CHAPTER 8

Risk Analysis, Real Options, and Capital Budgeting

http://www2.gsu.edu/~fnccwh/pdf/ch8jaffeo_verview.pdf

Key Concepts and Skills

• Understand and be able to apply scenario and sensitivity analysis
• Understand the various forms of break-even analysis
• Understand Monte Carlo simulation
• Understand the importance of real options in capital budgeting
• Understand decision trees

Chapter Outline

8.1 Sensitivity Analysis, Scenario Analysis, and Break-Even Analysis
8.2 Monte Carlo Simulation
8.3 Real Options
8.4 Decision Trees

8.1 Sensitivity, Scenario, and Break-Even

• Each allows us to look behind the NPV number to see how stable our estimates are.
• When working with spreadsheets, try to build your model so that you can adjust variables in a single cell and have the NPV calculations update accordingly.

Example: Stewart Pharmaceuticals

• Stewart Pharmaceuticals Corporation is considering investing in the development of a drug that cures the common cold.
• A corporate planning group, including representatives from production, marketing, and engineering, has recommended that the firm go ahead with the test and development phase.
• This preliminary phase will last one year and cost $1 billion. Furthermore, the group believes that there is a 60% chance that the tests will prove successful.
• If the initial tests are successful, Stewart Pharmaceuticals can go ahead with full-scale production. This investment phase will cost $1.6 billion. Production will occur over the following 4 years.

NPV Following Successful Test

<table>
<thead>
<tr>
<th>Investment</th>
<th>Year 1</th>
<th>Years 2-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenues</td>
<td>$7,000</td>
<td></td>
</tr>
<tr>
<td>Variable Costs</td>
<td>(3,000)</td>
<td></td>
</tr>
<tr>
<td>Fixed Costs</td>
<td>(1,800)</td>
<td></td>
</tr>
<tr>
<td>Depreciation</td>
<td>(400)</td>
<td></td>
</tr>
<tr>
<td>Pretax profit</td>
<td>$1,800</td>
<td></td>
</tr>
<tr>
<td>Tax (34%)</td>
<td>(612)</td>
<td></td>
</tr>
<tr>
<td>Net Profit</td>
<td>$1,188</td>
<td></td>
</tr>
<tr>
<td>Cash Flow</td>
<td>-$1,300</td>
<td>$1,588</td>
</tr>
</tbody>
</table>

Note that the NPV is calculated as of date 1, the date at which the investment of $1.600 million is made. Later we bring this number back to date 0. Assume a cost of capital of 10%.
NPV Following Unsuccessful Test

<table>
<thead>
<tr>
<th>Investment</th>
<th>Year 1</th>
<th>Years 2-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td>$4,050</td>
<td></td>
</tr>
<tr>
<td>Variable Costs</td>
<td>(1,735)</td>
<td></td>
</tr>
<tr>
<td>Fixed Costs</td>
<td>(1,800)</td>
<td></td>
</tr>
<tr>
<td>Depreciation</td>
<td>(400)</td>
<td></td>
</tr>
<tr>
<td>Profit</td>
<td>$115</td>
<td></td>
</tr>
<tr>
<td>Tax (34%)</td>
<td>(39.10)</td>
<td></td>
</tr>
<tr>
<td>Net Profit</td>
<td>$75.90</td>
<td></td>
</tr>
<tr>
<td>Cash Flow</td>
<td>-$1,600</td>
<td>$475.90</td>
</tr>
</tbody>
</table>

Note that the NPV is calculated as of date 1, the date at which the investment of $1,600 million is made. Later we bring this number back to date 0. Assume a cost of capital of 10%.

$$NPV = -\frac{1}{1.10} \times (1,600 + \frac{475.90}{1.10} - 75.90) = -91.461$$

Decision to Test

- Let's move back to the first stage, where the decision boils down to the simple question: should we invest?
- The expected payoff evaluated at date 1 is:
  $$\text{Expected Payoff} = (0.60 \times 3,433.75) + (0.40 \times 0) = 2,060.25$$
  The NPV evaluated at date 0 is:
  $$NPV = -1,000 - \frac{2,060.25}{1.10} = 872.95$$
  So, we should test.

