REAL OPTIONS IN CAPITAL INVESTMENT DECISIONS

Strategic NPV = Passive NPV + Present value of options arising from the active management of the firm's investment opportunities

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TERMS AND DEFINITIONS

- An option is a right to buy or sell a particular good for a limited time at a specified price (*the exercise price*). A call option is the right to buy. A *put* option is the right to sell.
- The *expiration* date is the date when the option matures. An *American option* is exercisable anytime until the end of the expiration date while a *European option* is exercised only at the expiration date.
- The *writer* of an option contract sells the call or put option while the buyer purchases the option contract from the seller. For real options, the firm is the implied buyer and the market is the implied seller. No actual contract is traded.
- A call option is *out-of-the-money* when the price of the underlying assets is below the exercise price of the call and *in-the-money* when the price of the underlying assets is above the striking price of the call. The opposite is true for a put option, which is *out-of-the-money* when the price of the underlying assets is above the striking price of the call and *in-the-money* when the price of the underlying assets is below the striking price of the call.
- Buyers may hold a *long (buy)* or *short (write)* position in the option.

FACTORS WHICH AFFECT THE VALUE OF AN OPTION

Symbol	Factor as it relates to stock option value	Factor as it relates to capital budgeting
P_0	Price of the underlying asset (i.e., stock price)	PV of expected operation CFs discounted at the project's cost of capital
X	Exercise price	For call options—the initial investment. For put options—the value of the project's assets if sold or shifted to a more valuable use
t	Time until the option expires	Time until the option expires or is no longer available
K_{rf}	Risk-free rate of interest	Risk-free rate of interest (use the yield on U.S. T-bills)
σ	Standard deviation of the underlying asset(volatility of stock price)	Project risk—standard deviation of the operating cash flow as a percent of total investment

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RELATIONSHIP BETWEEN OPTION FACTORS AND OPTION VALUES

$$V_c = (\overset{+}{P_0} \quad \overset{-}{X} \quad \overset{+}{t} \quad \overset{+}{K_{rf}} \quad \overset{+}{\sigma})$$

$$V_p = (\overset{-}{P_0} \quad \overset{+}{X} \quad \overset{+/-}{t} \quad \overset{-}{K_{rf}} \quad \overset{+}{\sigma})$$

REAL OPTIONS IN CAPITAL INVESTMENT DECISIONS

Option:	Valued as a:
wait & learn more before investing	call
default during construction (staged investment)	a series of put options
alter operating scale (expand, restart)	call
alter operating scale (contract, shut down)	put
abandon	put
switch inputs or outputs	call + put
grow and build-on previous investments	call

K_{rf} = in all cases, this is the risk-free rate as measured by the return on U.S. T-bills closest to option expiration.

A COMPARISON OF OPTIONS PRICING MODELS

	Binominal Model	**Black-Scholes Model**
Description	*assumes that the time to an option's maturity can be divided into a number of subintervals, in each of which, there are only two possible price changes	*the binomial model estimated over an infinite number of sub-intervals
Advantages	*easier for executives to understand *bigger range of applications(B-S model cannot be used in all cases) *similar in structure to a decision tree but a much more concise representation of complex relationships	*easy to calculate with tables
Disadvantages	*more than one or two sub-intervals requires computer simulation	*not easy to explain to executives

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HOW TO ESTIMATE THE VALUE OF REAL OPTIONS USING OPT

Binomial Model:

Portfolio Replication Method

1. Calculate the option delta = $\frac{\text{Spread of possible option prices}}{\text{Spread of possible share prices}}$

   Example: A stock which currently sells for \$100 with an exercise price of \$110. In the next period, it could rise to \$125(\$125-\$100 = \$15 option value) or it could fall to \$80(\$0 option value). The option delta = (15-0) / (125-80) = 1/3. This says that three calls are replicated by using one share and borrowing, or the value of 3 calls = value of 1 share- band loan.

2. Determine the value of the bank loan that would have the same payoff as the out-of-the-money option, in our case a future value of \$80. If the interest rate is 10 %, then the bank loan would equal \$72.73. (In one year, you repay principal of \$72.73 + \$7.27 interest) = \$80. Thus, the value of 3 calls = \$100-\$73.73 = \$27.27, and the value of 1 call = \$ 9.09.

Risk- Neutral Method

1. At each point in time, determine the two possible outcomes for the value of the asset.

2. Recognize that the value of an out-of-the-money option is 0 and an in-the-money option is (P_0-X) for a call and (X-P_0) for a put.

3. If an investor is risk-neutral the expected return = interest rate.

4. Solve for the probability of a price rise using the following formula:
   Risk-free interest rate = [(Prob. Of rise) x % Increase in price] + [(1- Prob. of rise) x % Decrease in price]

5. Solve for the expected future value of the option using the following formula:
   Expected FV of option = [(Prob. of rise) x Option value in case of price increase] + [(1-Prob. of rise) x Option value in case of price decrease]

6. Current value of the option = $\frac{\text{Expected future value of the option}}{1 + \text{Interest rate}}$

Black-Scholes Model (using the option pricing tables):

1. Calculate $\sigma \sqrt{t}$. Locate your resulting number on the left hand side of the table.
2. Calculate the present value of the exercise price using the continuous compounding formula: $PV(X) = X / e^{t*krf}$.
3. Calculate P_0 / PV(X). Locate your resulting number on the top of the table.
4. Look up the call value percentage in the body of the table using the numbers found in steps 1 and 3. Multiply the call value percentage times P_0 (value of the underlying asset).
5. Use put-call parity to calculate the value of the put options: Put = Call + PV(X) - P_0.

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WHEN TO APPLY DIFFERENT OPTION PRICING MODELS

	Dividend	Call	Put
European	No dividend (in capital budgeting applications, this means no intermediate cash flows)	B-S model	Solve for t call using the B-S model. Use put-call parity to find the value: Put = Call + PV(X) – Value of asset
	Dividend	Reduce the price of the underlying asset by the PV of dividends of cash flows paid before the option's maturity. If the option is not exercised, the owner of the option is not entitled to receive these cash flows. Then use the B-S model.	Solve for the call using the B-S model. Use put-call parity to find the value: Put = Call + PV(X) – Value of asset
American	No dividend (in capital budgeting applications this means no intermediate cash flows)	Should never be exercised early; value as a European option using the B-S model.	May want to exercise early and reinvest the exercise price. An American put is always more valuable than a European put. Use the step-by-step binomial model checking at each point to determine whether the option is worth more dead than alive.
	Dividend	Should never exercise early if the dividend earned is less than the interest lost by paying the exercise early. In this case, use the B-S model. But if the dividend is large, exercise the option just before the ex-dividend date. Step-by-step binomial is more appropriate in this case. Check at each ex-dividend date.	Step-by-step binomial model.

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