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Improving the Accuracy and Timeliness of Project Outcome Predictions

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Improving the Accuracy and Timeliness of Project Outcome Predictions

**Prepared by
Construction Industry Institute
Research Team 291, Improving the Accuracy and Timeliness
of Project Outcome Predictions**

**Research Summary 291-1
Version 1.1
September 2013**

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The University of Texas at Austin

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Printed in the United States of America.

Version 1.0 (July 2013)

Version 1.1 (September 2013) – minor edits throughout

Contents

<i>Chapter</i>	<i>Page</i>
Executive Summary	v
1. Introduction	1
2. Research Methodology	5
3. Findings	21
4. Application and Implementation Tools	41
5. Conclusions and Recommendations	47

Executive Summary

Seeking to continually improve the project delivery process, the Construction Industry Institute initiated Research Team 291, Improving the Accuracy and Timeliness of Project Outcome Predictions, to address the myriad challenges to making reliable project outcome predictions. Making any prediction of future performance, particularly with respect to final cost and schedule, is a difficult endeavor. Owners and contractors alike base key strategic decisions on their project forecasts, and typically ask project teams to make continual refinements to cost and schedule predictions, with the goal of providing management with valid, timely, and reliable information. However, the ability to accurately predict project outcomes is highly varied within the industry, sometimes even within a single organization; this variability means that all too often, many companies experience “surprises” or unexpected negative consequences.

As a key departure from previous CII research studies and other investigations on predictability, this research did not focus primarily on quantitative forecasting methods to predict outcomes. Instead, the research team concluded that project outcome predictability is actually influenced by factors across multiple core competencies intrinsic to capital project delivery. Moreover, the team found that the processes and tools used to generate, communicate, and revise a project’s cost and schedule forecasts are as diverse as any other assessment or evaluation undertaken within the industry. However, the research revealed that there were distinct and identifiable practices, that when implemented, distinguished effective project from ineffective ones, with respect to their ability to forecast final cost and schedule outcomes. The team found that these practices fall into four categories: 1) human behavior and organizational culture; 2) project characteristics; 3) forecasting practices; and 4) management processes. Of these, the practices within the human behavior and organizational culture category were statistically shown to have the greatest influence on predictability. Using this four-category structure, the team developed its *Four-casting* model

to sustain the implementation of the predictability-enhancing practices. The *Four-casting* model is presented in Implementation Resource (IR) 291-2, *Four-casting for Early and Accurate Predictability*. To facilitate industry adoption of this model, IR 291-2 addresses each of the four practice categories in separate chapters. Each chapter provides key “take away” findings, a list of potential predictability “de-railers,” and mitigation actions. The team also produced the Excel-based *Four-casting* assessment tool to enable project teams to continuously evaluate the effectiveness of their predictability processes during a project, and to identify the categories and predictability practices in the *Four-casting* model that require attention.

In addition to finding and categorizing predictability-improving practices, the research team identified the types of changes that negatively affect the predictability of cost and schedule outcomes. These statistical findings indicate that the disruptive nature of change on owner and contractor project performance presents itself in varied form, frequency, and intensity. The team identified a total of 36 change reasons, grouping them into 10 types of change: 1) scope changes; 2) standard, regulatory, and legal requirements; 3) engineering design; 4) work planning and execution; 5) commissioning and start-up; 6) control functions; 7) vendor/supplier and procurement; 8) economic conditions; 9) legal and social conditions; and 10) *force majeure*. For owners, changes associated with scope, work planning, and execution disrupt predictability the most, while for contractors, changes associated with scope and control functions were statistically found to be the most disruptive. Also, the results provide quantitative evidence to support the long-held perception that highly recurrent changes tend to have a low impact on cost and schedule deviations, while infrequent changes tend to have a high impact on such deviations. These findings on change reasons are also detailed in IR 291-2.

