Real options

Corporate Finance and Incentives

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Flexibility

When there is flexibility in an investment opportunity, the classic NPV rule does not work

In this case, the NPV rule underestimates the value of an investment opportunity

The reason is that it doesn't take into account the value of flexibility

Real Options

A project is coupled with a put or call option - a real option.

Standard DCF only looks at PV of a single expected cash flow.

However, the firm may have strategic options along the way, which influence the possible cash-flows arising from a given project.

Real option: Gives the investor the right, but not the obligation, to take an action at a predetermined cost (exercise price) at a certain point of time (expiration time).

Example

Assume Apple is considering the introduction of a new iPod, which includes an internet modem. This will allow customers to link up directly from their iPod to iTunes, in order to download new music. The project will require a one-year development fase, followed by a one year production fase. The initial development fase will require a cash outlay of $30 mio. at time t=0. The following production fase will require a cash outlay of $70 mio. at the start of the second year, t=1. The product will not be ready to launch before at the end of year two, and so cash inflows from sales will not occur before time t=2.

Example

Since this is a new product, there is some uncertainty about the possible cash inflows to be generated by the product. How will consumers welcome the product?

Apple currently believes there is a 75% chance consumers will embrace the product. They also believe that it will become more clear over the next year, whether this is the type of product consumers will demand. They believe there is a 70% chance that the current market sentiment will continue to be present in 1 years time.

Assume the required rate of return on this type of products is 15%.

Problem with traditional NPV

Doesn't take the strategic options the company has along the way, into account.
Also, the project becomes less risky when we take the option into account - less downside.
The discount rate used to evaluate the project must therefore be adjusted.

Types of real options

- The opportunity to shrink or abandon a project.
- The opportunity to expand and make follow-up investments.
- The opportunity to "wait" and invest later.
- The opportunity to vary the mix of the firm's output or production methods.

Value of "real option" = NPV with option - NPV w/o option

Methods

Binomial model

- Tracking portfolio method
- Risk-neutral valuation

Black-Scholes

- Requires underlying asset to be lognormally disributed
- Doesn't allow for early exercise

The opportunity to shrink or abandon a project

If things are going badly, you may wish to shrink or abandon a project.

- Abandonment option - if the NPV of the remaining cash flows of a project are less than the liquidation value, the underlying assets may be sold and production terminated.
- These options to abandon should be included when evaluating the value of the project.
- Temporary-stop or shutdown options.
- The option to contract.

Valuing a copper mine with a shutdown option - Example 12.2

A copper mine will be able to produce 75 mio. pounds of copper one year from now. There are two possible values for the copper price one year from now. If we end up in a bad state one year from now, the copper price will be \$0.5 per pound. If we end up in a good state the price will be \$0.9 The current 1 year forward price on copper is \$0.6 per pound. The extraction costs are \$0.8 per pound. The 1 year risk-free interest rate is 0.05%.
On page 430-431 of G&T the option is valued using the tracking portfolio approach.
A more intuitive approach (in my mind) is the risk-neutral valuation method. The two give the same result, but let's see how.

The opportunity to expand and make follow-up investments

- The total value of an investment may be different than just the NPV of the investment itself.
- You may have to spend money today in order to obtain the opportunities (the option) to expand in the future.
- Standard capital budgeting techniques involve computing the expected PV of such projects, based on some anticipated future implementation date.
- This implicitely assumes the growth options must be exercised.
- In reality, management will only exercise those options that appear profitable at the time they are to be initiated.

The option to make follow-up investments - iPod example

Assume we are back in the year 2000, before digital music players became mainstream.
Apple is considering the introduction of a new digital music player, with large storage capacity and easy to use interface design.
The project will require a 1 year development fase with an initial outlay of $200 mio.

The expected future cash flows from the project are:

	2000	2001	2002	2003	2004
Cash flow from operations			350	600	300
Change in working capital			60	150	100
Capital investment	200	500	0	0	0
Net cash flow	-200	-500	290	450	200

Assume Apple has a hurdle rate of 20% (annual compounding) on this type of project.
$NPV = -200 + \frac{-500}{1.2} + \frac{290}{1.2^2} + \frac{450}{1.2^3} + \frac{200}{1.2^4} = -\$58.4 mio.$

iPod example - continued

The 1. generation iPod is necessary in order to be able to introduce a 2. generation iPod.

Assume the 2. generation iPod will be introduced primo 2004, if it appears profitable at that time.

