Week Five

A Project is Not a Black Box

Copyright © Bruce N. Lehmann 2005

Types of Real Options

- Option to defer
- Time-to-build option
  + Staged investment
- Option to alter operating scale
  + Expand, contract, shut down, and restart
- Abandonment option
- Option to switch
  + Multiple purpose facilities
- Growth option

Copyright © Bruce N. Lehmann 2005

Option to Shut Down: Silver Mine Example

- Silver mine can produce 10,000 ounces copper at a variable cost of $8 per ounce
- Fixed costs of operating the mine are $10,000 per year.
- Silver prices
  - + $11 per ounce in half the years
  - + $7 per ounce in half the years
  - + Each happens with probability ½
- Ignore taxes

Copyright © Bruce N. Lehmann 2005

Option to Shut Down: Silver Mine Example, Continued

- Average cash flow if mine always kept open
  - + Expenses = (10,000 x $8) + $10,000 = $90,000
  - + Revenue is either:
    - $10,000 x 11 = $110,000
    - $10,000 x 7 = $70,000
  - + Expected CF = 0.5(110,000 - 90,000) + 0.5(70,000 - 90,000) = 0
- What if mine closes in low price state?
  - + Expected CF = .5(110,000 - 90,000) + .5(0) = $10,000

Copyright © Bruce N. Lehmann 2005

Option to Abandon: McCaw Diet Whiskey Example

- MacCaw developed diet whiskey and considers pilot production and test marketing
  - + Phase 1: takes a year and costs $200,000
  - + 50-50 chance of successful pilot or marketing
  - + Successful: MacCaw will build $2 MM plant that generates $480K/year perpetual expected annual after tax cash flow
  - + Failure: MacCaw abandons project with no salvage value
- Opportunity cost of capital = 12%

Copyright © Bruce N. Lehmann 2005

Option to Abandon: McCaw Diet Whiskey Example, Continued

- Should MacCaw build without testing?
  + NPV = -2 MM + (0.5 x 480K/0.12) + 0.5 x 0 = 0
- Should MacCaw proceed with testing?
  + Investment of $200,000 for a 50% chance of $2 MM is a good deal at almost any OCC
- Note the value of walking away
  + Exploit good outcomes
  + Limit the cost of bad outcomes
- Is opportunity cost of capital likely to be the same for the testing as for the product?

Copyright © Bruce N. Lehmann 2005

Option to Abandon: Flexibility in Production Technology

- Wigeon Co. can produce new Wankel-engine outboard motor in two ways
  + Technology A uses custom-designed machinery to produce Wankel engines at low cost
    - Equipment worthless if Wankel engine doesn't sell
  + Technology B uses standard machine tools.
    - Higher labor costs but tools easily resold
- NPV_A looks better due to low production cost but B's flexibility looks attractive with uncertainty about future product success

Copyright © Bruce N. Lehmann 2005

Option to Abandon: Hit or Miss Sports

- Hit or Miss Sports introduces new see-at-night soccer balls
  - + If successful, firm expects to sell 50,000 units a year at a price of $60 each
  - + If not, 30,000 units can be sold at $55 each
- Cost side
  - + Investment of $6 MM
  - + Variable cost is $30/ball and fixed costis zero
  - + Depreciate straight-line over 10-year project life
  - + Firm's tax rate is 35% and discount rate is 12%

Copyright © Bruce N. Lehmann 2005

Option to Abandon: Hit or Miss Sports

- Equally likely scenarios

	Optimistic	Pessimistic
Price	60	55
Sales	50,000	30,000
Variable cost	30	30

- Cash flows
  - + CF = (1-T)(Revenue-Cash Expenses)
    - + T x Depreciation
- Is this a positive NPV project?

Copyright © Bruce N. Lehmann 2005

Option to Abandon: Hit or Miss Sports, Continued

- Optimistic cash flows and npv
  - + Optimistic CF = 0.65 [(60 - 30) x 50,000]
    + 0.35 x 600,000 = 1,185,000
  - + NPV = -6,000,000 + 1,185,000 x 5.65 = 695,514
    - AF(12%, 10 Years) = 5.65
- Pessimistic cash flows and npv
  - + Pessimistic CF = 0.65 [(55 - 30) x 30,000]
    + 0.35 x 600,000 = 697,500
  - + NPV = -6,000,000 + 697,500 x 5.65 = -2,058,969
- Expected NPV = -$681,728 $\Rightarrow$ reject project

