Lecture 7: Real Options

Outline

1. Motivation

2. The Option to Wait and the Value of Information

3. The Option to Expand

4. The Option to Open and Close

1. Motivation

- Thus far we have considered simple "static" projects where the only choice was whether to invest or not invest at a single point in time.

- The central question in this lecture is: how do we make "dynamic" investment choices (i.e. over time)?

- Some projects have "embedded real options" allowing you to make additional choices as time progresses, such as
  - gathering more information
  - shutting down the project if things go badly.
  - expanding capacity if things go well.

2. The Option to Wait and the Value of Information

- Example 7-1a: You are thinking of buying a chain of coffee shops, “Stirbucks”, and operating it for exactly one year. The purchase price is $25M. The end-of-year cash flows, which include both operating profits and resale value, depend on how successful you are at establishing your coffee brand, which in turn depends on consumers’ tastes. With probability 0.8 consumers love your coffee, in which case the cash flow is $32M. However, with probability 0.2 consumers merely like your coffee, in which case the cash flow is only $22M. The opportunity cost of capital is 5%. Should you buy the coffee shops?

- Example 7-1b: Suppose by conducting a field study (going to coffee shops and studying coffee drinkers' choices) you can learn perfectly consumers' tastes within one year. That is, you would know for sure whether consumers loved your coffee or whether they merely liked it. If you wait and conduct the field study you would purchase the coffee shops in one year from now and get the cash flows in two years from now. Should you invest now or wait?

- Solution method:

  Solve the decision tree backwards. At each node of the tree make an **optimal** decision using **all** available information.

- Decision tree:

- Quiz question: Where does this option value come from?

Benefit of field study:

Cost of field study:

Net benefit of field study:

- Example 7-1c: Suppose you are unable to do the field study yourself but rather have to hire an expert to do it. The expert’s fee is due immediately and it takes the expert also one year to learn perfectly consumers’ tastes. What is the maximum amount you are willing to pay for the study?

- Example 7-1d: Suppose consumers' tastes are more extreme than previously assumed. Consumers either absolutely love your coffee, in which case the cash flow is \$35M, or they hate it, in which case the cash flow is only \$10M. Are you willing to pay more for the study in this case?

- Remarks:

  – In Example 7-1 the NPV from investing today is positive, yet it is optimal not to invest. Thus, the option to wait has positive value.

  – An investment opportunity with an embedded option to wait is like a call option with the exercise price being the investment layout and the underlying being the value of the project. By investing we lose (precisely: we exercise) the option. However, there may be value in keeping the option alive and waiting for more information to arrive.

3. The Option to Expand

- <u>Example 7-2a:</u> It is the early 1990s and you are thinking of investing in an Internet bookstore. The investment costs $100M and generates profits of $11M each year forever if consumers' attitude towards the Internet turns out positive and $0 otherwise. Both possibilities are equally likely. The opportunity cost of capital is 10%. Should you make the investment?

- <u>Example 7-2b:</u> Due to your established brand name as the leading Internet bookstore you have the opportunity to expand into Internet sales of CDs a year from now. By that time you have also learned perfectly consumers' attitude towards the Internet. The expansion investment costs $2,000M and generates the following cash flows each year forever starting two years from now:

Consumers Attitude towards Internet	Probability	State of the Economy	Probability	Cash Flow
Positive	0.5	Boom	0.6	$300M
		Recession	0.4	$100M
Negative	0.5	Boom	0.6	$0M
		Recession	0.4	$0M

Given that you have already invested in the Internet bookstore, should you expand into CD sales? Should you invest in the Internet bookstore in the first place?

a) Given that you have already invested in the Internet bookstore, should you expand into CD sales?

b) Should you invest in the Internet bookstore in the first place?

- Remarks:

  – In Example 7-2 it is optimal to invest even though the NPV of the initial investment (i.e., without the option to expand) is negative.

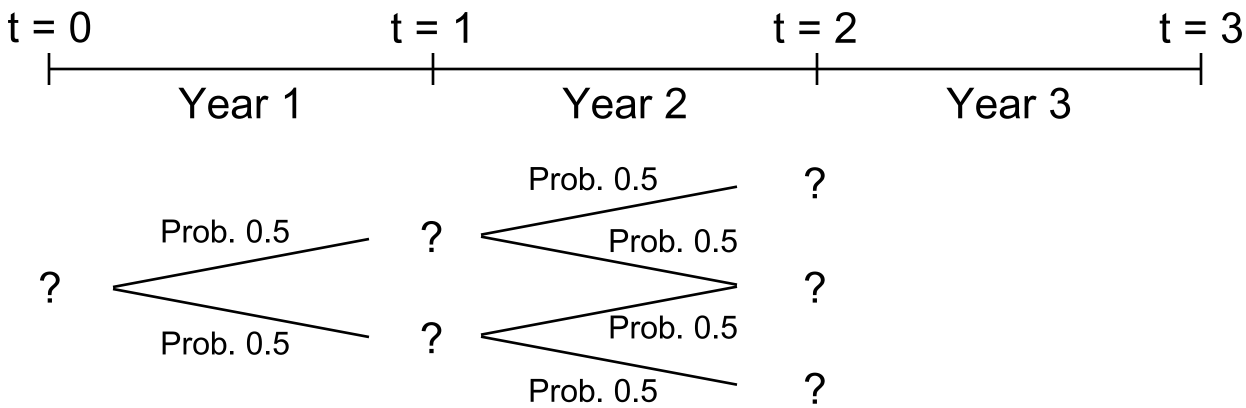
  – From today's perspective, the expansion investment is like an out-of-the-money call option. If consumers' attitude toward the Internet turns out to be positive the option is in the money, and it becomes optimal to exercise it (i.e., to make the expansion investment).