The research also provides strong evidence that, because early and accurate predictions enable proper management decisions, the ability to proactively predict project outcomes increases value to the organization. Indeed, project team performance should be evaluated on the basis of a

project team's ability to mitigate cost and schedule deviations through the early and accurate prediction of cost and schedule outcomes, as opposed to the now prevalent evaluation of a team's performance based solely on the magnitude of such deviations at project completion. To support the need to measure the predictability of project outcomes, the team also conceptualized, validated, and produced the Predictability Index, a novel project performance metric that enables owner and contractor organizations to quantitatively benchmark and individually assess the predictability performance of their completed projects. IR 291-3, *The Predictability Index*, explains the research behind this metric and how to use its corresponding Excel-based measurement tool.

The outcomes of this research show predictability to be an effective risk mitigation and value-increasing mechanism. As a departure from existing risk management approaches that largely rely on the identification of potential risks, RT 291 presents a novel set of predictability practices that will facilitate accurate forecasts early in the project delivery process. Project teams cannot eliminate surprises, but they can mitigate the potential negative effects of such surprises with the early recognition and the early documentation of them. Such early awareness of the effects of external and internal events helps project teams and the organizations they work for make better well-informed management decisions, at both the project and portfolio levels. Early predictability adds value by enabling the proper response to surprises and changes. Project managers who can foresee impending cost and schedule deviations can mitigate the causes by assigning the right people, implementing the right processes, and encouraging the right behaviors.

Introduction

There are numerous examples of project stakeholders putting their trust in a project outcome prediction that proves to be wrong—often, significantly so—to the great detriment of the project, organization, and managers involved. Owners and contractors alike base key strategic decisions on project forecasts, and often ask project teams to refine cost and schedule predictions throughout the duration of a project. While their goal is to get valid, timely, and reliable information, the ability to predict project outcomes accurately is highly varied within the industry. This means that many CII member companies are often not informed about deviations from forecasts and, thus, only become aware of unexpected negative consequences late in the project execution process.

Purpose of Research Team 291

The purpose of this research was to improve the reliability of project cost and schedule forecasts by enabling teams to produce early and accurate project outcome predictions as a project progresses. This ability would allow teams to adopt, when appropriate, proper mitigation actions sooner. The thinking was that being proactive, rather than reactive, would significantly improve a team's ability to minimize the deviation between predicted and actual outcomes. Negative events and surprises cannot be eliminated, but their impact on project performance can be mitigated with the right behaviors and early recognition and documentation of such changes. For example, the early recognition that the baseline cost has been significantly underestimated cannot guarantee meeting such a cost target at project completion, but it will enable the project team to be proactive and address and improve cost performance with the appropriate corrective actions. Also, in a contrasting scenario, the early recognition that the baseline cost has been significantly overestimated enables an organization to invest the overcommitted funds to other financial endeavors as soon as it is aware of the discrepancy, in order

to realize the expected rate of return. To achieve the purpose of this study and enable project teams to reliably predict project and schedule outcomes, the following objectives were defined:

1. Identify and analyze underlying drivers, events, or conditional issues that affect the accuracy of project outcome predictions.
2. Propose prediction practices that can effectively improve the transparency and accuracy of predicted project outcomes in a timely manner.
3. Evaluate whether forecasting practices should change on the basis of the stage of completion during project execution.
4. Explain how forecasting practices should be applied to cost and schedule measures of project performance.
5. Develop high-value and high-impact tools and recommended practices that can be widely adopted by CII member companies.

Scope

The scope of the research team was defined by the following four limits: 1) the consideration of prediction techniques as a comprehensive set of processes rather than the evaluation of quantitative forecasting techniques alone; 2) a tight focus on cost and schedule performance metrics; 3) an assumption of budget authorization release; and 4) a presumption of adequate front end planning efforts.

First, the team investigated proposed prediction techniques without a specific focus on the quantitative predictive tools and/or algorithms that they require. The prediction of project outcomes is understood as a management process that requires an understanding beyond the deterministic and/or stochastic approaches used to generate numeric forecasts. Quantitative forecasting approaches are known to industry members, and have been studied by CII. In contrast to a numeric forecasting method or approach, this research has focused on the identification of practices that improve the accuracy, timeliness, and transparency of project cost and schedule outcome predictions.

