CONSTRUCTION INDUSTRY VALIDATION
OF SCHEDULE PERFORMANCE MEASURE

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Final Presentation

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by

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Research Team

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Origins of the Problem

• National Research Council – Two Overriding Defined Needs

“Construction firms do not have a single source of metrics for comparing the efficiency of their projects and processes, or for assessing their competitive position…and there is no single, official index or measure for the productivity of the construction industry.”

“U.S. construction industry does not have an industry-wide research agenda that identifies or prioritizes research areas with the most potential for improving its productivity, its competitiveness, or its efficiency.”

• National Research Council – The Ultimate Desire

“Project-level measures are needed to contribute to the understanding of how an individual project compares with other, similar projects.” Source: National Research Council “NRC” Report, 2009, “Advancing the Competitiveness and Efficiency of the U.S. Construction Industry”
Fundamental Purpose

“To establish a ‘living’ schedule performance measure that will be comparable across all project types, complexities, and company sizes for the construction industry.”

• Expectations / Limitations
  – Measure / Index has to be rooted in existing proven methods
    (Capital Asset Pricing Model - CAPM: $E(R_i) = r_f + \beta_i [E(R_m) - r_f]$)
  – Measure / Index has to be easily determined and rooted in precedent (EMR: Standard Safety Measure)
  – Measure / Index has to be recognized and universal (ASTM)
Individual Stocks have a Beta ($\beta$)

- Amazon = 1.63
- Apple = 1.10
- Microsoft = 0.96
- Harris Corp = −0.21
- Newmont Gold = −0.11

So, too, can Subcontractors and the Construction Industry.
Scope of Research: Concept & Responsibility

Research
National Science Foundation
– Funded the Research on Theory

Testing & Validation
The Charles Pankow Foundation & Construction Industry Institute
– Funded the Development & Validation of the Process
Scope of Research: Concept & Responsibility

The Concept:

- Experience Modification Rate (Measurement Period)
- CAPM Beta (β) (Measurement Components)
- Schedule Beta (β) (Performance Correlation)

The Process:

"As-Built" – "As-Planned"
+ ΔChange Orders – ΔSuspensions
= Performance
Origin of Beta: Capital Markets

Beta $\beta$ (CAPM)
Helps investors understand whether a stock moves in the same direction as the rest of the market, and how volatile or risky it is compared to the market.
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Schedule Beta $\beta$ (CONSTR)
Helps understand individual subcontractor’s deviation, risk, and/or performance as correlated to the collection of projects completed over a defined period of time.
What Is Beta ($\beta$) and What Does It Mean for Us?

- Beta measures the risk of volatility of a stock compared to the overall stock market.

\[
\beta = \frac{\text{Covariance} \ (R_i, R_m)}{\text{Variance} \ (R_m)}
\]

becomes

\[
\beta = \frac{\text{Covariance} \ (d_i, d_m)}{\text{Variance} \ (d_m)}
\]

where $R_i$ is the return of an individual asset, $R_m$ is the return of the overall market, $d_i$ is the duration delta of an individual stock, and $d_m$ is the duration delta of the overall market.

- Stock market $\leftrightarrow$ Construction Industry
- Individual Stock $\leftrightarrow$ Individual Subcontractor
- Trading Day’s Results $\leftrightarrow$ Trading Day Results

i.e., as defined by CPM activities

i.e., the collection of completed projects

i.e., delta as-built to as-planned durations
## Case Study Data

- Industry Champion provided a portfolio of projects as a data source
  - Twenty-two (22) Mixed Use Residential / Commercial projects were identified
  - Selection criteria established with Industry Advisory Board:

<table>
<thead>
<tr>
<th>Location</th>
<th>Size</th>
<th>Complexity</th>
<th>Duration</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same region for commonality of subcontractors</td>
<td>Mix of S/M/L</td>
<td>Determined by schedule activities / dependencies</td>
<td>A diverse range short / medium / long</td>
<td>Completed (requirement for “as-built” durations)</td>
</tr>
<tr>
<td>Performance</td>
<td>Permission</td>
<td>Staffing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference (ahead / behind) expected</td>
<td>Written data sharing agreement required</td>
<td>Project Manager / Project Executive needs to be available</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Case Study Data

• Industry Champion provided a portfolio of projects as a data source
  – Initially one large Mixed Use project with multiple phases near Catholic University
  – Ultimately twenty-two (22) Mixed Use projects for consideration (not all complete)

