Real Options in Capital Budgeting – An Overview

The traditional measure of investment decision criterion, NPV, does not take into account the value of options inherent in capital budgeting. This may cause selection of projects with positive NPVs and no managerial flexibility over projects with lower NPVs and greater flexibility. Managerial flexibility is not the only source of real options. Bruner\(^1\) suggests that investments may also create managerial commitment contingent upon future events. Not every manager ignores valuable real options. Damodaran (2000)\(^2\) argue that managers undertake negative NPV investments by suggesting that the presence of real options makes them valuable.

An option gives the holder of the option the right, but not the obligation to buy or sell a given amount of underlying asset at a fixed price (strike price or exercise price) at or before the expiration date of the option. The most important part of this clause is the “right, but not the obligation” to take an action. The two basic types of options are calls and puts. A call option gives the buyer the right to purchase the underlying assets and a put option gives the buyer the right to sell the underlying asset. These are “long” positions since the holder of the option has the right. The writer of the option maintains a short position. If the holder of the option decides to exercise his/her option then the option writer (short position holder) has to honor the option. This should make sense because long options require upfront payments (value of option) to acquire the option.

**Option Payoff Diagrams:**

1. **Buying a Call Option on British Pound**

   ![Buying a Call Option on British Pound Diagram]

2. **Writing a Call Option on British Pound**

   ![Writing a Call Option on British Pound Diagram]

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The value of option is determined by the following variables:

1. Value of the underlying asset: Since options are derivatives their value depends on the value of the underlying assets.

2. Standard deviation of the value of the underlying asset: The standard deviation of the underlying assets gives insight into how likely the underlying asset value may exceed or fall below the exercise price.

3. Exercise price of the option: The price at which the option may be exercised.

4. Time to expiration: American options can be exercised at any time while European options can only be exercised at expiration. Due to its flexibility an American option should usually be worth more than a European option.

5. Risk-free interest rate: The risk-free rate helps us to take into account the time value of money in valuation framework. It is used to determine the present value of the exercise price.

6. Dividend yield on the underlying asset: The value of the underlying asset decreases with the dividend payment. Therefore, the value of a call option is a decreasing function of dividend yield while the value of a put option is an increasing function of dividend yield.

**Options in Capital Budgeting:**

The following is a list of options taken from Bruner\(^3\) that may exist in a capital budgeting project.

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Long call:
- Right to invest at some future date, at a certain price
- Right to harvest at some future date
- Generally, any flexibility to invest, to enter a business, or to delay harvesting

Long put:
- Right to sell at some future date at a certain price
- Right to abandon at some future date at zero or some certain price
- Right to force someone else to harvest
- Generally, any flexibility to disinvest, to exit from a business, or to accelerate harvesting

Short call:
- Promise to sell if the counterparty wants to buy
- Generally, any commitment to disinvest or accelerate harvesting upon the action of another party

Short put:
- Promise to buy if the counterparty wants to sell
- Generally, any commitment to invest or delay harvesting upon the action of another party

Three of the most common real call options in capital budgeting include: (1) option to delay until key variables change favorably, (2) option to expand if a project turns out to be more promising and (3) option to abandon if worse case occurs.

**Valuing a Call Option using Black-Scholes Formula**

The following is based on Black-Scholes call option valuation formula.

\[
\text{Value of a Call Option} = SN\{d_1\} - Xe^{-rT}N\{d_2\}
\]

where,
\[ d_1 = \frac{\ln \frac{S}{X} + \left( r + \frac{\sigma^2}{2} \right) T}{\sigma \sqrt{T}} \]

\[ d_2 = d_1 - \sigma \sqrt{T} \]

\( S \) = price of the underlying asset
\( X \) = exercise price of the call
\( T \) = time to exercise in years
\( r \) = risk-free interest rate
\( \sigma \) = standard deviation of returns on underlying asset

**Dividend Yield Adjustment to Call Option Value:**

If the underlying asset has a dividend yield than “S” has to be multiplied by \( e^{-dyT} \), where “dy” is the dividend yield.

