

8.1 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.

Stewart Pharmaceuticals

The Stewart Pharmaceuticals Corporation is considering investing in developing 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 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 next 4 years.

Stewart Pharmaceuticals NPV of Full-Scale Production 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>$1,600</td>
<td></td>
</tr>
</tbody>
</table>

\[
NPV = \frac{-1,600 + \frac{-1,588}{1.10}}{1.10} = $3,433.75
\]

Note that the NPV is calculated as of date 1; the date at which the investment of $1.6 billion is made. Later we bring this number back to date 0.
Stewart Pharmaceuticals NPV of Full-Scale Production following Unsuccessful Test

<table>
<thead>
<tr>
<th>Investment</th>
<th>Year 1</th>
<th>Years 2-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenues</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>Pretax 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>

NPV = -$1,600 + \sum_{t=1}^{5} \frac{-475.90}{(1.10)^t} = -$91.46 m

Stewart Pharmaceutical: 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:

\[ \text{Expected payoff} = \text{Prob. (success given payoff)} \times \text{Prob. (failure given failure)} \]

So we should test.

Decision Tree for Stewart Pharmaceutical

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 = -$91.46 m

8.3 Sensitivity Analysis, Scenario Analysis, and Break-Even Analysis

Allows us to look behind the NPV number to see firm our estimates are.

When working with spreadsheets, try to build your model so that you can just adjust variables in one cell and have the NPV calculations key to that.

Sensitivity Analysis: Stewart Pharmaceuticals

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.

\[ \% \Delta \text{Rev} = \frac{\$6,000 - \$7,000}{\$7,000} = -14.29\% \]

\[ \% \Delta \text{NPV} = \frac{\$1,341.64 - \$3,433.75}{\$3,433.75} = -60.93\% \]

For every 1% drop in revenue we can expect roughly a 4.25% drop in NPV.

Scenario Analysis: Stewart Pharmaceuticals

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 their drug.

For each scenario, calculate the NPV.
8.4 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.

The Option to Expand

- Imagine a start-up firm, Campusteria, Inc. which plans to open private (for-profit) dining clubs on college campuses.
- The test market will be your campus, and if the concept proves successful, expansion will follow nationwide.
- Nationwide expansion, if it occurs, will occur in year four.
- The start-up cost of the test dining club is only $30,000 (this covers leaseholder improvements and other expenses for a vacant restaurant near campus).

The Option to Delay

- Has value if the underlying variables are changing with a favorable trend.

The Option to Abandon

- Has value if demand turns out to be lower than expected.
- Has value if demand turns out to be higher than expected.

The Option to Expand: Valuing a Start-Up

- Note that while the Campusteria test site has a negative NPV, we are close to our break-even level of sales.
- If we expand, we project opening 20 Campusterias in year four.
- The value of the project is in the option to expand.
- If we hit it big, we will be in a position to score large.
- We won’t know if we don’t try.

Campusteria pro forma Income Statement

<table>
<thead>
<tr>
<th>Year 0</th>
<th>Years 1-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment</td>
<td>Year 0</td>
</tr>
<tr>
<td>Revenues</td>
<td>$60,000</td>
</tr>
<tr>
<td>Variable Costs</td>
<td>($42,000)</td>
</tr>
<tr>
<td>Fixed Costs</td>
<td>($18,000)</td>
</tr>
<tr>
<td>Depreciation</td>
<td>($7,500)</td>
</tr>
<tr>
<td>Pretax profit</td>
<td>($7,500)</td>
</tr>
<tr>
<td>Tax shield 34%</td>
<td>$2,550</td>
</tr>
<tr>
<td>Net Profit</td>
<td>$4,950</td>
</tr>
<tr>
<td>Cash Flow</td>
<td>$30,000</td>
</tr>
</tbody>
</table>

NPV = $30,000 + $2,550 / (1.10)^4 = $219,168.4

Discounted Cash Flows 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. 
  \[ M = NPV + Opt \]
- 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 that 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.

\[
NPV = \frac{500 - 300}{1.10} = \frac{200}{1.10} = 181.82
\]

Expected Payoff = (0.50×$575) + (0.50×$0) = $287.50

\[
NPV = -300 + \frac{287.50}{1.10} = -300 + 260.91 = -38.09
\]

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

Valuation of 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.

\[
M = NPV + Opt
\]

\[
75.00 = -38.61 + Opt
\]

\[
75.00 + 38.61 = Opt
\]

\[
Opt = 113.64
\]

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 remain 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.
8.5 Summary and Conclusions

- This chapter discusses a number of practical applications of capital budgeting.
- We ask about the sources of positive net present value and explain what managers can do to create positive net present value.
- Sensitivity analysis gives managers a better feel for a project's risks.
- Scenario analysis considers the joint movement of several different factors to give a richer sense of a project's risk.
- Break-even analysis, calculated on a net present value basis, gives managers minimum targets.
- The hidden options in capital budgeting, such as the option to expand, the option to abandon, and timing options were discussed.