Making Decisions in the Face of Risk and Uncertainty

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Information, Risk and Operations Management
The University of Texas at Austin

Case Study in the Oil Industry
Session Objectives

- State of the IOCs
- Eating Cookies
- What Drives Share Price?
- Long-Term Investment Decisions
- Implications of Risk and Uncertainty
- ‘Risk and Uncertainty Scribbletron’
- Our Tools Break Down
- Deterministic vs Probabilistic Analysis
- Hypothesis Testing
18 Month Share Price History

18 Month

02/22/16
107.50
105.00
102.50
100.00
97.50
95.00
92.50
90.00
87.50
85.00
82.50
80.00
77.50
75.00
72.50
70.00
67.50
65.00
62.50
60.00
57.50
55.00
52.50
50.00
47.50
45.00
42.50

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3
### Quarterly Performance (YoY)

<table>
<thead>
<tr>
<th>TICKER</th>
<th>NET INCOME Adj</th>
<th>%change YoY</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVX</td>
<td>512</td>
<td>-85.25%</td>
</tr>
<tr>
<td>BP</td>
<td>196</td>
<td>-91.25%</td>
</tr>
<tr>
<td>XOM</td>
<td>2,780</td>
<td>-57.69%</td>
</tr>
<tr>
<td>RDS.A</td>
<td>1,825</td>
<td>-44.05%</td>
</tr>
</tbody>
</table>

**Figures in million US$**
# Share Price ending 5 Feb 2016

<table>
<thead>
<tr>
<th>TICKER</th>
<th>5-Day</th>
<th>7-Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVX</td>
<td>-2.83%</td>
<td>-3.54%</td>
</tr>
<tr>
<td>XOM</td>
<td>4.97%</td>
<td>4.01%</td>
</tr>
<tr>
<td>BP</td>
<td>-3.91%</td>
<td>-4.48%</td>
</tr>
<tr>
<td>RDS.A</td>
<td>3.00%</td>
<td>3.12%</td>
</tr>
<tr>
<td>WTI</td>
<td>-2.31%</td>
<td>-7.01%</td>
</tr>
</tbody>
</table>
Cash Flow

ExxonMobil

Royal Dutch Shell

Source: Bloomberg
Break-Even Oil Price Required in 2016

Source: Bloomberg
Why do you try to eat every cookie on the shelf?  
XOM Executive to RDS Executive

Why do pass by all of the cookies on the shelf?  
RDS Executive’s Retort

Corporate culture eats strategy for breakfast…  
Origins Unknown
Expectations of ‘Wall Street’

IOCs evaluated based on expectations of future cash flows:

- Assets
- Operating Profits
- Global Energy Markets
- Risk Assessments

Challenging strategic environment...
Most important asset is *proved reserves*

ExxonMobil 2010:
- Reserves replacement at 209% of production
- 17 consecutive years > 100%
- “Leads the industry”

Be careful – look beyond the headlines…

*Liquids (10 year average) is only at 95%*
Risk and Reward

Indicative Asset Volatility Over Recent 2-5 Yr Period

<table>
<thead>
<tr>
<th>Sector</th>
<th>Ann Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Pipelines</td>
<td>6-7%</td>
</tr>
<tr>
<td>Ref &amp; Mktg</td>
<td>12-14%</td>
</tr>
<tr>
<td>Integrated O&amp;G</td>
<td>~14%</td>
</tr>
<tr>
<td>E&amp;P Only</td>
<td>14-18%</td>
</tr>
<tr>
<td>Oil Services</td>
<td>~22%</td>
</tr>
</tbody>
</table>

Source: SalomonSmithBarney
Delicate Balance

Strategic concerns for large IOCs:

- Limited access to conventional (liquid) reserves
- Increasing reliance on unconventional resources
- Materiality and commerciality of new resources
- Upside (potentially) constrained by new agreements
- Downside (potentially) unlimited due to legal liability
Moving Target

An 'Evolving Bargain' – Rules of the game for IOCs can be a moving target

Political

Legal

Policy

Market Design

Regulatory

Institutional & Professional Infrastructure (ability to implement)