Sensitivity Analysis: Stewart

- We can see that NPV is very sensitive to changes in revenues. In the Stewart Pharmaceuticals example, a 14% drop in revenue leads to a 61% drop in NPV.

  $$\%\Delta \text{Rev} = \frac{6,000 - 5,341.64}{5,341.64} = -14.29\%$$

  For every 1% drop in revenue, we can expect roughly a 4.26% drop in NPV:

  $$\%\Delta \text{NPV} = \frac{475.90 - 3,433.75}{3,433.75} = -60.93\%$$

Scenario Analysis: Stewart

- A variation on sensitivity analysis is scenario analysis.
- For example, the following three scenarios could apply to Stewart Pharmaceuticals:
  1. The next years each have heavy cold seasons, and sales exceed expectations, but labor costs skyrocket.
  2. The next years are normal, and sales meet expectations.
  3. The next years each have lighter than normal cold seasons, so sales fail to meet expectations.
- Other scenarios could apply to FDA approval.
- For each scenario, calculate the NPV.

Break-Even Analysis

- Common tool for analyzing the relationship between sales volume and profitability
- There are three common break-even measures:
  - Accounting break-even: sales volume at which net income = 0
  - Cash break-even: sales volume at which cash flow = 0
  - Financial break-even: sales volume at which net present value = 0

Break-Even Analysis: Stewart

- Another way to examine variability in our forecasts is break-even analysis.
- In the Stewart Pharmaceuticals example, we could be concerned with break-even revenue, break-even sales volume, or break-even price.
- To find either, we start with the break-even operating cash flow.
Break-Even Analysis: Stewart

- The project requires an investment of $1,600.
- In order to cover our cost of capital (break even), the project needs to generate a cash flow of $504.75 each year for four years.
- This is the project’s break-even operating cash flow, OCF_{BE}.

\[
\begin{align*}
N &= 4 \\
PMT &= 10 \\
PV &= 1,600 \\
FV &= 0
\end{align*}
\]

Break-Even Revenue: Stewart

Work backwards from \( OCF_{BE} \) to Break-Even Revenue

\[
Revenue = \frac{OCF_{BE}}{1 - \text{TAX}}
\]

\[
\begin{align*}
\text{Revenue} &= \frac{104.75}{1 - 0.34} \\
\text{Variable cost} &= 3,000 \\
\text{Fixed cost} &= 1,800 \\
\text{Depreciation} &= 400 \\
\text{EBIT} &= 158.71 \\
\text{TAX (34%)} &= 53.96 \\
\text{Net Income} &= 104.75 \\
OCF &= 104.75 + 400
\end{align*}
\]

Break-Even Analysis: \( P_{BE} \)

- Now that we have break-even revenue of $5,358.71 million, we can calculate break-even price.
- The original plan was to generate revenues of $7 billion by selling the cold cure at $10 per dose and selling 700 million doses per year.
- We can reach break-even revenue with a price of only:

\[
P_{BE} = \frac{5,358.71}{700} = $7.66 / dose
\]

8.2 Monte Carlo Simulation

- Monte Carlo simulation is a further attempt to model real-world uncertainty.
- This approach takes its name from the famous European casino, because it analyzes projects the way one might evaluate gambling strategies.

Monte Carlo Simulation

- Imagine a serious blackjack player who wants to know if she should take the third card whenever her first two cards total sixteen.
  - She could play thousands of hands for real money to find out.
  - This could be hazardous to her wealth.
  - Or, she could play thousands of practice hands.
- Monte Carlo simulation of capital budgeting projects is in this spirit.