Eight (8) projects ultimately Selected
## Case Study Data

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Projects</td>
<td>8</td>
</tr>
<tr>
<td>Average # Activities</td>
<td>1,037</td>
</tr>
<tr>
<td>Average # Subs</td>
<td>39</td>
</tr>
<tr>
<td>Average Actual Duration</td>
<td>691 days</td>
</tr>
<tr>
<td>Average Value</td>
<td>$51 MM</td>
</tr>
</tbody>
</table>
Case Study Data

- Required data from each project

Activity Data
- Activity ID
- Subcontractor Name
- Subcontractor Discipline
- Activity Description
- Subcontractor As-Planned Duration
- Subcontractor As-Built Duration
- Subcontractor Duration Delta (Calculated)

Project Data
- Project As-Planned Duration
- Project As-Built Duration
- Project Duration Delta (Calculated)
### Case Study Beta (β) Calculation (Sample)

<table>
<thead>
<tr>
<th>Activity ID</th>
<th>Name</th>
<th>Blind Designation</th>
<th>Task</th>
<th>Activity Duration</th>
<th>Project Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>U04090</td>
<td>Redacted</td>
<td>MSM29</td>
<td>Electrical</td>
<td>20 – 10 = 10</td>
<td>911 – 911 = 0</td>
</tr>
<tr>
<td>SO1308</td>
<td>Redacted</td>
<td>MSM29</td>
<td>Electrical</td>
<td>5 – 5 = 0</td>
<td>779 – 740 = –39</td>
</tr>
<tr>
<td>SO1312</td>
<td>Redacted</td>
<td>MSM29</td>
<td>Electrical</td>
<td>1 – 2 = 1</td>
<td>779 – 740 = –39</td>
</tr>
<tr>
<td>SO1314</td>
<td>Redacted</td>
<td>MSM29</td>
<td>Electrical</td>
<td>5 – 5 = 0</td>
<td>779 – 740 = –39</td>
</tr>
<tr>
<td>SO1316</td>
<td>Redacted</td>
<td>MSM29</td>
<td>Electrical</td>
<td>60 – 60 = 0</td>
<td>779 – 740 = –39</td>
</tr>
</tbody>
</table>

- **Activity Count**: 6
- **Project Count**: 2
- **Variance**: 44.27
- **Covariance**: –67.17
- **Beta**: –1.52
Case Study Beta ($\beta$) Calculation Results

Desirable Range: $0 < \beta < 1$

$\beta > 0$

Subcontractor performance tends to move the same as the projects on which they work.
Case Study Beta (\(\beta\)) Calculation Results

\[ \beta < 0 \]

Desirable Range: \(0 < \beta < 1\)

Acceleration Range: \(\beta < 0\), when Subcontractor performance is ahead of as-planned. While it may occur in small datasets, it is considered unrealistic over longer timeframes.
Case Study Beta (β) Calculation Results

Desirable Range: 0 < β < 1 or –1 < β < 0

Subcontractor has less deviations than the project and is less risky.
Case Study Beta (β) Calculation Results

Desirable Range:
\[0 < \beta < 1\]

- β > 1
- or
- β < -1

Subcontractor incurs stronger deviations than the project itself and is risky
**Case Study Beta (β) Calculation Results**

Desirable Range: $0 < \beta < 1$

- **β = 1**

Subcontractor performance has no distinction between it and the overall project performance.
Case Study Beta (β) Calculation Results

Desirable Range: 0 < β < 1

β = 0

Activities move independently from their projects, which is unlikely, or planned and actual values are identical.
Conclusion

Schedule Beta ($\beta$) can be used to benchmark subcontractor performance and aid in the selection of which ones to use, given the specific project parameters, goals, and needs.
Conclusion

AND,

As developed, Schedule Beta may not be limited to the Construction Industry. . . All that is needed is a group of schedule participants and a correlating group of projects.
Next Steps

• ASTM Standard (American Society for Testing and Materials)
  – Draft Standard accepted for consideration by E06.81 Subcommittee on Building Economics
  – External Review Committee / Advisor engaged

It will become an industry standard if adopted by ASTM
Additional Topics / Questions

• Inclusion of Separate Positive and Negative Schedule Beta Values
  – Question Answered: Does a single Schedule Beta value accurately depict duration deltas? Separate Positive / Negative Betas may lead to more detailed values – depicts magnitude of proclivity to perform ahead of as-planned versus proclivity to perform behind as-planned, not a blended value.

• Case Study across a Single Discipline or Trade
  – Question Answered: What are the Schedule Beta values expected? Do they differ by trade, position in project (early, late, long, short, etc.)
Questions

$\beta \ ?s$