Second, this research focused on improving the ability to predict project cost and schedule performance. Even with this focus, the team acknowledged the importance of other project performance metrics such as safety, quality, operability, and stakeholder satisfaction. Indeed, the team understood that, while safety has only one acceptable target at all times (zero accidents), the measurement of quality, operability, or stakeholder satisfaction varies greatly, depending on the perception of the client and/or project sponsor and the evaluation criterion employed in each case. Given the variability in perspective and the qualitative assessment of such metrics, the team kept its focus on cost and schedule forecasting performance.

Third, this research investigated the predictability of project outcomes between the budget authorization release and project completion milestones. Because the level of scope definition can vary substantially at preliminary project phases, i.e., before authorization, the expected accuracy of projected performance outcomes also varies. For instance, a 50-percent cost accuracy may be a commonly accepted deviation during the early project phase of feasibility analysis. This large variability of project outcome predictions during preliminary project phases is intrinsic to the nature of capital projects. Thus, in order to realistically address the goal of improving predictability, the team limited this research to project activity between budget authorization release and project completion.

Finally, this research assumes that adequate and comprehensive front-end planning efforts are being applied to capital projects. It is clear from previously published CII materials that poor front end planning efforts significantly diminish the likelihood of project success. Indeed, poor planning results in higher levels of variability and the reduced predictability of every project performance measure. It is not the purpose of this research to revisit or revalidate the significance of comprehensive front end planning practices. Rather, this study assumed that projects properly implement them.

Implementation Resource Products

Within this scope of work, the research team produced two implementation resources: IR 291-2, *Four-casting for Early and Accurate Predictability*; and IR 293-3, *The Predictability Index*. To develop the IR 291-2 *Four-casting* model and its accompanying Excel-based tool, the team used quantitative evidence, statistical findings, observations, and subject matter expert input. As discussed above, the model sustains and promotes the implementation of predictability-enhancing practices across four categories: 1) human behavior and organizational culture, 2) project characteristics, 3) forecasting practices, and 4) management processes. IR 291-2 also discusses the team's identification and classification of change reasons, and explains their impact on both cost and schedule predictions. IR 291-3 explains how the Predictability Index and its accompanying Excel-based tool enable owner and contractor organizations to quantitatively benchmark and individually assess the predictability performance of their completed projects.

Research Methodology

To fulfill the research objectives, the team designed and implemented a four-step research methodology: 1) identification and categorization of both factors of influence on predictability and change reasons; 2) conceptualization of a reliable, yet practical predictability measure; 3) identification, impact assessment, and substantiation of practices for effective predictability; and 4) impact assessment of change reasons on cost and schedule predictability and deviations. (See Figure 1.) Required research tasks not explicitly identified in Figure 1, such as data collection or data analyses, were rigorously performed and are described in this chapter.

In total, 18 CII member companies participated in the study, some represented on the team and some with no representatives on the team. To build the *Four*-casting model, the team collected detailed retrospective data for 135 completed projects, and validated the *Four*-casting assessment tool with data from an additional 27 completed projects. Overall, the team validated and substantiated the findings through one or more of the following mechanisms: statistical tests, research charrettes, workshops, and/or survey questions.

