Improving Construction Cost Learning Curves by Implementing Organizational Learning Tools for Risk Identification and Risk Assessment

Department of Engineering and Public Policy
Carnegie Mellon University

Sola M. Talabi, Ph.D., M.Sc. (Eng), MBA, B.Sc. RMP

sola@talabi.com
4124486823
Proposing and demonstrating the use of Bayesian inference as an optional or complimentary method to update expert assessments

- Model expert updates using Bayesian inference
- Identify the limitations and opportunities

**Process:**

- Develop CDF of expert prior assessments
- Fit a Beta distribution to the expert prior assessments
- Update priors based on historical frequency using Beta/Binomial conjugacy property
- Using K-S test compare expert empirical update and group feedback update with Bayesian update
Incorporation of Expert Estimates into Bayesian Belief Network

- Prior (I)
- Beta Estimate
- Empirical update (I+H)
- Historical Data
- Bayesian update

CDF of 10 Experts

Probability of Risk Driver 1

Maximum Difference
Results: Assessment of difference in distributions using K-S test

Empirical update had highest agreement – 8/12
Group feedback had less agreement with Bayesian 5/12
Summary of findings

- Conjugacy property for distributions (e.g. Beta/Binomial) simplifies Bayesian updating and is applicable for use in the context of EPC projects.
- Bayesian updates were not significantly different from the empirical updates for 8 out of 12 risk drivers.
- Group feedback increased the difference in distributions between Bayesian and experts: 5 out of 12 risk drivers were not different.
- Bayesian updating may serve as an alternative to expensive and time consuming expert updates.
  - If there is agreement amongst experts and agreement with historical frequency.
- Group feedback captures some knowledge that may not be captured in historical data.
  - The issue of “incomplete” data is seen more with certain drivers than with others.
- Risk assessments may be improved by incorporating Bayesian and expert assessments in a complimentary manner to reduce bias and improve risk assessment efficiency.
Objectives:

- Identify opportunities for learning based on a case-study of practices in firms working on large infrastructure projects
- Investigate the absence of learning in historical large construction projects
- Identify methods to introduce industry-wide learning based on a comparison with operations and maintenance practices
Identify opportunities for firm-level learning based on a case-study of practices in a large construction firm

Method:

- Development of a metric to measure learning
- Using data from large infrastructure projects:
  - Cost overrun categorized by:
    - functional groups
    - time
  - Employee turnover rates
- Establish “potential learning curve” by showing relationship between cost overruns and learning coefficient
Development of a metric to measure learning: Learning Measured by Rate of Change of Cost Expenditure on Risks

**Learning**: Increasing rate of change of cumulative cost overruns

**No - Learning**: Decreasing rate of change of cumulative cost overruns
Results: Assessment of learning in various categories

Improving Construction Cost Learning Curves
Derived “potential” learning curve for a construction firm

![Learning Curve Diagram]

- Supply Chain
- Schedule
- Org & Process
- Technical & Quality
- Resource
- Commercial

Equation: $y = 0.07e^{-0.29x}$

$R^2 = 0.44$
Association between derived learning coefficient and turnover rates

\[ y = 0.57e^{-0.28x} \]

\[ R^2 = 0.17 \]
Summary of findings

- Rates of risk occurrence vary across various functional organizations within a firm.

- There is an association between the derived learning coefficient and the percent cost overruns.

- A potential learning curve may be developed within an organization based on the relationship between cost overruns and the learning coefficient.

- Performance may be improved by standardizing best-practices in higher performing areas of an organization.
Investigate the causes of an absence of learning in historical large construction projects

- Statistical analysis of historical construction data including:
  - Estimated and realized costs
  - Estimated and realized lead-times (schedule)
  - Plant size
  - Constructor information

- Sample of plants in dataset:
  - 67 non-turnkey US projects, hence overruns reported by utility
  - Start dates between 1966 – 1977, completion by 1986