Value of a Call Option = \( S e^{-dyT} N(d_1) - X e^{-rT} N(d_2) \)

The \( N(d_1) \) and \( N(d_2) \) are the cumulative normal distribution for a given value of \( d \). This can be obtained with “=NORMSDIST(d_1 or d_2).” The term \( e^{rT} \) and \( e^{-dyT} \) can be calculated using “=EXP(-r*T)” or “=EXP(-dy*T).” The \( d_1 \) and \( d_2 \) can be calculated as:

\[ d_1 = \frac{\ln \frac{S}{X} + \left( r - dy + \frac{\sigma^2}{2} \right) T}{\sigma \sqrt{T}} \]

\[ d_2 = d_1 - \sigma \sqrt{T} \]

**Real Options in Capital Budgeting: Formulation of Option to Exchange One Asset for Another**

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**Option to Switch**

Option to Switch combines call on one asset and put on the other. The following equations are drawn from the Supplemental Note 2. I follow the same terminology as the author. The original work of Margrabe (1978)\(^4\) can be found at JSTOR link. Margrabe’s example involves switching from Japanese technology to German technology once German technology becomes viable.

Value of Option to Switch = \( P_G N(d_1) - P_J N(d_2) \)

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where,

\[ P_G = \text{Exercise price of making investment G} \]
\[ P_J = \text{Exercise price of making investment J} \]
\[ V_G = \text{standard deviation of the uncertain returns on investment G} \]
\[ V_J = \text{standard deviation of the uncertain returns on investment J} \]
\[ \rho = \text{correlation of NPV}_G \text{ and NPV}_J \]
\[ V^2 = V_J^2 + V_G^2 - 2V_GV_J\rho \]

\[ T = \text{term to maturity in years} \]

The Supplemental Note 2 fails to define \( N\{d_1\} \) and \( N\{d_2\} \). Using the original source of the equation (Margrabe (1978)) we have the following for \( d_1 \) and \( d_2 \).

\[
d_1 = \frac{\ln \frac{P_G}{P_J} + \frac{1}{2} V^2 T}{V \sqrt{T}} \]
\[
d_2 = d_1 - V \sqrt{T} \]

The \( N\{d_1\} \) and \( N\{d_2\} \) are the cumulative normal distribution for a given \( z \) value of \( d \). This can be obtained with “=NORMSDIST(d_1 \text{ or } d_2).” \( \sqrt{\cdot} \) can be calculated using “=SQRT(T).”

**Option Valuation Examples**

1. “Assume that you are interested in acquiring the exclusive rights to market a new product that will make it easier for people to access their e-mail on the road. If you do acquire the rights to the product, you estimate it will cost you $500 million upfront to set up the infrastructure needed to provide the service. Based upon current projections, you believe that the service will generate $100 million in after-tax cash flows each year. In addition you expect to operate a year in after-tax cash flows for 5 year.” The discount rate is assumed to be 15%. The demand for the product is uncertain and test marketing indicates a potentially larger market over time. The variability of cash flows leads to a 42% standard deviation in present value of cash flows with an expected value of $335 million. The risk-free rate is 5% per year and dividend yield is 20% per year over five-year period.

2. “Consider an offshore oil property with an estimated oil reserve of 50 million barrels of oil; the cost of developing the reserve is expected to be $600 million, and the development lag is two years. The firm has the rights to exploit this reserve for the next 20 years, and the

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5 These examples are taken from Damodaran, Aswath, “The Peril and Promise of Real Options,” available at http://pages.stern.nyu.edu/~adamodar/.
marginal value per barrel of oil is $12 currently [assume it does not change over time] (price per barrel – marginal cost per barrel). Once developed, the net production revenue each year will be 5% of the value of the reserves. The riskless rate is 8%, and the variance in ln(oil prices) is 0.03.”

3. “Assume that The Home Depot is considering opening a small store in France. The store will cost 100 million FF to build, and the present value of the expected cash flows from the store is 80 million FF. Thus, by itself, the store has a negative NPV of 20 million FF. Assume, however, that by opening this store, the Home Depot acquires the option to expand into a much larger store any time over the next 5 years. The cost of expansion will be 200 million FF, and it will be undertaken only if the present value of the expected cash flows exceeds 200 million FF. At the moment, the present value of the expected cash flows from the expansion is believed to be only 150 million FF. If it were not, the Home Depot would have opened to larger store right away. The Home Depot still does not know much about the market for home improvement products in France, and there is considerable uncertainty about this estimate. The variance is 0.08.” Assume that the risk-free rate is 6%.