OR and Risk Management Failures: What are we doing wrong?

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Background

• Two implementations:
  • NBA scheduling (Bean, JRB 1980)
  • Michigan State Senate (JRB 1983)

Lesson: Know who makes the decisions and what her/his objective is

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3 Events

Financial Crisis  Oil Spill  Volcanic Eruption

Did risk management and OR fail in these crises?
If so, why and how can we do better?

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Theme

• There is a plenty of blame to go around in each crisis

• OR shares some blame but...
  – problems are mostly by viewing decisions from the wrong perspective
  – we can improve the value of models by recognizing decision-makers’ self-interested behavior and designing policies with consistent incentives
The Financial Crisis: How bad?
Worst crisis since…?
Relative Dow Jones IA over 2 years:

Which line is from 1929-1931 and which is from 2007-2009?
Only the losses in the Great Depression rivaled the loss in equity value during the current crisis.

DJIA from 10/2007 to 3/2009: -52%

Worst all-time 17 months: (1/1931 to 6/1932): -75%

Down Across Sectors

Financial Assets - U.S. Households and Non-Profit Organizations ($ Trillions)

Net Worth – U.S. Households and Non-Profit Organizations ($ Trillions)

Corporate Equities (Stocks) Held by U.S. Households and Non-Profit Organizations Market Value ($ Trillions)

U.S. Household Real Estate ($ Trillions - Bars/Left Axis) And Owners Equity as % Real Estate Value (Right Axis/Line)

Source Data: Federal Reserve Flow of Funds Report Q1 2009

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One Part of the Crisis: AIG

AIG: Insurer that became “too big to fail”
- Losses and connections to multiple counterparties brought the financial sector close to brink of collapse
- Sophisticated risk management practices in place
- What went wrong?
# AIG's Income Statement

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>Revenues</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Insurance</td>
<td>$ 35,854</td>
<td>$ 51,708</td>
<td>$ 49,206</td>
<td>$ 45,174</td>
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<tr>
<td>Life Insurance &amp; Retirement</td>
<td>14,271</td>
<td>53,570</td>
<td>50,878</td>
<td>48,020</td>
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<tr>
<td>Financial Services</td>
<td>(16,016)</td>
<td>(1,309)</td>
<td>7,777</td>
<td>10,677</td>
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<tr>
<td>Asset Management</td>
<td>658</td>
<td>5,625</td>
<td>4,543</td>
<td>4,582</td>
</tr>
<tr>
<td>Other</td>
<td>531</td>
<td>457</td>
<td>483</td>
<td>344</td>
</tr>
<tr>
<td>Consolidation &amp; Eliminations</td>
<td>(436)</td>
<td>13</td>
<td>500</td>
<td>(16)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$ 34,862</td>
<td>$110,064</td>
<td>$113,387</td>
<td>$108,781</td>
</tr>
<tr>
<td><strong>Operating Income (Loss)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Insurance</td>
<td>(393)</td>
<td>$ 10,562</td>
<td>$ 10,412</td>
<td>$ 2,315</td>
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<tr>
<td>Life Insurance &amp; Retirement</td>
<td>(19,561)</td>
<td>8,186</td>
<td>10,121</td>
<td>8,965</td>
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<tr>
<td>Financial Services</td>
<td>(22,880)</td>
<td>(9,515)</td>
<td>383</td>
<td>4,424</td>
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<tr>
<td>Asset Management</td>
<td>(2,709)</td>
<td>1,164</td>
<td>1,538</td>
<td>1,963</td>
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<tr>
<td>Other</td>
<td>(2,899)</td>
<td>(2,140)</td>
<td>(1,435)</td>
<td>(2,765)</td>
</tr>
<tr>
<td>Consolidation &amp; Eliminations</td>
<td>237</td>
<td>722</td>
<td>668</td>
<td>311</td>
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<tr>
<td><strong>Total</strong></td>
<td>(48,205)</td>
<td>$ 8,943</td>
<td>$ 21,687</td>
<td>$ 15,213</td>
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</tbody>
</table>

CDS Insurance – AIG story

• Credit Default Swaps (CDSs) protect against default on underlying securities
• AIG sold $526 billion in CDSs
• Many at AAA level (1 in 10,000 default odds?)
• Problems? Large collateral requirement changes (+$6B in one month out of $18B for all uses)
Collateral Requirement

- Consider $562 billion in protected debt
- Chance of default each security is 1/10000
- On any single security, collateral is 10 times the premium (or about 0.1% of notional amount)
- Total collateral required: ~$600 million
- If $562 billion is composed of ~3000 independent securities, chance of loss>$600 million is very small but …
Expected Loss and Collateral Changes

• What happens to expected loss if all the securities are actually linked (i.e., correlation from 0 to 1)?
  - Expected Loss: <$1 million => $60 million

• But, AIG still has $600 million in collateral, so what is the problem?

• What happens to collateral if correlation is high and all downgraded (AAA to A: 0.01% to 0.1%)
  - Collateral up 10 times: $600 million => $6 billion
Problems for AIG

• Collateral requirement in the event of a downgrade can bring ruin
• Chance of downgrade if systemic (highly correlated) is ~ 1/10
• If AIG knew this, should they have sold $562 billion in CDS’s?
Decision Tree for AIG Shares

Best decision:
Do not issue more CDSs
Expected share value up $10
Did they just not do the analysis?
If not, then what could have happened?

