Capital Projects as Real Options

Why treat a corporate investment proposal as an option, rather than as equity + bond (DCF valuation)?

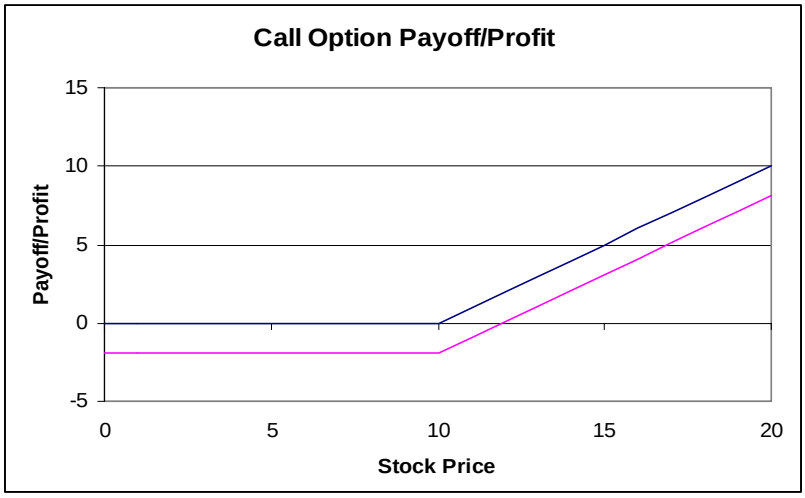
- Many projects (especially strategic ones) look more like options than stocks or bonds.
- Ignoring option like features of such projects can lead to incorrect decisions.
- DCF techniques treat projects as follows: *managers make a decision to invest (or not), then wait to see what happens.*
- However, sometimes, *managers wait and see what happens, and then make a decision to invest or not*.
- The latter is an option, quite different from the former.
- An efficient capital market would not place the same value on both, so why should a corporation?
- Most often, projects contain elements of both types:
  - An R&D program may create a cash producing new product, as well as opportunities for further R&D aimed at yet more new products.
  - Investing in a new market may lead to immediate cash flow as well as future expansion opportunities.
  - Creating a new brand may simultaneously create future brand extension possibilities.
- All these examples contain both cash producing *assets in place*, as well as *growth options.*
- Projects with high options content are likely to be misevaluated by DCF techniques.

Basic Option Pricing

- An option is a *derivative* asset, since it *derives* its value from some other underlying asset or reference price.
- An option contract gives the option buyer *the right (not the obligation) to buy (or sell) an asset from (to) the option seller*, at a predetermined price on a pre-specified date.
- The option seller is *obligated* to sell (or buy) the asset, if the option buyer so demands.
- The option to buy an asset is known as a *call* option, and the option to sell an asset as a *put* option.
- The specified asset is known as the *underlying asset*.
- The specified price at which the asset may be bought (or sold) in the future is the *exercise or strike price* (K).
- The specified date is the option *maturity* date.
- If the option buyer decides to buy (or sell) the underlying asset as per the option terms on the option maturity date, it is referred to as *exercising the option*.
- *European* options are contracts that can be exercised only at maturity, while *American* options can be exercised any time at or prior to maturity.
- The price of the option is the *option premium*.

Example: Consider a Dec expiration, $10 strike (European) call option on Enron, (current stock price is $9.05), trading at $1.90.

- Underlying asset is Enron's stock.
- The expiration date is Dec 21, 2001 (*stock options expire on the third friday of the month*).
- The option price is $1.90, strike is $10.
- The option buyer has the right to buy one Enron share for $10 on Dec 21, if he or she wishes to.
- If the stock price is greater than $10 on Dec 21 (the expiration date), it is beneficial for the option holder to exercise the option and buy the stock cheaper (at $10) than the prevailing market.
- Hence the option holder will exercise this option *only if* the stock price on expiration date is greater than $10 - the option is said to expire in-the-money (ITM) in this case.
- Currently the option is out-of-the-money (OTM), since the underlying stock price is below exercise price, and its a call.
- If stock price equals the strike, the option is said to be at-the-money (ATM).
- The call option holder will make a profit only if the option expires *sufficiently* ITM, i.e., if the underlying stock price at expiration is greater than $11.90.



