



Forecasting a Project's Duration under Various Topological Structures

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Abstract

In this third paper about the simulation study to measure the accuracy of three earned value based forecasting techniques to predict the final project duration, we elaborate on the influence of the degree of project criticality on the quality of project duration predictions. Based on simulation results of Vanhoucke and

Vandevoorde (2007b) and the network paper of Vanhoucke et al. (2008), we present an indicator to measure the structure of a project network, defined by the distribution of activities and the amount of precedence relations and show that this measure clearly influences the accuracy of duration forecasting. Rather than drawing results on a small set of real-life projects, we present simulation results for a large and diverse set of different project networks to be able to draw general results that hold for a wide variety of projects in practice.

Introduction

In this third paper about a simulation study to measure the forecast accuracy of earned value based metrics to predict a project's final duration, we elaborate on our search to factors that might influence the accuracy of the forecast.

Indeed, the forecast accuracy depends on numerous often unknown factors. In this article, we conjecture that the structure of the project network is an important influencing parameter, which will be discussed and tested by means of project simulations initiated by Vanhoucke and Vandevoorde (2007b). Other results of the simulation study have been discussed in previous editions of *The Measurable News*: a first study focused on the general forecast accuracy of projects finishing early and late (Vanhoucke and Vandevoorde, 2007a) while a second study presented forecasting results for projects under different degrees of criticality (Vanhoucke and Vandevoorde, 2008).

In this article, we extend the simulation study by measuring the influence of the topological structure of the project network on the average duration forecast accuracy of earned value based predictive methods. The outline of this manuscript is as follows. In

“Characterization of Project Networks”, the settings of the simulation study are briefly outlined. The “Simulation Results” section discusses the results for early and late projects, and the “Conclusion” section gives overall conclusions and future research avenues.

Characterization of Project Networks

The simulation study uses fictitious projects for which an initial baseline schedule is constructed based on the straightforward critical-path-based calculations. The set of projects contains 4,100 project networks with 30 activities and a varying number of precedence relations. The projects have been generated by the RanGen network generator (Demeulemeester et al., 2003; Vanhoucke et al., 2008) to vary the topological structure of the project network, resulting in a large and diverse set of projects.

The topological structure of a network is defined by the distribution of the activities in the network and the precedence relations between these activities. Projects with various network structures have been generated that differ substantially from each other to draw general conclusions that hold for a wide variety of projects.

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We used four network structure indicators to assure diversity in their project set, originally investigated in the PhD of Vanhoucke (Vanhoucke, 2001) and further developed in a research project in collaboration with the Technical University of Lisbon (Portugal). These four indicators are as follows:

Serial/parallel indicator SP: measures how closely the project network lies to a 100% serial or 100% parallel network. This indicator can be considered as a measure for the amount of critical and non-critical activities in a network.

Activity distribution indicator AD: measures the distribution of the activities along the network, from a uniformly distribution across the project network to a highly skewed distribution (e.g., a lot of activities in the beginning, followed by only a few activities near the end). Consequently, the AD indicator serves as a measure for the workload variability.

Length of arcs indicator LA: measures the tightness of each precedence relation between two activities as the distance between two activities in the project network.

Topological float indicator TF: measures the degrees of freedom for each activity as the amount of slack or float an activity has.

In this article, results for only one indicator, the serial/parallel SP indicator, are presented in detail³. The motivation for this choice lies in the remark given by Jacob and Kane (2004) in an article in *The Measurable News* who correctly claimed that the best forecasting accuracy can be reached by calculating the earned value metrics on the activity level (and not on higher WBS levels). They show on a simple project example that small delays in critical activities and huge accelerations in non-critical activities might mask potential problems since the schedule performance indicator SPI might report good project performance while the opposite is true. Hence, they implicitly conjecture that this potential error is influenced by the degree of criticality in the project network, which can be measured by the SP

indicator as previously explained. Indeed, a more serial network results in a lot of critical activities (in the extreme, a 100% serial network contains only one path that is undoubtedly the critical path consisting of only critical activities), while a more parallel network might result in a lot of non-critical activities. In the next section, we present the details and results of the simulation study on a large set of projects by varying the degree of criticality of a project measured by the SP indicator.

Simulation Results

This section displays results of the simulation runs on a set of projects where each project has a different degree of criticality. More precisely, the networks have been generated for different values of the SP indicator, going from a complete serial project network to a complete parallel network, including all possible SP values in between. In doing so, we have the guarantee that our project dataset contains a very diverse set of projects, each having a different degree of criticality.

Each project activity has a randomly generated activity duration and cost. During the simulation runs, the activity durations may differ from their original planned values, leading to an overall project finishing early or late. During the simulations, the final project duration is predicted along the review periods during the life of the project by means of the EAC(t) formulas of the three forecasting methods, i.e., the planned value method PV (Anbari, 2003), the earned duration method ED (Jacob, 2003) and the earned schedule method ES (Lipke, 2003). Each simulation run contains 100 repetitions to guarantee convergence. The simulation settings are similar to the study presented in the Summer 2008 edition of *The Measurable News* (Vanhoucke and Vandevoorde, 2008).

