Project Risk Quantification: A Practitioner’s Guide to Realistic Cost and Schedule Risk Management

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Experience
- Owner, Validation Estimating LLC since 2005. I help owner companies improve their Cost Engineering capabilities including PRQ
- 38 years experience for owner, contractor and benchmarking firms in the process industries (oil, gas, chemicals, mining, metals, power, etc.)

AACE International
- AACE: Fellow, Life Member, Award of Merit, Past Director
- Led development of the AACE Decision and Risk Management Professional (DRMP) certification and related technical content

Book Author
- Total Cost Management Framework (lead author/editor, AACE, 2006)

Education
- BS Mining Engineering and Masters in Business Administration
“Project Risk Quantification”

- This presentation is based on *Project Risk Quantification: A Practitioner’s Guide to Realistic Cost and Schedule Risk Management*,
- Fresh off the press from *Probabilistic Publishing* • www.decisions-books.com
- Most of the images in this presentation are from the book
Presentation Introduction

- Project investment decisions depend on effective project cost and schedule risk quantification (PRQ)
  - Review the challenging situations that PRQ methods must model and the failure of common PRQ methods to do so
- PRQ must be realistic, practical and integrated
  - Present “Methods That Work”
  - Discuss methods those that do not and why
- Present the Top Ten Reasons Risk Quantification Fails
What is Project Risk Quantification (PRQ)

- Probabilistic estimation of the impact of identified risks
- Key step in the overall project risk management process; comes to the forefront at the decision gate
- Combines estimating with planning and scheduling in probabilistic, integrated *modeling* approaches
- Provides the basis (distributions with causal info) for incorporating risk in project plans and budgets
- Provides capital cost (capex) and project duration (start of revenue) inputs to NPV analysis
PRQ “Methods That Work”

Criteria

• **Realistic**
  • Backed by **historical data analysis**; you can prove that it works (the *Janus* meme reflects the view to the past and future)

• **Practical**
  • Apply to **every project**; simple or complex, large and small, conceptual or detailed, good or bad quality planning
  • Can be done **in-house** every day; no special software (other than Excel and an MCS add-on) and no consultants needed other than for the *outside view* for strategic projects

• **Integrated**
  • Addresses all risk types and considers cost and schedule together (trade-off)
Methods That Work

- This is the recommended PRQ process we will cover
  - Empirically valid
  - Models optimized for each risk type and planning need
  - All risks are covered in a stepped approach
  - Supports NPV modeling
- But first let’s review the challenges that these models address
Challenge #1: Underestimation by 2-3x Factor for Large Projects

- The high end (i.e., p90) of actual cost outcomes are 2x to 3x what we are forecasting for large projects.
Example of the 2-3x Factor

- Figure overlays RP18R-97 range-of-ranges (shaded bands) with the findings of a study of hydropower projects (boxes and dashed lines).
- The actual high end overrun is 2 to 3X the AACE “expected” accuracy.
- Contingency under estimation bias is evident in every empirical study examined.

Figure 4.3: AACE Range-of-Ranges (18R-97) vs. Hydropower Project Study (2014)

Challenge #2: Overestimation on Small Projects

- Underruns are significant (long tail on the low side)
  - Underruns can be OK because it means that the team returned the unused funds, but it also means over-estimation bias and less than ideal capital management
- Few projects overrun by more than 10%
Challenge #3: Underestimation of Escalation (2-3x in Volatile Times)

- This chart compares the IHS CERA Downstream cost index (DCCI) with the Chemical Engineering Plant Cost Index (CEPCI) and the US Consumer Price Index (inflation).
- Most companies use inflation or something near CEPCI
- Again, actual escalation is **2-3X** our estimates
- Worse still, it can be the most costly risk but almost **nobody** estimates it probabilistically
Challenge #4: Failure to Recognize Complexity Risks (non-linear)

- Complexity is the latest “buzz” word, but few make any practical attempt to either measure it or quantify it.
- The impact of weak systems + complexity + stressors is often disorder; a “blowout” with labor cost overruns of 50 to 200%.
- We can model it well enough to provide at least a warning of its encroachment.
Challenge #5: Cost/Schedule Trading and Risk Responses Not Considered