Determinants of Option Value

- Underlying asset price: For calls, the higher the asset price, more likely it will remain above strike at expiration, hence higher the option premium - inverse relationship for puts.
- Strike price: For calls, a higher strike implies a lower chance that the option will be ITM at expiration, hence a lower premium (opposite for puts).
- Volatility of underlying asset price: More volatility implies higher option value.
  - The max loss for the option buyer is always the option premium (can't lose more than that!).
  - The max gain, though, depends on how much ITM the option is at expiration.
  - Greater volatility implies greater upside, with the downside still being the same (option premium) - hence asymmetrical upside and downside.
- Time to expiration: The longer the time to maturity, higher is the call option value.
  - Discounted present value of exercise payment is lower if paid later (*interest rate effect*).
  - The more time there is to expiration, the more likely it is that a large price change will occur and increase the value of the option (*volatility effect*).
  - For puts, the interest rate effect is negative, so the net effective can be positive or negative depending on which effect dominates.
- Interest rates: As interest rates rise, call values increase, while put values decrease.

Projects as Call Options

- Opportunity to invest in a project is similar to a call option to invest in a stock - *both involve the right, but not the obligation, to acquire an asset at a certain price on or before a certain date.*
- *When the company can wait without losing the opportunity to invest*, the project is like an unexpired option.
- Project characteristics can be mapped onto the determinants of call option value:

Project Investment	Exercise Price
Value of assets acquired	Stock Price
Length of time decision may be deferred	Time to expiration
Riskiness of underlying assets	Variance of stock returns
Time value of money	Risk-free rate of return

- In standard DCF analysis, the NPV of a project is
  NPV=PV(expected net cash flows) - PV(investment)
  and the decision rule is to invest if NPV>0.
- Alternatively, the NPV can be expressed as a ratio
  NPV=PV(expected net cash flows)/ PV(investment)
  where the decision rule would be to invest if NPV>1.
- This is similar to a call option, which should be exercised if, at expiration, the stock price exceeds the exercise price (i.e., if the option is ITM).
- However, traditional DCF analysis ignores the variance of asset returns - the NPV combines four of the five determinants of option value.
- If the decision cannot be delayed, then this variability in future returns does not affect the NPV - *there is no time*

available for returns to fluctuate from their current expected values.

- The variability, per unit time, of returns is measured by the variance of returns (σ^2).
- The cumulative variance is given by multiplying it with the time remaining ($\sigma^2 t$) - *cumulative variance measures how much things could change before time runs out and a decision must be made.*
- *The more cumulative variance, the more valuable the option.*
- Options (or projects) for which either σ or t is zero have no cumulative variance, hence can be evaluated using standard DCF techniques.
- *When both σ and t are nonzero*, DCF analysis will give a wrong value, leading to wrong exercise (investment) decisions, hence option valuation techniques must be used.

Example: Consider a project requiring an investment of $100m, while the PV of expected cash flows if currently $90m. However, the project is risky, and its value can change - project returns have a s.d. of 40% per year. The company can wait upto 3 years before deciding to invest.

- Viewed conventionally, the project's NPV is -$10m.
- However, having the opportunity to wait 3 years and see what happens is valuable.
- In effect, the company owns a 3-yr call option at a strike of $100m, with the current underlying asset price being $90m.
- The cumulative variance is 0.69m ($0.4 \times \sqrt{3}$).
- Using Black-Scholes, this option is worth $25.56m.
- So what should the company do?

- The company should not invest in the project now - if it does, it will forfeit the option and waste $10m.
- But neither should it discard the project!
- It should wait, watch and actively cultivate the project over the next 3 years.
- By the end of 3 years, there is a good chance that the project might be worth greater than $100m, in which case it would be optimal to exercise the option (to invest in the project).
- Traditional DCF analysis would recommend discarding the project altogether.