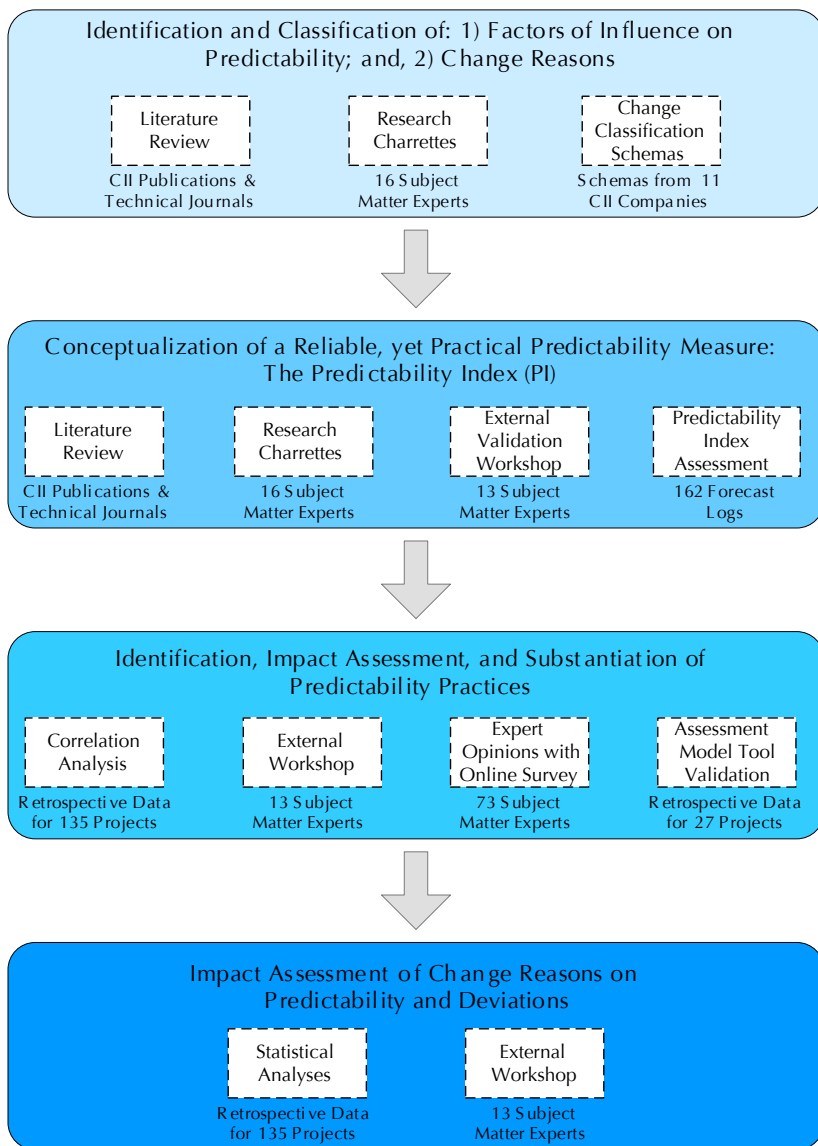


Figure 1. Methodology

Identification of influencing factors and change reasons

The team conducted an extensive literature search, elicited subject matter input, and surveyed CII member organizations in order to identify and categorize the factors with a potential influence on predictability and the change reasons it found. This identification and categorization process included three face-to-face meetings and multiple conference call meetings. The research methods used to assess the influencing factors and change reasons are detailed below.

Influencing Factors

The team developed an initial list of factors with the potential to influence predictability, based on an extensive review of the research literature. Using the findings of this review, the team's subject matter experts (SMEs) participated in research charrettes during three face-to-face meetings to further identify and group the initial set of influencing factors. Research charrette participants are able to generate and share a large amount of information in a short amount of time in a dynamic and creative atmosphere. In the RT 291 charrettes, the team's SMEs typically worked in small subgroups, reporting the conclusions of their respective charrette sessions back to the entire team for further discussion and elicitation. Examples of core influencing factors included alignment, transparency, forecasting methods, reporting, information issues, risk, or changes, among others. Based on the factors identified through the literature review and research charrettes, the team framed a total of 72 survey questions (most of them with a predefined set of answers), in order then to collect retrospective project data by means of a facilitated survey. Even though very few questions were related solely to any particular factors (such as project size or industry sector), most of them addressed industry practices related to corresponding factors. For example, questions were framed around the utilization of performance-based fee adjustments, integration of project management and control information, or forecast reporting frequency. Overall, survey questions were grouped into four categories: 1) human behavior and organizational culture; 2) project characteristics; 3) forecasting practices; and 4) management processes.

