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## Real Options 1.

Capital budgeting involves identifying *all* of the expected future cash flows from a project, ascertaining the appropriate cost of capital to finance the project, and then measuring the project's net present value. In many cases, financial decisions have a so-called real option feature that dominates the analysis. This is especially true when learning is involved.

Consider the following case:

Merck is a \$200 billion pharmaceutical company. Its capital structure is 85% equity and 15% debt. With an AA- rating its credit spread over 30-year Treasuries is 65 basis points. It has a beta of 1.05. Assume that the 30-year Treasury Bond yield is 4% and the risk premium on the market is 5%. Merck's statutory tax rate is 30%.

Merck is considering starting a new R&D project on whether the use of a patient's DNA can be used to improve the efficacy of its cancer fighting drugs. If the project is ultimately successful, it would pay off \$20 billion in 8 years. The probability that this will be successful, based on Merck's historical success rate is 1.35%. The time line for the required R&D investments is:

| Time (Year) | Investment | Probability of Success |
|---|---|---|
| 0 | \$10 million | —- |
| 2 | \$40 million | 30% |
| 4 | \$80 million | 30% |
| 7 | \$100 million | 30% |
| 8 | | 50% |

Merck's WACC is 8.3166%. The present value of the expected payoff is: $\frac{(1.35\% \times 20 billion)}{1.083166^8}$. Or \$142.5 million.

The present value of the costs is: \$10 million plus $\frac{40}{1.083166^2}$ plus $\frac{80}{1.083166^4}$ plus $\frac{100}{1.083166^7}$, or \$159.4 million. Therefore the project's NPV is about -\$17 million.

But this analysis ignores an important feature of R&D: learning. Let's further analyze what happens when we reach a time when additional investment is required. After 2 years, there is a 70% chance that we will have learned that the project will not be successful. In this case we would pull the plug. Yes we would lose the initial \$10 million, but we will not incur the additional capital outlays. Similarly if we were successful after two years, and invest the additional \$40 million at that time, after two more years there is a 70% probability that the project would be unsuccessful. If we are successful after 4 years (which has an unconditional probability of 9% (30% times 30%)), and invest another \$80 million, then we still only have a conditional probability of success after three more years of 30%. Finally, if all three of these trials were successful than we would invest \$100 million to enter a Stage III FDA trial. There is a 50% probability of success at this point. Notice that this is how we obtained the (unconditional) probability of success: 1.35% equals $30\% \times 30\% \times 30\% \times 50\%$.

This means that the project includes a valuable abandonment option. We can evaluate such projects using a decision tree, and working our way backwards through the tree (i.e., recursively). To discount cash flows in this decision tree, let's use the cost of equity, since we could not use debt to finance such a project.

When we solve recursively we start at the end – the last decision "node" in the project. Suppose that we find ourselves in Year 7, after successes at Stages 1, 2 and 3. Should we invest the \$100 million? From the perspective of this decision node, the answer is yes – the project's value is: $\frac{0.5 \times 20\,\text{billion}}{1.0925} - 100$ million or \$9,053 million. So this is the value of the project at Year 7. Next we go back to Year 4, and ask whether –if things have been successful to that point – we should invest in the project. From the perspective of Year 4–conditional on achieving success in Years 2 and 4– the expected project value is $.3 \times \$9,053$ million, or \$2,716 million. Which has a present value of \$2,083 million. So the NPV of the investment in Year 4 is \$2,003 million. We should undertake the \$80 million investment in this state of nature. Working our way back to the investment in 2 years, the expected value of the project if it is successful at that point is \$601 million, and the present value is \$503 million. So the NPV undertaking the investment in Year 2 is \$463 million. Now back to today, the expected present value of the project in 2 years is \$116 million, so the NPV is \$106 million. Using this analysis, even with a higher cost of time (i.e., using Merck's cost of equity not its WACC), we should undertake the project.

Why was the original NPV wrong?

It ignored the value of information that is produced by the earlier stages of R&D. Using the decision tree approach, we would only incur the capital outlay in year 2 if the results of the initial experiments are positive. And in this case, the *conditional* probability of ultimate success is higher than at the outset. Similarly, when we get to Year 4, we will only invest the \$80 million if both initial stages were successful. At this point, the probability of ultimate success is increased to 15%.

What are the broader implications?

Many investments produce “only” information. Because this information is very valuable, our decision approach has to take account of this value. From the overall perspective of this project, it has several “abandonment options.” At each point that information is produced we have the option to continue with the project or abandon it. Valuation of the project should take into consideration the fact that we will do what is optimal at these points in time. Because there are options in the project’s investment process, analysts use the phrase “Real Options” to characterize the valuation process.

This valuation approach uses the principle of optimality – which means that the value of the project today depends on our doing what is optimal at each future node. So if we find out after seven years that the project failed, we will not incur the last capital outlay. This means that we will not suffer from the “sunk cost fallacy.” Which means suboptimally continuing with a failing project to rationalize past expenses. A successful manager knows that decisions depend only on their future consequences– not their histories. This should be part of the planning process ex-ante, so that pulling the plug is not incorrectly seen as failure.

Each decision node is an option, then. For this reason this dynamic optimization approach to capital budgeting is referred to as a “real options” approach.