Reference Class Forecasting to improve time and cost forecasts: Empirical and statistical analysis

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Keywords: Time and cost forecasting; Reference class forecasting; Empirical study.

1 Introduction

In highly complex and uncertain projects, project control techniques are used to monitor the progress and take corrective actions if necessary. However, these techniques require an ambitious, yet realistic, baseline schedule as a point-of-reference during project control. In practice, the construction of such a realistic baseline schedule in terms of realistic time and cost estimates is difficult since project risks are systematically underestimated, which might result in large time delays and cost overruns. As a result, the initial underestimation of risk, and the corresponding underestimation of time and budget, is problematic as it hinders effective and efficient project control actions. The possible explanations or root causes of the risk underestimation are twofold: deliberate and unintentional underestimation (Cantarelli *et al.* 1999, Flyvbjerg *et al.* 2002). In the former case, project managers are part of the problem, not the solution, and the installation of improved governance is advised (Flyvbjerg *et al.* 2004). In the latter case, it is recommended to use more advanced project management techniques. These techniques need to consider an outside view, rather than an inside view, to project risk estimation in order to overrule the project manager's perspective on the project risk. Using an inside view, the project manager will provide time and cost estimates based on past experience and gut-feeling, potentially overestimating the project team's capabilities and/or underestimating the project's risk. Using an outside view, the project estimations are (partially) based on historical information and objective metrics in order to cancel out systematic biases.

In this research, we investigate the ability of the reference class forecasting (RCF) method to improve the project forecasts for both the time and cost dimension. This method does not rely on specific estimates of the project manager, but instead compares the project to a statistical distribution of similar historical projects (Flyvbjerg 2006). Two important aspects of RCF are (1) the size of the reference classes and (2) the properties used to construct the reference classes (e.g. industry, project size, nationality). First, the reference classes cannot be too large as this might have a negative impact on the similarity between the projects in a reference class, but they cannot be too small either because the results might become statistically insignificant. Secondly, the selection of the correct properties of similarity is important to ensure that projects are compared with other, similar projects. Although these aspects of RCF are crucial to ensure a good outcome of the approach, they are often neglected in RCF studies in the existing literature. More precisely, the properties that are used to construct the reference classes are pre-defined and derived from other studies without critical assessment. Also, the choice of properties is often left to the project manager, which might again result in a subjective inside view, rather than an objective outside view. Therefore, we present a research study that aims to empirically investigate the important properties for RCF in a wide variety of industries as well as statistically analyse the ability of RCF to improve the project forecasts. A summary of the RCF method is shown in Figure 1. It is clearly indicated that RCF requires both a high similarity between the projects in a single reference class and a high dissimilarity between the different reference classes.

The contributions of our research study are threefold. First, project managers from Belgium and Italy were questioned about the ranking of different project properties for their ability to identify similar projects. In contrast to existing research studies, project managers were involved in the RCF method to give their opinion about properties of similarity, rather than that the properties of similarity were pre-defined or selected by the researchers themselves. Secondly, we investigate the individual and combined impact of the six best project properties on the forecasting accuracy of the RCF method using a real-life dataset of 52 projects collected from the interviewed project managers. In the literature, there already exists a lot of research on the improvement of project forecasts (for time and cost) using the earned value management method (Vandevoorde and Vanhoucke 2006, Vanhoucke and Vandevoorde 2007, Vanhoucke and Vandevoorde 2008), however, we extend these research efforts to the RCF methodology. Finally, we provide insights on the optimal number of project properties that should be used to create reference classes.

