Prospective R&D Portfolio Evaluation: How is a Portfolio More Than an Aggregation of Projects?

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Scope

- Prospective, ex-ante, analysis of R&D investments
- Focus on applied research with clear connection to commercial application

Givens

- With R&D, must consider both return and risk
- Returns may not be additive (complements, substitutes)
- Because fluctuations in returns at project level at least partially offset, risk is never additive
R&D Projects as Real Options

- Payoffs to R&D projects don’t resemble typical financial investments with (roughly) symmetric risk
- Risk aggregation not readily amenable to closed form solutions
Moving Forward

- How to prospectively assess risk and return?
  - This Study: Portfolio Simulation
  - Point of departure = 2006 NRC Report

- Developed, applied method for ex-ante, project-level, analysis of R&D impact:
  - Incremental energy cost savings, net of implementation cost
  - Weighted by probabilities of technical, commercial success

- My Focus: 19 Chemical Industrial Technology R&D Projects ($67.54m)
2006 NRC Study: Two Concerns

- Forecast Annual Energy Prices: 2003-2030
  - Point estimates, no uncertainty
    - Discounted Cash Flow (DCF), not Real Option, method
  - Energy prices, \( p(\text{commercial success}) \) not linked

- Portfolio Characterization
  - Assumed return additivity
    - Expected value = $534m
  - Terse risk characterization
    - Ignored project correlations
Methodology: Portfolio Simulation

- Monte Carlo simulation of portfolio
  - 250,000 iterations
  - Energy prices (& project benefits) vary stochastically
  - Each project treated as real option
  - Output: Distribution of potential portfolio values

- Probability of technical failure for each project
  - Estimated by NRC Panel
  - Range: 32%-90%; Mean: 69%
Methodology: Project Relationships

- 171 inter-dependencies analyzed by Chemical PE

Technical Relationships during R&D:
- 16 Relationships Identified
- Positive/Negative → High/Moderate/Weak

Commercial Relationships if R&D successful:
- Complements/Substitutes → Strong/Moderate/Weak
- 6 Complements Identified; 3 Substitutes Identified
Methodology: Deep Correlations

- Two Projects
  - P2: Millisecond Oxidation of Alkanes
  - P14: Integrated Distillation w Micro-channel Tech

- Interdependencies
  - Technical Relationship: “No Correlation”
  - Commercial Relationship: “Independent”

- P2 & P14: all benefits from natural gas savings
Methodology: Definitions of Risk

- Traditional: Standard deviation of likely portfolio values
- Tassey: Risk = p(failure to achieve hurdle rate)
  - Breakeven: $67.54 million
  - Corporate R&D Hurdle (25%*): $241.40 million
  - Public Social Rate of Return (50%*): $543.14 million

* Nominal Return
Results: NRC/DCF vs. Real Option Method

<table>
<thead>
<tr>
<th>Statistic</th>
<th>NRC/DCF Method</th>
<th>Real Option Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ($m)</td>
<td>$570.9</td>
<td>$1,405.8</td>
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<tr>
<td>Standard Deviation</td>
<td>$750.7</td>
<td>$1,980.8</td>
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<tr>
<td>Coefficient of Variability</td>
<td>1.31</td>
<td>1.41</td>
</tr>
<tr>
<td>Prob(Portfolio Value &lt; $67.54m)</td>
<td>31.6%</td>
<td>6.0%</td>
</tr>
<tr>
<td>Prob(Portfolio Value &lt; $241.40m)</td>
<td>53.7%</td>
<td>18.2%</td>
</tr>
<tr>
<td>Prob(Portfolio Value &lt; $543.14m)</td>
<td>70.3%</td>
<td>40.4%</td>
</tr>
</tbody>
</table>

Portfolio Value ($M)
Results: Effect of Project Relationships

<table>
<thead>
<tr>
<th>Statistic</th>
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<th>W/O Corrs</th>
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<tbody>
<tr>
<td>Mean</td>
<td>$1,405.8</td>
<td>$1,367.4</td>
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Conclusions

- Real option method yields significantly different results than standard DCF method (best practice)
- Project interdependencies have profound effect on portfolio risk, and potentially, on return
- "Deep correlations" may exist because portfolio value influenced by underlying third variable(s)
- Because we care about risk and return, we are compelled to do portfolio analysis
- This study demonstrates that doing so is feasible
Thanks!

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