4. The Option to Open and Close

- Example 7-3a: You are thinking of buying the rights to operate a gold mine in Siberia for a three-year period starting today.
  - The mine produces 50K ounces of gold each year.
  - There are no fixed costs of running the mine.
  - Total extraction costs are $230 per ounce.
  - The price of gold is determined at the beginning of a year and stays constant throughout the year. It is currently $220 per ounce.
  - The price of gold either rises by 20% or falls by 10% with equal probability in each of the following two years.
  - The opportunity cost of capital is 5 percent.

How much are you willing to pay for the rights to operate the mine assuming the mine always stays open? Assume cash flows are realized at the end of each year.

- Price of gold (determined at beginning of year):



- Expected (end-of-year) cash flows:

C_1 =

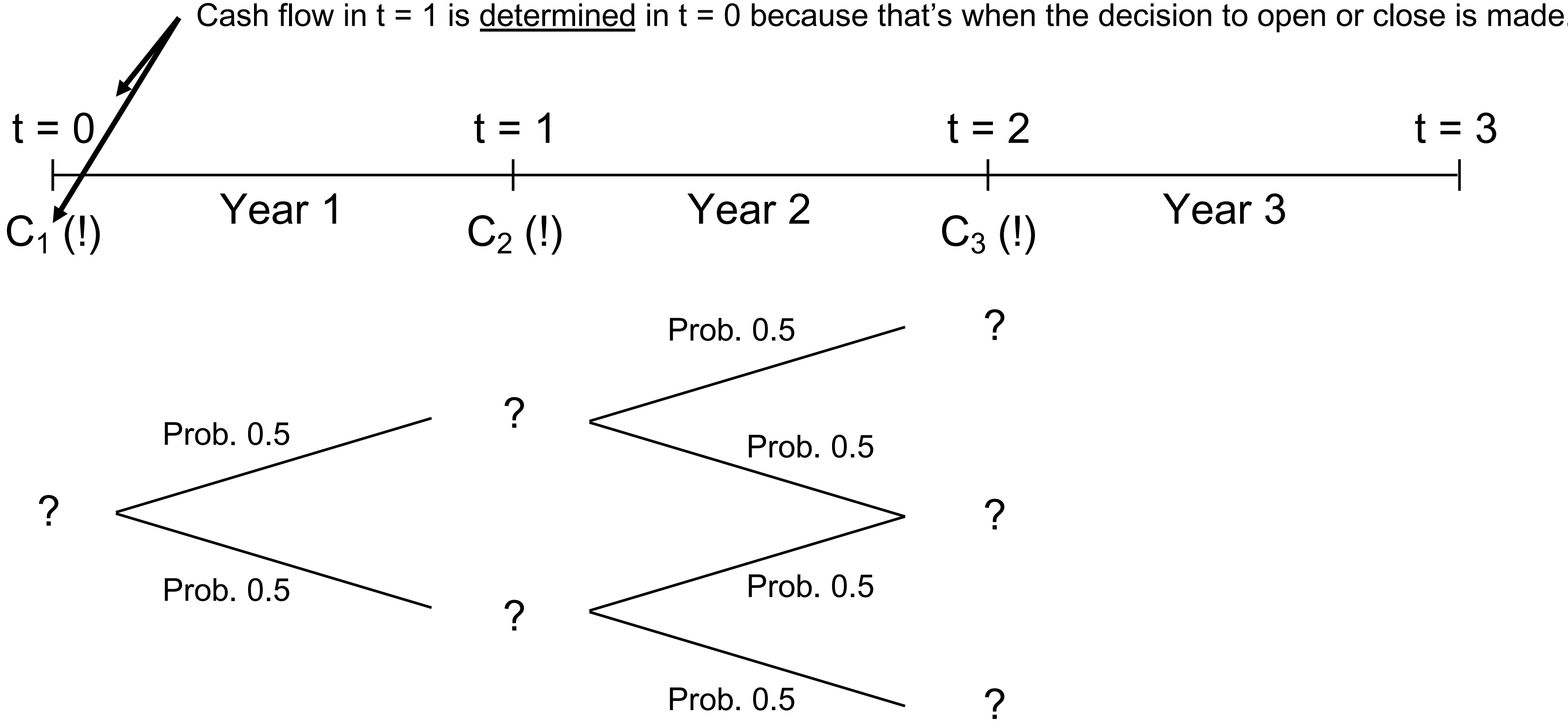
C_2 =

C_3 =

- NPV:

- Example 7-3b: Suppose it is costless to open and close the mine. What is the value of operating the mine taking into account the option to open and close?