Copyright © Bruce N. Lehmann 2005

Option to Abandon: Hit or Miss Sports, Continued

- Suppose the manufacturing equipment has a salvage value of $5.4 million
- Suppose Hit or Miss will make the abandonment decision at end of year one
- Abandonment scenario cash flow and npv
  - + CF = 697,500 + 5,400,000 = 6,097,500
  - + NPV = -6,000,000 + 6,097,500/1.12
    = 5,444,196 - 6,000,000 = -$555,804
- Expected NPV = $69,855 $\Rightarrow$ abandonment option makes project worth pursuing

Copyright © Bruce N. Lehmann 2005

Option to Expand: Hit or Miss Sports, Continued

- Suppose firm can expand if successful
  + Can increase production by 20,000 units by paying workers overtime $\Rightarrow$ VC = \$35/unit
  + Increases cash flow in good state by \$325,000
    - i.e., 0.65 [20,000 x (60 - 35)]
- Impact on NPV
  + Year one NPV up: 5.3282 x 325K = 1,731,665
    - 9 years left at end of year one $\Rightarrow$ AF = 5.3282
  + NPV up: 1,731,665/1.12 = 1,546,129
  + Expected NPV up: 0.5 x \$1,546,129 = \$773,065

Copyright © Bruce N. Lehmann 2005

The Option to Expand: Oil Field Example

- Prospective oil field: 50/50 chance of:
  - + 15 million barrels
  - + 5 million barrels
- Valuation: PV in:
  - + Good state: $8 million
  - + Bad state: $2 million
- Costs
  - + $3 million to drill the well
  - + $100,000 seismic test can verify the amount of oil under the ground

Copyright © Bruce N. Lehmann 2005

The Option to Expand: Oil Field Example, Continued

- Does it pay to do the seismic test?
  + Drilling costs $3 MM and so there is a 50% chance of losing $1 MM
  + It pays to spend $100,000 to avoid a 50% chance of losing $1 MM
- New project NPV
  + Project NPV = 0.5 x $8 MM + 0.5 x $100K
    = $4,050,000
- If the test took a year, what would the appropriate OCC be?

Copyright © Bruce N. Lehmann 2005

What About the Opportunity Cost of Capital?

- Is MacCaw diet whiskey testing likely to have the same OCC as the overall project if the firm proceeds?
- What about oil field testing vs. oil refining?
- Is OCC of silver mine likely to be the same when open and closed?
- Is OCC of the cash flows from expansion or contraction likely to be the same as those of "regular" cash flows?

Copyright © Bruce N. Lehmann 2005

Why Options Fundamentally Alter Capital Budgeting

- Valuing a loan guarantee to BailedOut, Inc.
  + Has drug R&D project with expected value of future cash flows of:
    - $180 MM in the good state with probability 0.5
    - $60 MM in the bad state with probability 0.5
  + Project requires initial investment of $104 MM
  + Government supports this project with guaranteed buy out in bad state of $180 MM
- If the project OCC is r = 20% and the riskless rate is r_f = 8%, what is present value of the project and of government guarantee?

Copyright © Bruce N. Lehmann 2005

Project and Abandonment Option Valuation via Capital Budgeting

- $V = V_0 + G$
  - + V_0 = project value without guarantee
    $= [(0.5 \times 180) + (0.5 \times 60)]/1.2 = 100 < 104$
  - + V = project value with guarantee
    $= \{(0.5 \times 180) + [0.5 \times (60 + 120)]\}/1.2 = 150$
  - + G = value of guarantee = $V - V_0 = 150 - 100 = 50$
    $= [(0.5 \times 0) + (0.5 \times 120)]/1.2 = 50$
- What's wrong with this answer?

Copyright © Bruce N. Lehmann 2005

Project and Abandonment Option Valuation, Continued

- Capital budgeting answer is wrong
  - + Project value in good state = $180 MM
  - + Project value in bad state = $180 MM
  - + $\Rightarrow$ project is riskless so:

    $V = \$180/1.08 = \$166.7$ MM

    $G = V - V_0 = 166.7 - 100 = \$66.7$ MM
- Discounted PV is wrong because option to abandon alters project risk and discount rate
  - + PV = traditional PV + embedded option values
  - + $\Rightarrow$ Cannot use same OCC to value options

Copyright © Bruce N. Lehmann 2005