Chapter 22: Real Options

I. Introduction to Real Options

A. Basic Idea

=>

=>

=>

=>

B. Valuing Real Options

Basic idea: can use any of the option valuation techniques developed for financial options in Ch. 21

Problems:

1)

2)

1. Binomial option prices

Information needed:

1) current market prices of securities used to create replicating portfolio
=> need securities with same source of risk as the real option
2) payoffs on the securities and on real option in both possible states

2. Black-Scholes

Information needed:
S = market value of the asset on which have the option
K = exercise price of the option
σ = annual volatility on asset on which have the option
T = years until the option expires
r_f = return on Treasuries that mature when the option expires
Note: used to calculate PV(K)
Div = cash flow give up between now and exercising the option

3. Decision Tree

a. Basic idea:

=>

b. Notes

1) two types of "nodes"

Box = decision node –

Circle = information node –

2) more than two possible outcomes or decisions at each node

3)

Note: in each section, I'll use a different approach than the book since any of the approaches are valid if have the relevant information.

II. The Option to Delay an Investment Opportunity

1. Basic idea: being able to wait to make investment decision (rather than deciding now) is a long call

2. Issues:

1)

2)

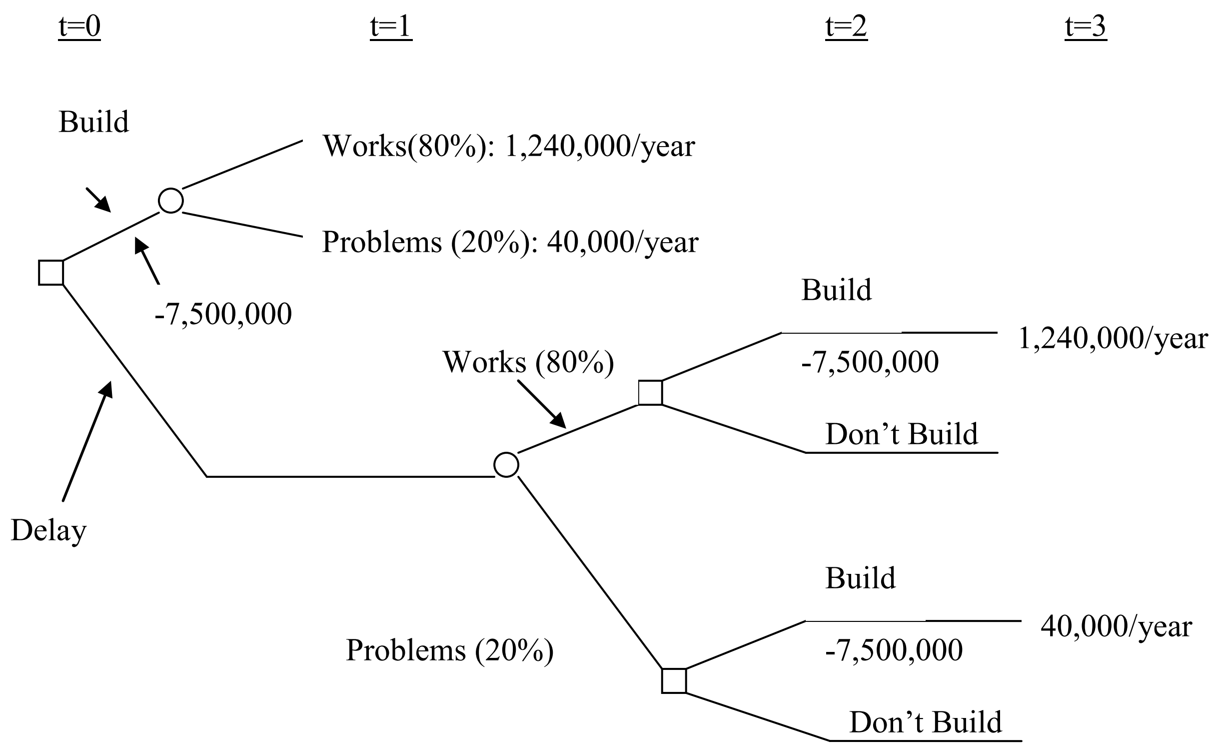
3) div (for Black-Scholes) = loss of value from waiting

-

-

4) book has example with Black-Scholes but can use other methods.

Ex. Your firm is considering investing $7,500,000 in a factory to build home ethanol systems that will allow individuals to create ethanol from grass clippings. There is an 80% chance that the technology will work as planned and expected net cash flows will be $1,240,000 per year and a 20% chance of technical problems that will reduce expected net cash flows to $40,000 per year. Either way, net cash flows would begin a year from today and continue for 20 years (when your patents will expire and new technology will allow personal solar power systems to become viable). Alternatively, in two years, your firm will know whether the technology will work and thus whether net cash flows will be $1,240,000 or $40,000 per year. Should your firm build now or wait two years if the required return on the project is 10% per year?



