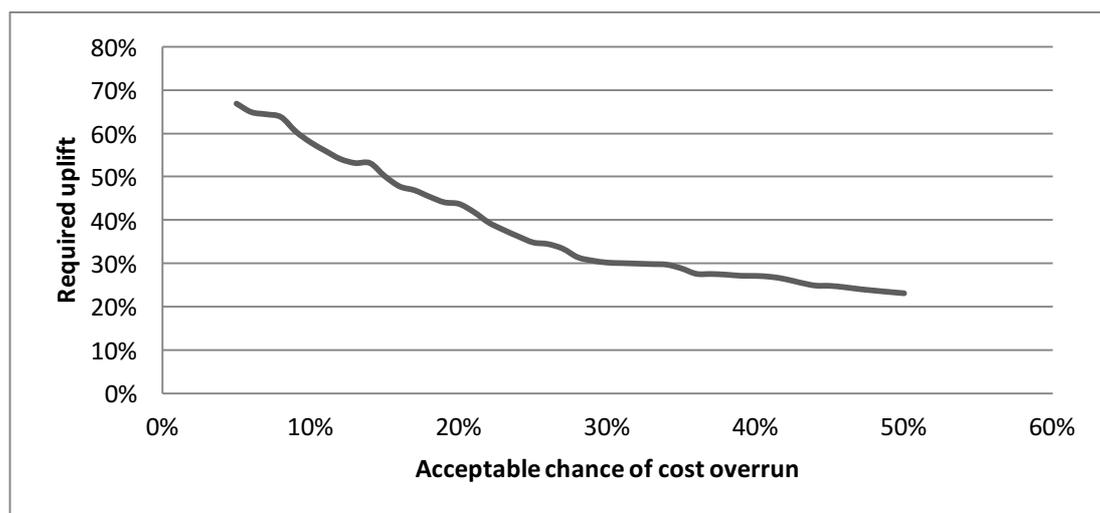

Fig. 6. Required uplift as a function of the maximum acceptable level of risk for cost overrun – Roads (contractors)
Abb. 6. Erforderliche Auftrieb als Funktion der maximalen akzeptablen Risiko für Kostenüberschreitung – Strassen (Contractor)

Figures 7 and 8 apply to Reference Class 2 (Fixed Links) and show the required uplift that should be added to ICERA's and the contractor's cost plans.
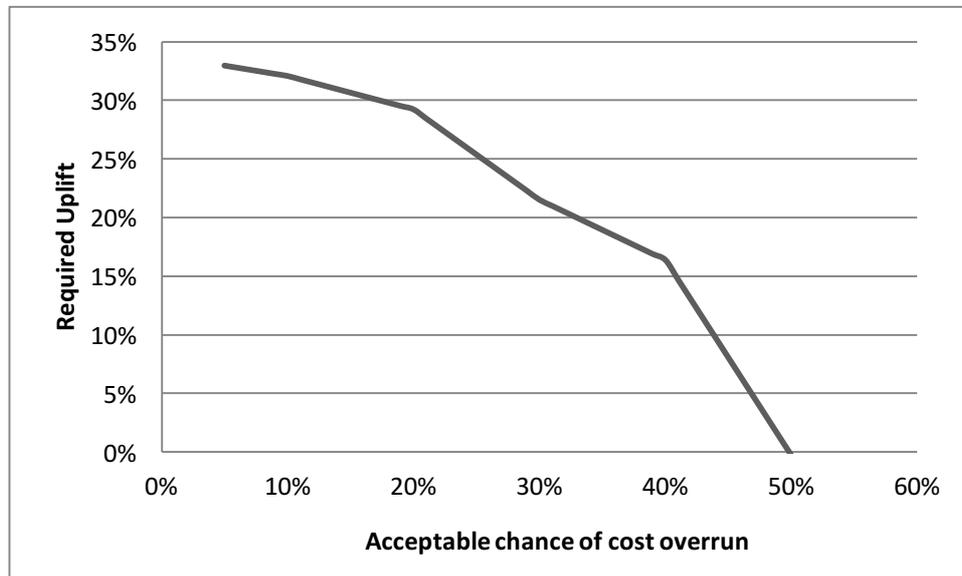