*Sourcing from Emmons, The Evolving Bargain, 2000, HBS Press

Courtesy: UT Center for Energy Economics
Revenue Streams
At any point in time, is this a point or a distribution?
CAPEX (capital expenditures)
OPEX (operating expenditures)
Cash Flows
Profitability Indicators (ROA, NPV, Ultimate Cash Surplus)

Sensitivity Analysis
Expenditures

Asset CAPEX and OPEX Expenditures

Years

$0

($50)

($100)

($150)

($200)

($250)

CAPEX (NOM)  OPEX (NOM)
Revenues

Asset Revenue Stream

Revenues (NOM)

Years

$0

$50

$100

$150

$200

$250

$300

$350

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Nominal Net Cash Flow

[Graph showingNominal Net Cash Flow with the years from 2016 to 2025 on the x-axis and Cash Flow in $MM on the y-axis. The graph includes bars for CAPEX (NOM), OPEX (NOM), and Revenue (NOM) along with a line for Net Cash Flow (NOM).]
Discounted Cash Flows

<table>
<thead>
<tr>
<th>Inflation Rate</th>
<th>3.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount Factor</td>
<td>8.00%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total CAPEX</th>
<th>$ (815)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total OPEX</td>
<td>$ (857)</td>
</tr>
<tr>
<td>Total Production</td>
<td>54,020,000</td>
</tr>
<tr>
<td>Screening Price</td>
<td>$70.00</td>
</tr>
<tr>
<td>Total Revenue</td>
<td>$ 4,322</td>
</tr>
</tbody>
</table>

![Graph showing discounted cash flows with Net Cash Flow (NOM), Cash Flow (RT), and Net Cash Flow (Disc) over time.](image)
Fundamental Economic Metrics

There are a number of key economic metrics typically used for projects, and they all consider inflation and the cost of capital:

1. **Ultimate Cash Surplus** – the Expected NPV of the cash flow, after both inflation and investor discount…

2. **Return on (Capital) Assets (ROA)** – the Ultimate Cash Surplus divided by the Expected NPV of the CAPEX expenditures. This is similar to the ROI calculation (non-normalized) used by other capital intensive industries…

3. **Internal Rate of Return (IRR)** – the investor discount rate, after inflation, such that Ultimate Cash Surplus = 0

4. **Breakeven Price at X%** – the price required to provide an IRR of X%

5. **Payback Period** – year in which Ultimate Cash Surplus first reaches 0

6. **Exposure** – maximum depth of cash sink (real terms, including inflation but not investor discount rate)

Economic evaluation is extremely complex and relies heavily on experience and judgment…
Economic Evaluation

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflation Rate</td>
<td>3.00%</td>
</tr>
<tr>
<td>Discount Factor</td>
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<td>$70.00</td>
</tr>
<tr>
<td>Total Revenue</td>
<td>$4,322</td>
</tr>
<tr>
<td>NPV Cash Surplus</td>
<td>$370.7</td>
</tr>
<tr>
<td>NPV CAPEX</td>
<td>$(519.0)</td>
</tr>
<tr>
<td>ROIC</td>
<td>0.714</td>
</tr>
<tr>
<td>IRR</td>
<td>19.5%</td>
</tr>
<tr>
<td>Breakeven at 20%</td>
<td>$80.45</td>
</tr>
<tr>
<td>Payback</td>
<td>12</td>
</tr>
<tr>
<td>Exposure</td>
<td>$(541)</td>
</tr>
</tbody>
</table>

Graph showing Net Cash Flow (NOM), Cash Flow (RT), and Net Cash Flow (Disc) over time.
Dealing with Uncertainty

The project’s profitability, like its cost, is not a point – it is a range estimate. So, vary the parameters in your analysis...

Specifically:
- Ask “what if” questions.
- Test robustness against changes in assumptions.
- Identify critical assumptions.
- Analyze the impact of the variations on project economics.

Can we live with the results???
Does this Process ‘Work’?

