Chapter 103
Project Control Using a Bayesian Approach

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ABSTRACT

The capability to elaborate a reliable estimate at completion for a project since the early stage of project execution is the prerequisite in order to provide an effective project control. The non-repetitive and uncertain nature of projects and the involvement of multiple stakeholders increase project complexity and raise the need to exploit all the available knowledge sources in order to improve the forecasting process. Therefore, drawing on a set of case studies, this chapter proposes a Bayesian approach to support the elaboration of the estimate at completion in those industrial fields where projects are denoted by a high level of uncertainty and complexity. The Bayesian approach allows the integration of experts' opinions, data records related to past projects, and data related to the performance of the ongoing project. Data from past projects are selected through a similarity analysis. The proposed approach shows a higher accuracy in comparison with the traditional formulas typical of the earned value management (EVM) methodology.

INTRODUCTION

Forecasting is a critical activity in project management: relying upon sound estimates to complete, the project manager can steer the ongoing project in order to meet specific time and cost objectives (Dvir and Lechler, 2004). Moreover, foresight is needed to avoid constantly being forced to manage emergencies, since emergency implies a reactive action. Without anticipation there can be no rationale in making a decision and what we can do is just to be adaptable to changing circumstances.

Planning and forecasting are strictly intertwined both in the early stage when the project baseline must be determined and throughout the entire project life cycle when the project baseline has to be followed (Hogarth and Makridakis, 1981). Forecasting feeds (re)planning (corrective measures are taken based on forecast) and (re)planning feeds forecasting (corrective measures will influence the future).

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In the project control process the role of the Estimate to Complete (ETC) is critical, since the information drawn from the ETC, compared with the project baseline, should highlight the need for and the type of corrective action that may improve the project performance. In fact, ETC is the base for any effective corrective action. This approach to project control corresponds to a *feed-forward* type control loop (Anbari, 2003; Christensen, 1996), since the forecast informs present-day decisions.

From a recent survey (Merrow, 2011), analyzing the data of more than 300 global mega-projects, it appeared that in 2010 65% of the industrial projects with a minimum budget of 1 billion US dollars did not succeed in meeting the objectives of cost, duration and quality. However, it remains an open question whether these failures are due to a poor performance during the execution stage or to a lack of forecasting accuracy during the planning and control process. In the former case, both positive and negative deviations from the project baseline should be expected. On the contrary, a systematic overrun in terms of cost and/or time may be easier explained as a weakness in the forecasting process since the beginning of the project. As a consequence, the forecasting process plays a critical role.

To explain the accuracy of the forecasting process, some considerations must be developed about the knowledge sources feeding the process, the forecasting techniques to be applied and the mitigating measures taken in order to avoid possible biases affecting the forecasting process.

As shown in Figure 1, at a given time of the project duration, i.e. the time now (TN), a certain amount of the work will be already completed (Work Completed, WC), while the rest of the work will be ahead, corresponding to the Work Remaining (WR). The cost and time performance related to the Work Completed will be known, while a forecast will have to be developed for the WR.

It should be noted that both the *accuracy of the forecast about WR* and the *impact of the corrective actions* that may be implemented based on the forecast depend on the progress of the project at the Time Now. The effectiveness of the corrective actions is greater in the early stages of the project execution and progressively diminishes while progress increases: in fact, as progress increases, the degrees of freedom available to steer the project tend to reduce progressively. On the other hand, the capability to forecast the project final duration and the final cost follows an opposite trend. In fact, at an early time in the execution phase, the knowledge available to the decision maker is scant and rapidly evolving; therefore, the capability to provide a *reliable forecast* is jeopardized, particularly if the forecast is based only upon the knowledge related to the ongoing project.

Drawing on a set of case studies (Caron et al., 2013a; Caron et al. 2013b, Caron et al., 2016), this paper proposes a Bayesian approach to determine the estimate to complete for a project. The paper has a twofold objective:

Figure 1. Estimation at completion at time now (internal view)