The expected cash flows from the 2. generation iPod are

	2003	2004	2005	2006	2007
Cash flow from operations		600	850	600	100
Change in working capital		150	300	200	−50
Capital investment	700	0	0	0	0
Net cash flow	−700	450	550	400	150

The expected cash flows are uncertain. Assume the cash flows are lognormally distributed with an annual standard deviation of 30%.

iPod example - continued

Assume the hurdle rate is still 20% (annual compounding) and the riskfree rate (interest rate) is 5% (continuous compounding).

$$\begin{aligned} E(PV_{2003}) &= \frac{450}{1.2} + \frac{550}{1.2^2} + \frac{400}{1.2^3} + \frac{150}{1.2^4} = \$1060.8 \\ E\left(PV_{2000}\right) &= \frac{\$1060.8}{1.2^3} = \$613.9 \end{aligned}$$

Black-Scholes

$S = E\left(PV_{2000}\right) = \$613.9$
$K = 700,\ \sigma = 0.3,\ t = 3,\ r_f = 0.05$

$$
\begin{aligned}
call &= SN(d_1) - Xe^{-r_f t}N(d_2) \\
d_1 &= \frac{\ln\left(S/K\right) + \left(r_f + \sigma^2/2\right)t}{\sigma\sqrt{t}} \\
&= \frac{\ln(613.9/700) + \left(0.05 + 0.3^2/2\right)3}{0.3\sqrt{3}} = 0.296 \\
d_2 &= d_1 - \sigma\sqrt{t} = 0.296 - 0.3\sqrt{3} = -0.224 \\
N(d_1) &= 0.616 \\
N(d_2) &= 0.411 \\
call &= SN(d_1) - Ke^{-r_f t}N(d_2) \\
&= 613.9 * 0.616 - 700e^{-0.05*3} * 0.411 = 130.5
\end{aligned}
$$

Value of iPod investment

No option: $NPV = -700 * e^{-0.05*3} + 613.9 - 58.4 = -\$47.4 mio.$
Total value of project: $APV = -\$58.4mio. + \$130.5mio. = \$72.1mio.$
Possible further follow on projects (iPod nano, iPod shuffle, video iPod...)
First mover advantage.

Examples

- First-mover options.
- The option to make follow-up investments.
- R&D projects - give the option to undertake new profitable projects in the future.
- The option to expand a production facility.
- The option to increase operating scale.

The opportunity to "wait" and invest later

You could have an invest "now or never" opportunity - a call option about to expire.
The call option payoff is the NPV of the project.
If the NPV is negative, the option payoff is zero $\rightarrow$ don't invest in the project.

The opportunity to "wait" and invest later

But an investment opportunity could also be structured with a "wait and see" option.
You could invest now or wait six months before you decide whether to invest or not.
Six months out in the future you may have more information available about the profitability of the investment.

- American call option

It is never profitable to exercise an American call option early, on a non-dividend paying asset.
Waiting six months may mean that you loose 6 months of potentially profitable payoffs.

- Cash flows are equivalent to dividends.

It may be profitable to exercise the option early, if the cash flows are large enough.

Example 12.3

The opportunity to vary the mix of the firm's output or production methods

- Input mix or process flexibility options - the option to use different inputs to produce the same output.
- Output mix or product flexibility options - the option to produce different outputs from the same facility.

Risk-neutral method

1. Set up value tree for underlying asset
   - ex. 12.2: we know the value of copper from financial markets
   - ex. 12.3: use market price of condominium
   - ex. 12.5: use value tree for market portfolio
   - set up value tree for the project w.o. the option by finding the PV of expected future cash flows from the project at each node discounted by WACC
2. Use value tree for underlying asset to find risk-neutral probabilities between nodes

$$\pi = \frac{1 + r_f - d}{u - d}$$

3. Use risk-neutral probabilities to find NPV of project without option
4. Use risk-neutral probabilities to find NPV of project with option
5. Value of option = NPV from 4 - NPV from 3

Alternatives

- Tracking portfolio approach (ex. 12.2 in G&T)
- If we can assume the underlying asset is lognormally distributed and there is no possibility of early exercise, we can use Black-Scholes model to value option

Where do we get our input?

Is it necessary for a completely similar asset to be traded liquidly in the market?

- We need an asset portfolio that has the same distribution of cash flows across macroeconomic states.
  - Replicating portfolio.
- In a complete market, there are potentially many different ways of constructing such a portfolio.

Look at comparable assets and projects.
Perform scenario analysis.

Bias may arise from the subjective evaluation of input parameters.
Is it likely that the underlying behaves like a lognormal process (Black-Scholes)?

How realistic are our assumptions?

- Real options models tend to reflect "perfection" rather than economic reality.
- Assume option holders have perfect information about the relevant parameters that determine the underlying project's value and volatility.
- Option holders are assumed to exercise their option at the optimal exercise time.
- Option holders are assumed to ignore the actions of other option holders of identical options.

How realistic are our assumptions?

- Each option is treated as completely separable from other securities in the investor's portfolio (the firm's other projects).
- How do the various projects or options to invest within the company's portfolio interact with each other?
- The exercise of each option may affect the value of the company's current assets and the other options it holds.
- The incremental value of each growth option is difficult to assess accurately - follow on projects.

Theoretically accurate models are often poorly executed in practice because of their complexity, while simple models can often be quite effectively employed despite their lack of precision.

Which is better is not always clear.