- We are focusing on risks that do not matter
- For those risks that do matter ("critical" risks), we fail to consider and model our risk responses (i.e., what will we do if the risk happens?)
- Risk response analysis requires understanding of the project cost-schedule strategy; i.e., are we willing to trade cost for schedule? — Few ask this question.
  - Is impact fast and expensive (schedule-driven) or slow and cheap (cost-driven)?; In reality, cost growth is much greater than schedule slip, in large part due to trading
Challenge #6: The Most Common Method (Line-Item Ranging or LIR) Does Not Work

- In LIR, the team takes their estimate, assigns ranges to the line-items and runs Monte Carlo Simulation (MCS)

- Research findings:
  - “…contingency estimates are, on average, getting further from the actual contingency required.”
  - “This result is especially surprising considering that the percentage of projects using more sophisticated approaches to contingency setting has been increasing.”
  - For projects with poor scope definition the common approaches were “a disaster”
  - At best, LIR covers “estimating (or scheduling) uncertainty” which is a relatively minor risk at sanction

* Juntima and Burroughs, “Exploring Techniques for Contingency Setting”, 2004 AACE Transactions
Challenge #7; CPM Methods Are Highly Problematic

- CPM Challenges
  - Quality
    - Our CPM schedules are of poor quality; one study showed only 13% were suitable as a modeling basis for risk analysis *
  - Applicability
    - CPM network models are Static, but risks are Dynamic
    - one must use branching to be realistic, but that is often not practical
    - In early phases, there is no CPM schedule, and at later phases it is often not ready for analysis (e.g., lack of integration)
  - Difficult to address cost/schedule trading (no delay but high cost)
  - Expertise required (and time) is in very short supply

- If all of the above are dealt with (e.g., strategic projects), CPM can add value if integrated with parametric models for systemic risk

* Griffith, Andrew, “Scheduling Practices and Project Success”, AACE Transactions, 2005
Methods That Work
Start with a Robust Risk Management Process (e.g., AACE TCM 7.6)

TCM is unique in that it explicitly addresses **Risk Quantification** by recycling residual risks through Assessment at the Decision Gates.
1-Parametric Model for Systemic Risks

- The first analysis step is to quantify **systemic** risks using an empirically-based parametric model.
- **Systemic risks** = artifacts of the project system, technology, complexity, teams, etc.
- AACE RPs 42 & 43R-08
Example Model Applications from the Book (also, RP 43R-08 has working Rand & Hackney Models)

<table>
<thead>
<tr>
<th>Risk Driver</th>
<th>Parameter (a)</th>
<th>Coefficient (b)</th>
<th>a x b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>3</td>
<td>-30.5</td>
<td></td>
</tr>
<tr>
<td>Scope</td>
<td>3</td>
<td>9.8</td>
<td>32.3</td>
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<tr>
<td>Planning</td>
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<td>0.12</td>
<td>0.60</td>
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<tr>
<td>Engineering</td>
<td>3</td>
<td>1.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Scope Definition</td>
<td>3.3</td>
<td>9.8</td>
<td>32.3</td>
</tr>
<tr>
<td>New Technology</td>
<td>5%</td>
<td>0.12</td>
<td>0.60</td>
</tr>
<tr>
<td>Process Severity</td>
<td>3</td>
<td>1.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Complexity</td>
<td>5</td>
<td>1.2</td>
<td>6.0</td>
</tr>
<tr>
<td>Subtotal Base (prior to adjustments)</td>
<td>11.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Cost**