Fig. 7. Uplift as a function of the maximum acceptable level of risk for cost overrun – Fixed links (ICERA)
Abb. 7. Extra als Funktion der maximalen akzeptablen Risiko für Kostenüberschreitung – Festverbindungen (ICERA)
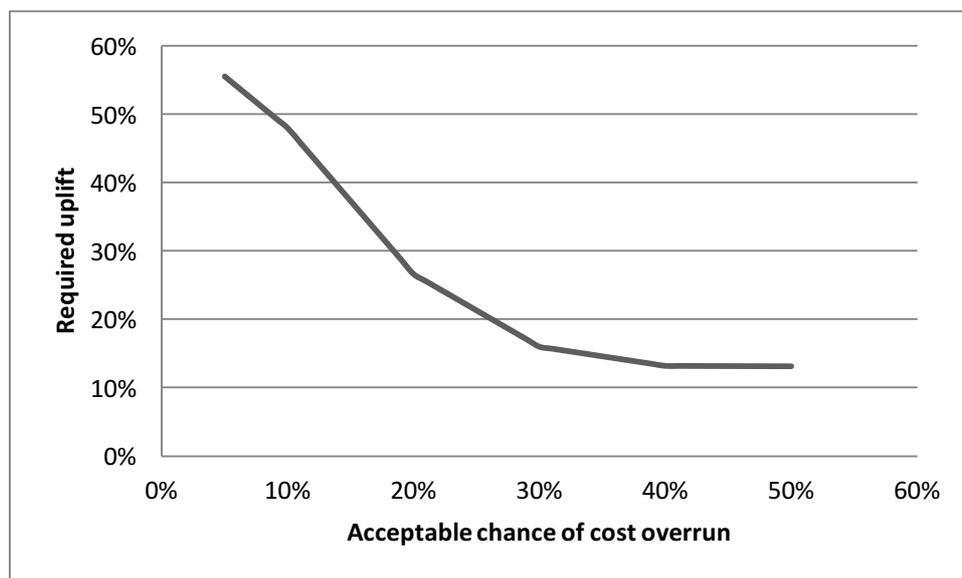

Fig. 8. Uplift as a function of the maximum acceptable level of risk for cost overrun – Fixed links (Contractors)
Abb. 8. Extra als Funktion der maximalen akzeptablen Risiko für Kostenüberschreitung – Festverbindungen (Contractor)

Figures 7 and 8 show that if it had been decided that the risk of cost overrun for a fixed link project should be less than 50% (having a 50% chance to be within budget), it would not be necessary to add an uplift on ICERA's primary cost plan. However, an uplift of 13% would be required on the contractor's primary cost plan. If it had been decided that the risk of a cost overrun should be less than 20% (having an 80% chance to be within budget), then an uplift of 29% should be added to ICERA's primary cost plan and 27% should be added to the contractor's primary cost plan.

Table 4 summarises the required uplift for selected percentiles for both reference classes for ICERA and contractors.

Table 4

Required uplifts for selected percentiles

Category	Types of projects	Applicable optimism bias uplifts				
		50%	*60%*	*70%*	*80%*	*90%*
ICERA						
Roads	*Main roads*	*5%*	*10%*	*12%*	*20%*	*29%*
	Connecting roads					
	Region roads					
Fixed Links	*Bridges*	*0%*	*16%*	*22%*	*29%*	*32%*
	Underpasses					
Contractors						
Roads	*Connecting roads*	*23%*	*27%*	*30%*	*44%*	*58%*
	Region roads					
Fixed Links	*Bridges*	*13%*	*13%*	*16%*	*27%*	*48%*
	Underpasses					

3. DISCUSSION

In Reference Class 1 (Roads), the shape of the distribution indicates an overrun and is similar for ICERA and contractors. In all cases, however, the uplift that has to be added to the contractor's primary cost plan is higher than the uplift that has to be added to ICERA's primary cost plan. This indicates that ICERA, in general, makes more realistic cost plans for road projects than contractors. The reason for this difference is probably attributable to the following reasons.