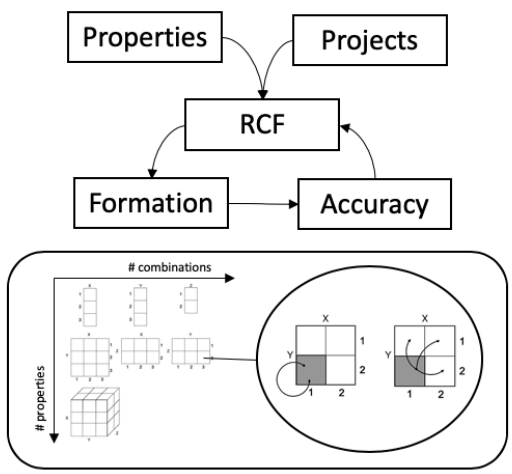

Fig. 1. General overview of RCF method

2 Methodology

The RCF method consists of four steps in order to obtain an accurate estimate of the duration and cost of the project prior to its start. First, a reference class of projects that is similar to the new project should be identified. In this study, we use a dataset of 52 real-life projects and we interview 76 project managers about good properties to measure the similarity between projects. Based on these interviews and data collection, we are able to construct different reference classes of historical projects. The interviews were conducted and the data was collected by Vandoorne *et al.* (2018). As shown in Figure 2 (Step 1), a new project will be identified based on the selected similarity properties and assigned to a specific reference class. Since the discrepancy between the initial estimated and final actual cost (i.e. the forecast error) is known for the historical projects in the dataset, a probability distribution of the forecast errors of the historic projects in this reference class is subsequently determined (Batselier and Vanhoucke 2016). We might observe that the forecasts for the new project are too optimistic (or pessimistic) based on the historical information captured in the reference class (see Figure 2 (Step 2)). Furthermore, this distribution of the reference class is transformed into a cumulative probability distribution (see Figure 2 (Step 3)). Finally, the original forecast for the new project (e.g. using a traditional inside view) should be changed (increased or decreased) based on the recommended uplift. In Figure 2 (Step 4), we show the inverse cumulative distribution to compare the willingness to accept risk for the new project and the required uplift of the estimated project duration and/or cost.

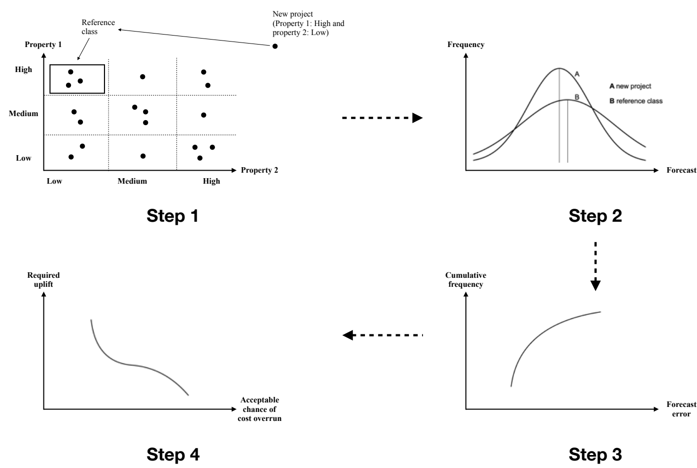

Fig. 2. Step-wise approach of RCF method

3 Computational results

In the computational experiments, we investigate the following features of RCF:

1. The individual and combined impact of the similarity properties on the forecasting accuracy of the reference classes.
2. The difference between time and cost forecasting.
3. The impact of computing the expected uplift with and without variance.
4. The impact of the number of similarity properties on the forecasting accuracy.

The preliminary results indicate that the RCF method results in more accurate forecasts for both the time and cost dimension. Table 1 shows that considering the variance in the probability distribution of the forecast errors in the reference class does not result in an improved performance of the RCF method. This might be due to the fact that the inclusion of variance in the computation of the uplift results in an overcorrection of the initial forecasts and, hence, too pessimistic (rather than optimistic) project duration and cost estimates, resulting again in forecasting inaccuracy. However, more extensive research is needed to investigate this specific observation. Finally, we notice that there exists an optimal number of properties to consider in the RCF method.

	Time		Cost	
	No Var	Var	No Var	Var
1	2.24	-9.15	1.13	-7.37
2	2.45	-7.75	1.20	-5.78
3	3.56	-7.46	2.65	-4.67
4	4.12	-5.97	3.52	-2.63
5	**6.89**	-4.21	**3.82**	-2.02
6	6.56	-3.60	3.15	-1.86
AVG	4.30	-6.36	2.58	-4.06

Table 1. Average percentage points improvement with/without variance for different numbers of properties and time/cost analysis

4 Conclusion

Based on a statistical analysis, we conclude that the RCF method results in robust improvements of the forecasting accuracy. While some combinations of properties result in a better performance of RCF than other combinations, a general observation is that a larger number of properties improves the RCF performance. In this case, the increased similarity between the projects outweighs the lower number of projects in each reference class. Finally, the results for the cost analysis (most common in the existing RCF literature) are validated for the time analysis.

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