**Execution Schedule Duration**

<table>
<thead>
<tr>
<th>Risk Driver</th>
<th>Parameter (a)</th>
<th>Coefficient (b)</th>
<th>a x b</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td></td>
<td></td>
<td>-23.5</td>
</tr>
<tr>
<td>Scope Definition</td>
<td>Average 3.3</td>
<td>9.6</td>
<td>31.7</td>
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<tr>
<td>New Technology</td>
<td>5%</td>
<td>0.10</td>
<td>0.5</td>
</tr>
<tr>
<td>Process Severity</td>
<td>3</td>
<td>0.50</td>
<td>1.5</td>
</tr>
<tr>
<td>Complexity</td>
<td>5</td>
<td>0.50</td>
<td>2.5</td>
</tr>
<tr>
<td>Subtotal Base (prior to adjustments)</td>
<td>12.7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ADJUSTMENTS**

| Schedule Basis | Good | 0 |
| TOTAL BASE (prior to bias adjustment; rounded to whole number) | 13 |
| Bias | Low | +3 |

**Systemic Execution Schedule Duration Contingency**

| Mean | 13 + 3 | 16% |
| p10  | 10 x (-0.2) + 3 | 0%  |
| p70 (indicated funding) | 25 x 1.5 + 5 | 43% |
| p90  | 25 x 2.6 + 5 | 72% |

Attendees will be sent a link and password to access an Excel version of these models
Next, quantify project-specific risks using Expected Value with MCS (CPM for strategic projects)

- **Project-Specific = critical risk events and uncertainty of conditions**

- AACE RP 65R-11
Parametric and Expected Value Methods Are Used Together

The Parametric Tool Output is Risk #1 in the Expected Value tool
Option: CPM Modeling Incorporating Outcome of Systemic/Parametric Model

- Strategic projects at sanction often to have the money, time and expertise to do quality CPM modeling
- To use CPM + Parametrics, start with AACE RP 57R-09 and instead of quantifying “uncertainties”, apply a parametric model to address systemic risks as a buffer at the end

<table>
<thead>
<tr>
<th>ID</th>
<th>Description</th>
<th>Remaining Duration</th>
<th>Start</th>
<th>Finish</th>
<th>Cost</th>
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<tr>
<td>0050</td>
<td>Commissioning</td>
<td>100</td>
<td>20-Jan-13</td>
<td>29-Apr-13</td>
<td>$16,500</td>
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<tr>
<td>0060</td>
<td>Project Turnover</td>
<td>0</td>
<td></td>
<td>29-Apr-13</td>
<td>$0</td>
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<tr>
<td></td>
<td>Systemic Risk</td>
<td>30</td>
<td>29-Apr-13</td>
<td>29-May-13</td>
<td>$3,000</td>
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<tr>
<td>0080</td>
<td>Final Completion</td>
<td>0</td>
<td></td>
<td>29-May-13</td>
<td>$0</td>
</tr>
</tbody>
</table>
3-Escalation/Exchange Estimating with MCS

- The next step is to quantify *escalation* and *exchange* risks by applying MCS to the deterministic model.
- Base cost and schedule uncertainty are included as inputs to this step.
- Therefore, output covers ALL capex risk.
- AACE RP 68R-11
Escalation

- Changes in price levels driven by economic conditions
- Includes economic conditions that prevail in your micro-economy (e.g., power) such as:
  - Industry productivity and technology
  - Industry and regional market conditions (demand, labor shortages, margins, etc.)
- Includes, but differs from inflation which is caused by debasement of a currency
- Varies for different cost items, regions, procurement strategy, etc.
The next step is to quantify additional program level risks (interaction risks).
This involves making a program level analysis “pass” of the systemic and project-specific risks.
Program Level Analysis Flowchart

- Separate but cumulative analysis of systemic and project specific risk analyses
- Focused on commonalities and interaction risks as well as added complexity
5-Portfolio Level Analysis

- The next step is to quantify additional portfolio level risks.
- This is similar to a program level analysis “pass”.
- An added risk is “management by cashflow”
6-Complexity (Tipping Point) Analysis

- Complexity and the stress of a weak system and accumulated risks can push a project into disorderly behavior (a blowout)
- Complexity/stressors are measured and the impact quantified as a warning
The Tipping Point Indicator

- Warns management that the project may be approaching a blowout
- Contingency values do not tell the potential disaster story...a wake-up call is needed! For example....