- How to deal with wide ranges in outcomes?
- How to address ‘riskiness’ of large capital projects with very long timelines?
  - Risk adjusted discount rate?
  - Risk adjusted costs and timing?
  - Scenario analysis?
  - Decision tree ‘Expected Outcome’?
- What to do about low probability but very high impact (Black Swan) risks?
- Are there SOX implications with reporting capital investment decisions?
Making “Risky” Decisions

The Lottery
1,000,000 tickets sold, 1 winning ticket
You pay $1.00 for a ticket
Winning ticket is worth $1,000,000
Do you play?

A Game of Chance
6 sided dice
$100,000 if you roll a 5
$50,000 if you roll an even number
$0 otherwise
What would you pay to play?
Back to Risk and Reward…

- What is the risk?

Low probability, high impact risks create huge financial challenges…

- What is the reward?
‘Black Swans’

Black Swans: low-probability, high-impact risk events

- Lies outside the realm of “realistic” expectations
- Carries extreme impact
- Difficult and/or expensive to mitigate
- Systematically excluded from further consideration

Severity Fallacy – the expected value (probability x impact) of a Black Swan risk is not a useful measure of severity

*Only the “house” wins at roulette…*

Risk Manager’s Dilemma – treating Black Swans can be difficult to defend since you either spent money on risks that didn’t occur, or you prevented risks from firing, but no one will ever know

*Engaging in a “no-win” situation…*
Black Swans distort range estimates for cost and schedule

- Project faces either no consequence or full consequence
- Moderately affects the P50 by expected value
- Significantly affects the P90 by almost full value
Cost Estimate Example

<table>
<thead>
<tr>
<th>Detailed Scope List</th>
<th>Variability</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>Estimate</td>
<td>a</td>
</tr>
<tr>
<td>Big Scope 1</td>
<td>$10,000,000</td>
<td>$8,000,000</td>
</tr>
<tr>
<td>Big Scope 2</td>
<td>$8,000,000</td>
<td>$8,000,000</td>
</tr>
<tr>
<td>Big Scope 3</td>
<td>$2,000,000</td>
<td>$2,000,000</td>
</tr>
<tr>
<td>Big Scope 4</td>
<td>$5,000,000</td>
<td>$4,000,000</td>
</tr>
<tr>
<td>Labor</td>
<td>$12,000,000</td>
<td>$9,000,000</td>
</tr>
<tr>
<td>Allowances</td>
<td>$3,000,000</td>
<td>$3,000,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$40,000,000</strong></td>
<td></td>
</tr>
</tbody>
</table>

\[
P_5 \approx 39,689,642 \\
Estimate \approx 40,000,000 \\
P_{50} \approx 43,166,667 \\
P_{95} \approx 46,643,691
\]
Cost Implication of ‘Black Swans’

Consider three risk events with impacts on CAPEX

- Risk 1: 10% probability with $10,000,000 impact
- Risk 2: 20% probability with $5,000,000 impact
- Risk 3: 5% probability with $10,000,000 impact
What Now?

- How do we decide whether or not to invest?
- What ‘number’ or ‘range’ do we report to our shareholders?
- How do we express the ‘riskiness’ of our investment decisions to analysts?

**Will a ‘portfolio approach’ allow use of options theory, or do we need something else...**
Deterministic vs Probabilistic Analysis

- **Deterministic Analysis (ExxonMobil)**
  - Consider major risks and uncertainties, but pick specific scenarios
  - Plan against ‘most likely/reasonable’ scenario
  - Hold specific people accountable for deviations from planned scenario

- **Probabilistic Analysis (Shell)**
  - Allow ranges for inputs to economic analysis
    - Subsurface volumes
    - Development costs and schedules
  - Manage against risks and uncertainties that create extreme positions in the range
  - Collective accountability for range outcomes
Hypothesis Testing

I have come to the conclusion that risky decisions REALLY follow hypothesis testing:

- What is the null hypothesis?
- What will it take to overturn the hypothesis?

ExxonMobil

- Null hypothesis – we will not engage unless we are absolutely certain we can manage the risks
- Veto is possible by any of the company executives

Royal Dutch Shell

- Null hypothesis – we can generally manage the risks and so will engage in any ‘attractive’ opportunities
- Consensus culture requires group majority (or very strongly held position) to overturn null hypothesis