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Earned value project management: Improving the predictive power of planned value

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Abstract

Earned value project management (EVPM) is an effective tool for managing project performance. However, most studies on extensions and applications of EVPM concentrate on improving final cost and duration estimates rather than improving upon the use of planned value (PV) to predict earned value (EV) and actual cost value (AC). This study proposes a straightforward modeling method for improving the predictive power of PV before executing a project. By using this modeling method, this study develops EV and AC forecasting models for four case projects. Out-of-sample forecasting validation using mean absolute percentage error (MAPE) demonstrates that the proposed method improves forecasting accuracy by an average of 23.66% and 17.39%, respectively, for EV and AC. This improvement on PV's predictive power prior to project execution provides management with more reliable predictive information about EV and AC performance, allowing for effective proactive action to ensure favorable performance outcomes.

Keywords: Earned value management; Planned value; Earned value; Actual cost; Prediction

1. Introduction

Project management studies widely assume that predictions of project performance guide management to engineer critical issues scientifically, allowing for proactive project performance management. Several researchers have proposed predictive models and approaches to better estimate project performance (Brandon, 1998; Brown, 1985; Chen, 2013, 2014; Cioffi, 2005, 2006a, 2006b; Farris et al., 2006; Keil et al., 2003). The level of detail in these models and approaches varies considerably with their various purposes and assumptions about information availability.

Earned value project management (EVPM), a method that employs scope, cost, and schedule to measure and communicate the real physical process of a project (Vanhoucke and Vandevoorde, 2007), is the most commonly used of the project performance forecasting approaches reviewed. EVPM produces variance and performance indices for project costs and schedules, and thus predicts project costs and schedules at completion, providing early indications of expected project performance results. A broad consensus exists among researchers and practitioners (Anbari, 2003, 2004; Christensen, 1998, 1999; Kim, 2014; Lipke, 2003; Lipke et al., 2009; Narbaev and Marco, 2014; Project Management Institute, 2013) about the usefulness of EVPM for monitoring and predicting project performance, and EVPM has become an important component of successful project management (Marshall, 2006, 2007; Marshall et al., 2008), with considerable research on the extensions and applications of EVPM being published.

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Despite the panoply of EVPM studies, prior studies (Anbari, 2003, 2004; Cioffi, 2006a; Henderson, 2003; Lipke et al., 2009; Vanhoucke and Vandevoorde, 2007) focus on enhancing the accuracy and reliability of predicting the final cost and duration of a project. Relatively few address improving the predictive power of planned values, considered initial estimates of earned values, and actual costs prior to project execution. As a result, there appears to be a lack of models capable of enhancing the prediction accuracy of earned values and actual costs before execution of projects.

The rest of the paper is organized as follows. Section 2 reviews related EVPM studies, Section 3 presents the research question and methodology, and Section 4 depicts the data, model building, and validation. Section 5 presents the research summary and conclusions. Section 6 describes research limitations and direction for future research.

2. Background

We first offer some definitions: planned value (PV) is the cumulative planned value as a continuous or periodic function summing the approved budget for accomplishing the scheduled work (activity, work package, or project) as a function of time. Earned value (EV) is the cumulative earned value either as a continuous or periodic sum of the approved budget for work performed to date. Actual cost (AC) is the cumulative actual cost value either as a continuous or periodic sum of the actual cost of work performed to date. PV, EV, and AC are respectively the budgeted cost of work scheduled (BCWS), the budgeted cost of work performed (BCWP), and the actual cost of work performed (ACWP).

PV, EV, and AC are the fundamental metrics of the earned value project management (EVPM) that generates variance and performance indices for financial performance and schedules. EVPM forecasts project costs and schedules at completion, providing early indications of expected project financial and scheduling results based on current information. Aside from that, the time-phased representation of PV is the performance-management baseline of a project, PV is actually the predictor for both EV and AC.

Specifically, PV predicts EV and AC prior to work performed at a given time in project. EV and AC are then measured subsequent to work performed at that certain point of time. The project manager then uses these measured values of EV and AC to evaluate project performance status.

Considerable research has been devoted to the extensions and applications of EVPM for project cost performance and schedule control (Batselier and Vanhoucke, 2015; Brandon, 1998; Brown, 1985; Christensen and Daniel, 1995; Colin and Vanhoucke, 2014; Kim, 2000; Kim et al., 2003). For example, Anbari (2003, 2004) shows the major aspects of EVPM and provides logical extensions for forecasting project cost (or earnings) and completion time using several scenarios, such as that the original cost (or time) estimate is flawed, that past cost (or time) performance is (or is not) a good predictor, and that the project will meet its original cost (or time) target upon completion, regardless of prior performance.

Cioffi (2006b) provided EVPM with a novel formalism derived from a scientific notation, allowing EVPM to extend easily to predicting project cost (or earnings) and duration. Vandevoorde and Vanhoucke (2006) presented a generic forecasting model based on the earned schedule (ES) method to predict project duration, which is applicable in different situations, including those involving a learning curve. Vanhoucke and Vandevoorde (2007) further validated their generic forecasting model by performing extensive simulations on a large set of 3100 generated networks created with 30 project activities based on nine simulation scenarios.

Subsequent work by Lipke et al. (2009) refined the EVPM and ES methods to include the confidence limits of prediction, thereby placing high and low bounds on forecasted costs (or earnings) and duration and thus improving project managers' abilities to make informed decisions. Chou et al. (2010) developed EVPM into a web-based visualized-implementation system, enabling managers to monitor, evaluate, and estimate project financial and scheduling performance by converting project data into manageable information clusters. Hanna (2012) presented a case study to illustrate the use and applicability of EVPM in the electrical construction industry. He concluded that early determination of probable project outcomes is possible with reasonable forecasting accuracy by EVPM.

Recently, Elshaer (2013) refined the EVPM and ES methods by integrating activity-based sensitivity information into the earned value calculations to remove and/or decrease false warning effects caused by non-critical activities, and thus improved the forecasting accuracy of project durations during project execution. Naeni et al. (2014) further developed EVPM into a fuzzy-based model using linguistic terms and fuzzy theory, enabling management to analyze, evaluate, and estimate project costs and scheduling performance under uncertainty during project execution.

More recently, Chen (2014) proposed a linear data-transformation formula and used data from 131 sample projects to demonstrate that the formula significantly improves the correlations between PV and EV and between PV and AC. He developed a mathematical model which he claimed can improve the prediction accuracy of EV and AC through further modeling PV prior to the project's execution stage.

Acebes et al. (2015) proposed a framework based on EVPM, Monte Carlo simulation, and statistical learning techniques for project control under uncertainty. They used a case project to demonstrate how to estimate the probability of cost overruns and the expected project duration during project execution. They concluded that their framework can detect anomalies with regard to possible correlations between project time and cost.

Vanhoucke and Colin (in press) assessed four multivariate regression methods for monitoring the activity level performance of an ongoing project from EVPM/ES observations. Based on a database of project networks, they concluded that using kernel principal component regression method with a radial base function kernel outperforms the other presented regression methods.

In particular, Chen's (2014) EVPM forecasting approach attempts to improve the forecasting accuracy of PV prior to