Contractors are in competition with each other to win projects, so it is in their best interest to have the bid as low as possible to increase the likelihood that their tender offer is accepted. The contractor's primary cost plan is the cost plan of the contractor who was awarded the project. Normally, the successful contractor has one of the lowest tender offers. In addition, ICERA prepares a cost plan for all road projects that are to be executed whilst each contractor undertakes a cost plan for just those road projects for which they have a bid. For that reason, ICERA has much more experience when preparing a cost plan for a road project and has a good overview of all road projects.

Both ICERA and contractors base their primary cost plan on unit prices. Contractors use unit prices they know they can achieve with a quantity discount included. ICERA bases its primary cost plan on unit prices obtained by taking the average unit price from all contractors over a 3-4 year period. In this way, ICERA evens out fluctuations and, in most cases, bases its primary cost plan on a higher unit price than the contractor with the lowest bid.

If Reference Class 1 is compared to the road reference class for transportation projects in the UK [7], it can be seen that the shape of the distribution of cost overrun for the reference class is similar to

the distribution of cost overrun that is obtained both for ICERA and for contractors in this research. When comparing the uplifts, it can be seen that the uplift in UK projects for optimism bias is higher than the uplift required for ICERA's primary cost plan but lower than the uplift required for the contractor's primary cost plan. It can also be seen that approximately 60% of ICERA's primary cost plan suffers from overrun, 95% of the contractor's primary cost plan suffers from cost overrun and about 80% of UK road projects have suffered from cost overrun. This indicates that forecasts are significantly more accurate as the project passes beyond the initial stage and enters the planning stage but, as previously stated, the UK studies are primarily based on the initial cost forecast.

Other reasons for the differences are that ICERA has provided for some uncertainty in its primary cost plan by basing it on higher unit prices. In the UK projects, the forecasted cost is most likely based on a plan that has not provided for uncertainty; however, this position is not entirely clear. The UK database is much larger than the database used in this research. The road reference class in the UK projects includes both more diverse and a larger number of projects (172 projects when compared with the 65 Icelandic projects).

The projects provided by ICERA for this study were mostly executed after the economic collapse in Iceland in 2008. Increased risk aversion was one of the immediate consequences. It is also possible that ICERA simply completes more accurate cost plans than is the case in the UK.

In Reference Class 2 (Fixed Links), the shape of the distribution of cost overrun is different for ICERA and for contractors. It depends on the risk of cost overrun chosen and whether a higher uplift is added to ICERA's primary cost plan or the contractor's primary cost plan. If the probability of staying within budget is 50% or 90%, then a higher uplift is needed for ICERA's primary cost plan. However, if the probability of staying within budget is from 60%-80%, then a higher uplift is needed for the contractor's cost plan. The reason could be that Reference Class 2 contains relatively few projects and because of that pre-qualification was not as strict as for projects in Reference Class 1. Seven of the 11 projects in Reference Class 2 did not have a precise actual cost due to the inclusion of additions. It is, therefore, not possible to place reliance upon this reference class when comparing all fixed link projects. If Reference Class 2 is compared to the fixed links reference class for UK projects, it can be seen that a much higher uplift for projects is proposed, which tends to lend some support to the concerns expressed above. In the UK, just four projects were found for this reference class, perhaps confirming that it is hard to collect reliable data for this type of project.

4. CONCLUSIONS

This research was motivated by the question: *"Could the Icelandic Road Administration (ICERA) improve its cost forecasting by using reference class forecasting at the planning stage of a transportation project?"* The short answer is that there is no urgent need for ICERA to adopt reference class forecasting as its current methodology that is based on time series data seems to work well enough. Projects completed over a five-year period record an average overrun of 6%, which could be considered a moderate indicator of success. The ideal position is to have an average overrun as close to zero as possible. To reach this position, ICERA could add a 5% uplift for optimism bias to all its primary cost plans for road projects, but it is questionable if the effort is worthwhile for such a small reward.

Even though the research did not succeed in finding a sufficient uplift for the proposed two reference classes, it is still the best estimate of the chance of cost overrun that currently exists for Icelandic transportation projects. If data are collected, the reference class forecasting is easy to adopt. For this reason, we expect that the forecasting model presented here will be further developed to reduce the incidences of inaccurate forecasting and cost overrun.

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