Change Reasons

The team's extensive review of CII literature and technical journals also led to its preliminary definition of the type of cost and schedule changes that can typically arise during project execution. This preliminary list of changes was complemented by the change classification schemas used by 11 CII member companies. Five owners, four contractors, and two service companies provided their detailed change log classifications, providing a total of 310 individual change reasons. From this collected data, the team found evidence of the industry perspective on change reasons, and revealed that its methods of documenting them are diverse. While some companies categorize changes through many individual change reasons grouped into key types of change, others choose to catalog changes through only a few individual reasons. Reported change reasons also reflected the different approaches to business taken by distinct industry sectors. Differences were also observed between owner and contractor organizations; one such difference was in the controllability assessment for changes in scope. Thus, in its effort to categorize changes that affect predictability, the team sequentially reduced the initial list of 310 change reasons to 36 distinct change reasons, grouped into 10 types of change: 1) scope changes; 2) standard, regulatory, and legal requirements; 3) engineering design; 4) work planning and execution; 5) commissioning and start-up; 6) control functions; 7) vendor/supplier and procurement; 8) economic conditions; 9) legal and social conditions; and 10) *force majeure*.

Conceptualization of a Predictability Metric – the Predictability Index (PI)

To differentiate between effective and ineffective project predictors, the research team conceptualized and validated the Predictability Index (PI), a quantitative measure to determine the predictability performance for completed projects. For a given project, the lower the Predictability Index score, the better the predictability performance. This tool should be used to both individually assess and benchmark the predictability of

completed projects. The PI is expressed in Equation 1 as the sum of cost and schedule predictability measures.

$$\text{Predictability Index (PI)} = \text{Cost Predictability (CP)} + \text{Schedule Predictability (SP)}$$

Equation 1

These cost and schedule predictability measures distinctly assess the cost and schedule forecasting errors along the project completion timeline as the product of the normalized timeliness error times the absolute deviation error (expressed in percentage of deviation). (See Equations 2 and 3.)

$$CP = [\text{Normalized Cost Timeliness Error}] \times [\% \text{ Cost Deviation Error}]$$

Equation 2

$$SP = [\text{Normalized Schedule Timeliness Error}] \times [\% \text{ Schedule Deviation Error}]$$

Equation 3

The computation of these two error components—deviation and timeliness—for cost and time predictability is produced as follows. First, the absolute values for the percentage of cost and time deviations are represented with the pair of equations immediately below. (Equations 4 and 5.) The percentage of deviation is measured in absolute (positive) values, and hence theoretically ranges from “0” to any percent deviation value, eventually beyond 100 percent.

$$\% \text{ Cost Deviation Error} = \frac{ | \text{Actual Installed Cost} - \text{Baseline Cost} | }{ \text{Baseline Cost} } \times 100$$

Equation 4

$$\% \text{ Schedule Deviation Error} = \frac{ | \text{Actual Completion Time} - \text{Baseline Completion Time} | }{ \text{Baseline Completion Time} } \times 100$$

Equation 5

Second, the normal timeliness error accounts for how timely the predictions were in terms of either cost or schedule along the project completion timeline, regardless of the magnitude of the final deviation. In short, getting to the correct outcome sooner, whatever that outcome might actually be, is much better than being surprised later when no mitigation actions are possible. The normal timeliness error is independently computed for cost and schedule predictions based on the definition of a normalized or unitary (equal to 1) deviation, which corresponds to the difference between baseline and completion values. The graphical representations of these calculations in Figure 2 show how, based on the unitary deviation, the normal timeliness error is equal to the area above and/or below the actual outcome value at project completion. More specifically, the graphs conceptually illustrate the computation of the normalized cost timeliness component for two projects, the forecasted costs of which are assumed to have been underestimated. Under such assumptions, both timeliness errors are strictly below their actual installed costs. (See Figure 2.)

As also illustrated in Figure 2, Project A is assumed to be an early and accurate predictor of the final project cost, while Project B is assumed to recognize the actual project cost growth very late in the project execution. Thus, Project B experiences large errors between forecasted and actual performance at a point late in the project execution. As reflected in the Cost Predictability expression, at equal percentages of cost deviations, Project A is a much better predictor of cost performance than Project B, since its normal cost timeliness error is much smaller. The same normal timeliness concept can be applied to compute the schedule predictability performance. A more detailed discussion of the Predictability Index, its use, and the interpretation of its value, is presented in IR 291-3, which also describes the use of the Excel-based Predictability Index tool. This tool enables CII members to gauge and benchmark the predictability of their completed projects over time and against an industry standard.