Figure 1 displays the results of the simulation runs for early (left) and late (right) projects for the three forecasting methods PV, ED, and ES. The horizontal axis measures the SP indicator, and hence, displays results for parallel to serial networks. The vertical

³Mathematical calculations of the indicators are beyond the scope of this manuscript. For details, we refer to Vanhoucke et al. (2008).

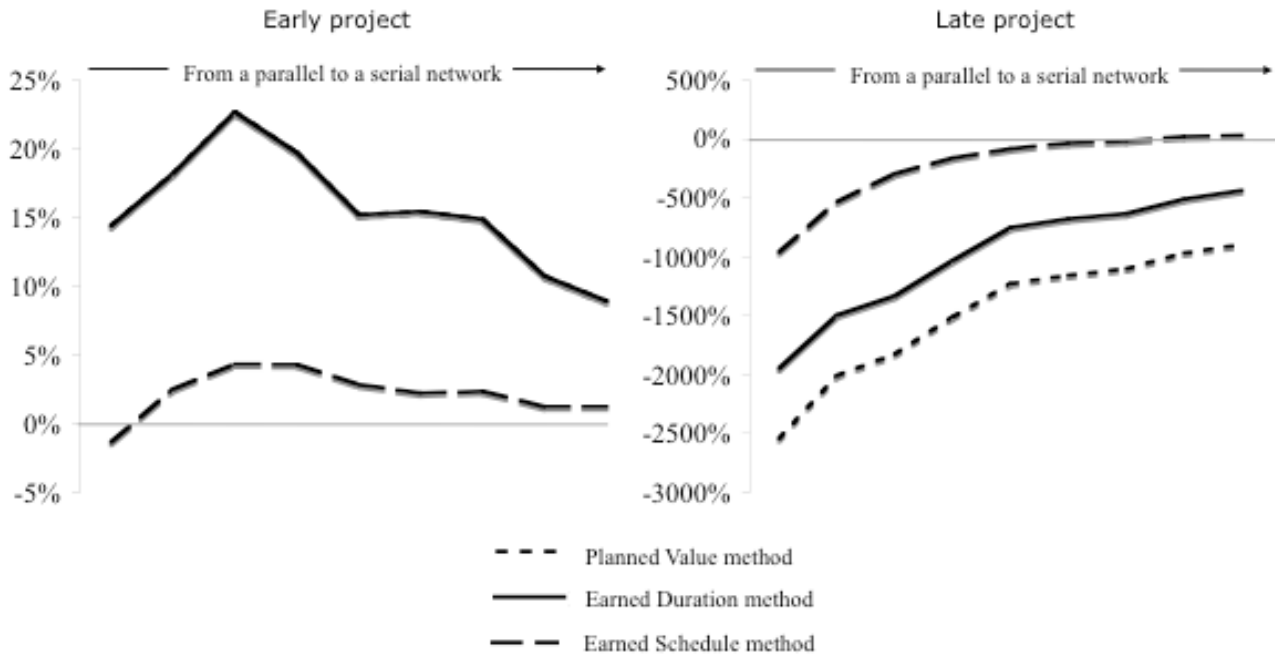


Figure 1. Duration forecast accuracy for early and late projects for three methods.

axis measures the forecast accuracy as the percentage deviation between the average predicted project duration along the project life cycle (i.e., the $EAC(t)$ formulas) and the final (simulated) project duration. Negative values indicate that the predictions are, on average, underestimations for the real project duration, while positive values indicate average overestimations of the final project duration. Obviously, the closer the values lie to zero, the better the forecast accuracy is.

The results of the table can be summarized as follows:

- The ES method clearly outperforms the two other duration forecasting methods (PV and ED), both for projects finishing early and late, which confirms the previously found results in Vanhoucke and Vandevorode (2007 a, b).
- The ED method is similar to the PV method for early projects and differs for late projects. Intuitively, the PV forecasting metric is measured as PD / SPI during the whole life of the project; however, the ED metric equals PD / SPI until the project exceeds the original baseline schedule (i.e., the planned duration PD) and becomes

equal to AD / SPI (with $AD > PD$ the actual duration of the project) from the moment the project is late.

- The more serial the project network, the better the average forecast accuracy of all duration forecasting methods. This conclusion is intuitively clear because more serial networks involve more critical activities, and hence, the probability that the schedule performance indicators masks potential errors and/or opportunities due to changes in non-critical activities decreases.

As a summary, this third simulation study confirms previous results that the earned schedule method outperforms the planned value and the earned duration methods when forecasting the final duration of the project. Moreover, these new results show that the forecast quality depends on the structure of the project network. The higher the degree of criticality of the various project activities (expressed in more serial networks), the more reliable the project duration forecasts made during the project progress will be.

Conclusions

In this article, we have shown that the topological structure of a project network, measured as the closeness of a project network to a serial or parallel network, clearly determines the forecast accuracy of earned value based metrics to predict a project's final duration. A more serial network contains, on average, more critical activities, which results in a better forecast accuracy compared to more parallel networks.

In the near future, our research will focus on other possible determinants that affect the forecast accuracy of earned value forecasting metrics. More details about the simulation methodology, the calculations of the network indicators, and many more results have been summarized in the book *Measuring Time* and implemented in the software tool ProTrack. More information can be found at www.protrack.be.

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