<table>
<thead>
<tr>
<th>Complexity/Stress Factors (Tipping Point Factors)</th>
<th>Size</th>
<th>Decisiveness</th>
<th>Team</th>
<th>Aggressiveness</th>
<th>Complexity</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systemic Risk Factors</td>
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</tr>
<tr>
<td>Systemic Risk Indicators</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Project Specific Risks</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OVERALL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

EXPLANATION: The distribution of project cost outcomes is bimodal or discontinuous. At some point, certain risks may push a project into a chaotic regime with significantly worse outcomes than forecast. The factors above represent complexity/stressor risks associated with the "tipping point" into chaotic, unpredictable behavior. The base contingency model does not cover chaotic outcomes; the potential occurrence if such outcomes is flagged by this indicator.
Use #1- Support Decision Analysis

- Decision Analysis requires integrated inputs for CAPEX risks
- Create a single CAPEX cost distribution plus an integrated schedule distribution (NPV is highly sensitive to the start of revenue stream)
Use #2- Support Planning/Budgeting

- Once the investment decision is made, one must budget and control the approved money and time
- This needs to be done in an integrated, disciplined manner
Closing the Loop - Historical Data

- Historical Data management is required for empirically valid risk quantification
- Also needed to improve the project “system” (the ultimate objective)
Applies to any Industry Construction Related Project for Owners and Contractors

- The book offers published example success stories from an owner and an EPC company
  - For the EPC (see Chapter 8), the method is the basis of hard-money bidding
  - The owner firm has integrated this with in-house estimating (know their bias), and historical data management

- Methods are generically applicable
  - Known users in oil & gas, chemical, mining, pipeline, power, wind, and project financing
  - Chapter 15 of the book benchmarks the method against published accuracy data in multiple industries (e.g., nuclear, transportation, etc.)
Top Ten Reasons Risk Quantification Fails

1) “I want it fast and cheap!”
   • The pressures to complete a project as early as possible and to keep costs low are immense. This results in a bias towards aggressive cost and schedule targets and increases risks that nobody talks about.

2) “If you miss the milestone or overrun >10%, your career is over!”
   • Punitive cultures destroy capital discipline by turning the system into a game with unrealistic budgets and plans that nobody buys into and analyses that nobody believes in.

3) “My projects never overrun…oh, that one was an exception!”
   • Most companies have a total lack of project history to realistically judge the risk; everything is based on selective memory that differs markedly from reality (most large projects overrun, and the average is over budget by 20%).

4) “If you were a better estimator, the range would be +/-10%”
   • Other than some minor uncertainty resulting from the estimating process, the estimator has little to no influence on or control of the range.

5) “The more rigorous the model, the better the analysis will be”
   • Many become enamored with methodological elegance, complexity, and/or arcane statistics. However, they never ask “does it work!”
Top Ten Reasons Risk Quantification Fails

6) “Let the contractors do it; they are the experts!”
   • EPC contractors simply do not have the empirical knowledge or incentive to perform valid cost and schedule risk quantification for owners.

7) “It’s Lump Sum; therefore, this is all the contractor’s risk”
   • Lump Sum only transfers a nominal portion of the risk to the contractors; e.g., about 10-20% is locked in; after that, owners tend to pay anyway.

8) “Escalation is Inflation (just ask Finance)”
   • Finance departments insist that project teams fund “escalation” using their internal “inflation” guidelines; inflation is often only a fraction of escalation (also few companies estimate escalation probabilistically)

9) “The Standards say so; what more is there to talk about?”
   • There are no industry accuracy standards. Once a company sets pre-determined ranges as policy, meaningful discussion about risk ends.

10) “You talkin’ to me?"
    • The greatest project risks belong to the business! “Systemic” risks (immature project systems, indecisiveness, poor communication, weak skills, etc.) are what kill projects and Senior Management are the risk owners, not teams.
Presentation Summary

- Reviewed the challenging situations (reality) that PRQ methods must model and the failure of common methods to do so
- Reviewed PRQ criteria for “Methods That Work” (realistic, practical and integrated) and summarized a step-by-step integrated approach that meets the criteria
- Presented the Top Ten Reasons Risk Quantification Fails
- I hope you can see how these PRQ methods support effective project decision analysis and planning and project system improvement in general!
Thank You!
Contact:
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