If delay:

t = 2:

Technology works:

If build: $\boldsymbol{NPV_{t=2} = 2,669,751 =}$

If don't build: $NPV = 0$

Technology doesn't work:

If build: $\boldsymbol{NPV_{t=2} = -7,171,944 =}$

If don't build: $NPV = 0$

$E(NPV_{t=2}) = 2,135,801 =$

t = 0:

$\boldsymbol{E(NPV_{t=0}) = 1,765,125 =}$

If build now:

t = 0:E(CF) = 1,000,000 =

$\boldsymbol{NPV = 1,013,564 =}$

=>

III. Growth Options

Growth option:

A. Valuing the Growth Potential of a Firm

Notes:

1)

2)

B. The Option to Expand

1. Applications

1)

Ex. opening factory in China establishes relationships so can build a second factory later at a lower cost

2)

2. example in book uses decision trees and risk-neutral probabilities, but can use other methods

=> value of project = NPV (ignoring option to expand) + value of option to expand.

Example: Suppose firm is considering building a new factory at a cost of $250,000. This factory is expected to produce cash flows of $26,000 per year for 25 years starting a year from today. Within 2 years, if the product is a success, then the plant could be expanded at a cost of $125,000. The expected cash flows from this expansion would be $13,000 per year for 23 years with the 1st cash flow coming 1 year after the expansion is complete (3 years from today). The standard deviation of returns on the expansion of 27% exceeds the standard deviation of returns on the initial factory of 22%. The return on Treasury strips vary by maturity as follows: 1-year = 3.3%, 2-year = 3.5%, 3-year = 3.6%, 25-year = 5%. The required return on this factory and the possible expansion is 9.5% per year. Using the Black-Scholes Option Pricing Model to value the expansion option, should the factory be built?

NPV excluding option to expand = -$4622.98 =

Calculation of PV of inflows:

$$PV_0 = 245{,}377.02 =$$

=> excluding option to expand, not worthwhile

Value of option to expand (Black-Scholes Option Pricing Model):

Variables:

S = present value of cash flows from the expansion
K = cost of expansion
σ = volatility of returns on the expansion over the life of the option
T = number of years during which can expand
r_f = risk-free rate between now and "T"

S:

$$PV_2 = 119{,}871.59 =$$

$$PV_0 = 99{,}974.22 =$$

T =

PV(K) = 116,688.84 =
σ =

$$d_1 = \frac{ln\left[\frac{S}{PV(K)}\right]}{\sigma\sqrt{T}} + \frac{\sigma\sqrt{T}}{2} = -0.21396 =$$

$$d_2 = d_1 - \sigma\sqrt{T} = -0.59580 =$$

$N(d_1) = .41529$; $N(d_2) = .27656$

=> value of option to expand = $C = S \times N(d_1) - PV(K) \times N(d_2)$

= 9352.32 =

NPV (including option to expand) = 4729.34 =

=> project is worthwhile

=> intuition not obvious:

=>

=>

=>

note:

IV. Abandonment Options

=>

key =>

=>

Ex.

Note: book values with a decision tree but can use other methods

=> value of project = NPV (ignoring option to shut down)+ value of shut down option (put)

Ex. Suppose a firm is considering a project costing \$100,000 that is expected to provide cash flows of \$13,000 per year for 15 years starting a year from today. The required return on the project is 11.25% per year and the standard deviation of returns on the project is 35% over the next 3 years but only 32% over its 15-year life. If the project fails to live up to expectations, the facility can be sold for \$50,000 any time within the next 3 years. The return on Treasury strips vary by year as follows: 1-year = 3.3%, 2-year = 3.7%, 3-year = 4%, 15-year = 5.5%. Should firm undertake project?

PV of inflows:

$PV_0 = 92{,}205.36 =$

NPV excluding shut down option = -\$7794.64 =

Value of option to abandon:

Variables

S = value of asset being abandoned

K = cash flows from selling assets when shut down

σ = volatility of returns over the life of the option on asset shutting down

T = time during which can shut down

r_f = risk-free rate between now and "T"

Note: since cash flows between now and expiration, need to use S^x

T =

$S^x = 60{,}574.69 =$

PV(K) = 44,449.82 =

σ =

$$d_1 = \frac{ln\left[\frac{S}{PV(K)}\right]}{\sigma\sqrt{T}} + \frac{\sigma\sqrt{T}}{2} = 0.8137 =$$

$$d_2 = d_1 - \sigma\sqrt{T} = 0.20746 =$$

=> $N(d_1)$ = .79209, $N(d_2)$ = .58217

=> $P = PV(K)[1 - N(d_2)] - S[1 - N(d_1)]$ = 5977.89 =

Value of project including option to abandon:

NPV (including the put) = -1816.74 = -7794.64 + 5977.89 = -100,000 + 98,183.25 =

=> not worthwhile even w/ abandonment option

V. Key Insights from Real Options

1.

2.

=>

=>

=>

3.