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AIG Decision Structure

- Traders with bonus compensation to improve share price
- Relatively small movement in the share price can yield large increases in compensation
- Low downside risk due to severance terms
Decision Tree for AIG Trader

Sell more CDSs

Hold CDS issues

Best decision: Issue more CDSs

Expected comp +$85MM

All the analysis could have been correct – just with a different form of payoff.

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Deepwater Horizon Oil Spill

Was the likelihood of a spill miscalculated? Was this a case of misapplied OR?
Causes and Chances

• Many potential causes and missed opportunities
• Water depth and experience at depth may have increased chances for failures
• Blowout preventer (blind shear ram) installed to shear and seal pipe in event of leak
• One blowout preventer installed but not two – a mistake in assessment?
BP Analysis

• Decision tree appears to indicate it is best for BP to install 2 BOPs
• Did BP just get the probabilities wrong?
• Again, what is decisions are in the interest of the managing executives?
• What is their decision tree?
Decision Tree for BP Exec

Install 2 BOPs

Install 1 BOP

$141.5MM

$94.97MM

0.1

$49.7MM

0.99

$20MM

$50MM

$100MM

$65MM

0.1

$20MM

$70MM

$150MM

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Effect of Different Perspective

• Exec’s losses are again limited on the downside
• Early completion as well as revenues leads to early share improvement and bonus compensation
• Even with best knowledge of probabilities, decisions might have been the same
Eyjafjallajökull Volcano

- European airspace closed for 6 days
- Losses focused on airlines - estimated at $2 billion
- Did the EU properly assess the total risk cost?
Decision Tree for EU

Best decision: Leave airspace open?

Right problem?
Decision Tree for EU Transport Commissioner

Best decision:
Close airspace
(even with very low probabilities)

Right problem?
Problems with Original Analysis

• Focus on the overall organization or broad constituency
• Actual decision-makers may have much narrower interest
• Misalignment of incentives can lead to very different results even if all the analysis is correct
What’s an OR analyst to do?

• Recognize the situation
• Model the decision-maker’s self interest
• Show how to construct systems that align incentives at the outset (form of mechanism design)
• Combine incentive design with analysis of alternatives
Examples for Crises

- **AIG Trader:**
  - Align compensation with the effect on shareholders
  - Delay compensation until outcomes of decisions are known (e.g., maturity of CDSs)
  - Include claw-back types of provisions
AIG Decision Tree - Adjusted

Sell more CDSs

+$98MM

0.9

+$110MM

- $10MM

+$100MM

Hold CDS issues

+$100MM

Best decision:
Hold on CDSs
Expected comp +$100MM

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Oil Spill and Volcano

• BP Compensation
  • Align with value of project
  • Defer compensation
  • Claw-back if unreasonable risk

• EU Transport
  • Align with value to industry
  • Penalty for losses?
Other Contexts

• Are managers’ ordering decisions always in best interest of the firm?
• Are hospital inefficiencies due to inadequate capabilities (or deliberate)?
• Why are many risky investment decisions taken?
• Why are many risk investment decisions not taken?
General Risk Management Solutions

- Alternatives (AIG):
  - Economic capital:
    - Capital retained to cover losses
    - Similar to the collateral they were obligated
    - Effect in risk management? (No)
  - Modified payoff (as in decision tree)
    - Can make firm-optimal individually rational (and incentive compatible)
    - Idea: design payoffs to provide incentives for effective risk management throughout organization

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Change of Paradigm

• Old Paradigm:
Choose Capital C, decisions u (states x) to:
Maximize $\mathbb{E}(f(x,u))$ (-Risk-adjusted, sequential: $x=(x_1,\ldots,x_T)$, $u=(u_1,\ldots,u_T)$)
s.t. $\text{Risk}(x,u) - C \leq 0$

• New Paradigm:
Choose payoffs P, managers pick u to:
Maximize $\mathbb{E}(f(x^*,u^*))$ s.t.
$\mathbb{E}(g(x^*,u^*,P)) \geq \mathbb{E}(g(x,u,P))$, $\mathbb{E}(g(x^*,u^*,P)) \geq 0$

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Shift of Viewpoint

• Single objective dynamic optimization to dynamic mechanism design
• Challenges:
  - Computational (problems already hard)
  - Ensuring incentive compatibility and individual rationality
  - Enforceability
Other Contexts

• Are managers’ ordering decisions always in best interest of the firm?
• Are (e.g., health care, government) inefficiencies due to inadequate capabilities (or deliberate)?
• Why are many risky investment decisions taken?
• Why are many risk investment decisions not taken?
Change of View

• If systems do not work as we feel they should, perhaps decision-makers are just using a different objective?

• We can use OR to find the objective that decision-makers actually use and not just to tell them what they are doing wrong

• Once we understand their objectives, then we can try to design policies to align with overall goals
Conclusions

- Recent crises and reactions to them may not have been examples of improper analysis
- Decisions may have been rational consequences of self-interested behavior
- We should model (and accept) such behavior but also design better systems to make that behavior align with overall goals for firms and society
- Need to change to consider all agent reactions requires better models, analysis, implementation, and continuous learning
- We can all contribute to this and use ORMS to avoid the next great crisis or recover more effectively from it
Thank you!

Questions?