Monte Carlo Simulation

- Monte Carlo simulation of capital budgeting projects is often viewed as a step beyond either sensitivity analysis or scenario analysis.
- Interactions between the variables are explicitly specified in Monte Carlo simulation; so, at least theoretically, this methodology provides a more complete analysis.
- While the pharmaceutical industry has pioneered applications of this methodology, its use in other industries is far from widespread.
8.3 Real Options

• One of the fundamental insights of modern finance theory is that options have value.
• The phrase "We are out of options" is surely a sign of trouble.
• Because corporations make decisions in a dynamic environment, they have options that should be considered in project valuation.

Real Options

• The Option to Expand
  – Has value if demand turns out to be higher than expected
• The Option to Abandon
  – Has value if demand turns out to be lower than expected
• The Option to Delay
  – Has value if the underlying variables are changing with a favorable trend

Discounted CF and Options

• We can calculate the market value of a project as the sum of the NPV of the project without options and the value of the managerial options implicit in the project.
  \[ M = NPV + \text{Opt} \]

A good example would be comparing the desirability of a specialized machine versus a more versatile machine. If they both cost about the same and last the same amount of time, the more versatile machine is more valuable because it comes with options.

The Option to Abandon: Example

Suppose we are drilling an oil well. The drilling rig costs $300 today, and in one year the well is either a success or a failure.

• The outcomes are equally likely. The discount rate is 10%.
• The \( PV \) of the successful payoff at time one is $575.
• The \( PV \) of the unsuccessful payoff at time one is $0.

Traditional NPV analysis would indicate rejection of the project.

\[ NPV = \text{Expected Payoff} \times \text{Prob.} + \text{Prob. \times Failure Payoff} \]

\[ \text{Expected Payoff} = (0.50 \times \$575) + (0.50 \times \$0) = \$287.50 \]

\[ NPV = -\$300 + \frac{\$287.50}{1.10} = -\$38.64 \]

Traditional NPV analysis overlooks the option to abandon.

The firm has two decisions to make: drill or not, abandon or stay.
The Option to Abandon: Example

- When we include the value of the option to abandon, the drilling project should proceed:

\[
\text{Expected Payoff} = (0.50 \times \$575) + (0.50 \times \$250) = \$412.50
\]

\[
\text{NPV} = -\$300 + \frac{\$412.50}{1.10} = \$75.00
\]

Valuing the Option to Abandon

- Recall that we can calculate the market value of a project as the sum of the NPV of the project without options and the value of the managerial options implicit in the project.

\[
M = \text{NPV} + \text{Opt}
\]

\[
\$75.00 = -\$38.64 + \text{Opt}
\]

\[
\text{Opt} = \$113.64
\]

The Option to Delay: Example

- Consider the above project, which can be undertaken in any of the next 4 years. The discount rate is 10 percent. The present value of the benefits at the time the project is launched remains constant at $25,000, but since costs are declining, the NPV at the time of launch steadily rises.

- The best time to launch the project is in year 2—this schedule yields the highest NPV when judged today.

8.4 Decision Trees

- Allow us to graphically represent the alternatives available to us in each period and the likely consequences of our actions.

- This graphical representation helps to identify the best course of action.

Example of a Decision Tree

- Squares represent decisions to be made.

- Circles represent receipt of information, e.g., a test score.

- The lines leading away from the squares represent the alternatives.

Decision Tree for Stewart

- The firm has two decisions to make: To test or not to test. To invest or not to invest.

- NPV = $3.4 b

- NPV = $0

- NPV = $0

- NPV = $0
Quick Quiz

• What are sensitivity analysis, scenario analysis, break-even analysis, and simulation?
• Why are these analyses important, and how should they be used?
• How do real options affect the value of capital projects?
• What information does a decision tree provide?

Contact Information

• Office: RCGB 18, U of West Georgia
• Office Phone and Voicemail: (770)301-8648 (cell) or (678)839-4816 (office)
• Class Webpage: Ulearn/WEBCT Vista
• E-mail: Ulearn/WEBCT Vista (pref.) or chodges@westga.edu (alt.)
• MSN Instant Messenger: mba8622@hotmail.com