- Decision tree with cash flows based on optimal decision:

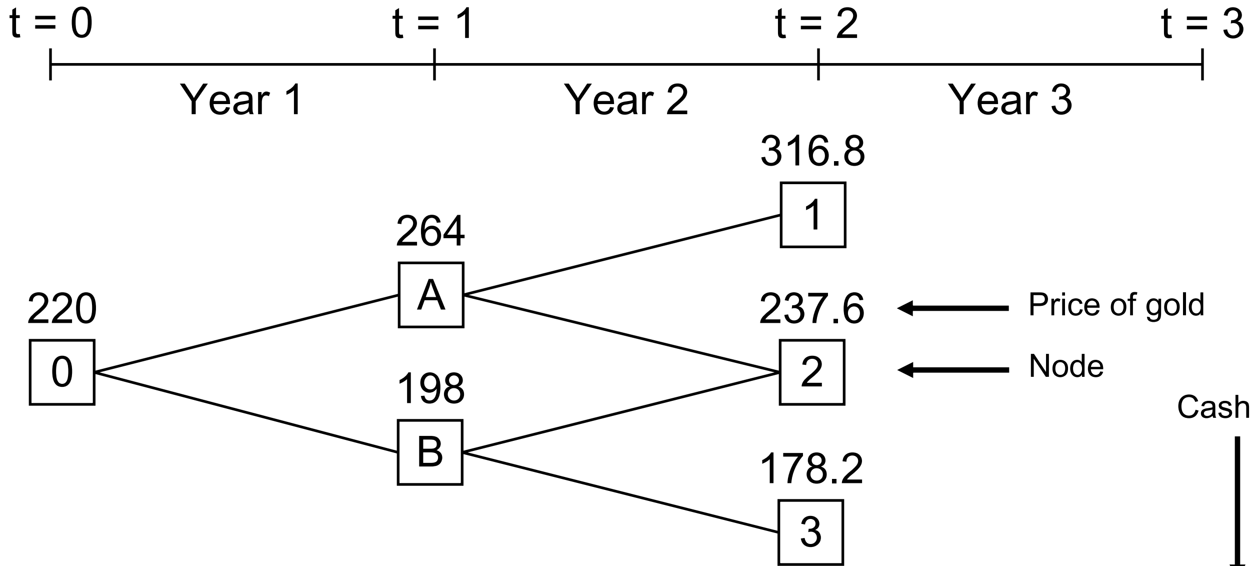


- NPV:

- Example 7-3c: Suppose instead that if the mine is closed it costs \$500K to open it. Likewise, if the mine is open it costs \$500K to close it. The costs of opening and closing the mine accrue at the beginning of a year. The mine is currently closed. What is the value of operating the mine now?

  Note: In Example 7-3b the optimal decision made at the beginning of each year depended only on the (current) price of gold. With opening and closing costs the optimal decision will additionally depend on whether the mine is currently open or closed.

- Solution Method: Must solve decision tree backwards. At each node must compute optimal decision **both** for the case where the mine is currently open **and** where it is currently closed.



			Cash flow based on *optimal* decision	Optimal decision
• Node 1:	• If mine is open	Keep open:	$\frac{50(316.8-230)}{1.05} = 4{,}133$	?
		Close it:	-500	
	• If mine is closed	Open it:	$4{,}133 - 500 = 3{,}633$	?
		Keep closed:	0	
• Node 2:	• If mine is open	Keep open:		?
		Close it:		
	• If mine is closed	Open it:		?
		Keep closed:		

- Node 3:
  - If mine is open $\left\{\begin{array}{ll} \text{Keep open:} & \frac{50(178.2-230)}{1.05} = -2{,}467 \\ \text{Close it:} & \boxed{-500} \end{array}\right\}$ Close it
  - If mine is closed $\left\{\begin{array}{ll} \text{Open it:} & -2{,}467 - 500 = -2{,}967 \\ \text{Keep closed:} & \boxed{0} \end{array}\right\}$ Keep closed

- Node A:
  - If mine is open $\left\{\begin{array}{l} \text{Keep open:} \\ \text{Close it:} \end{array}\right\}$?
  - If mine is closed $\left\{\begin{array}{l} \text{Open it:} \\ \text{Keep closed:} \end{array}\right\}$?

- Node B:
  - If mine is open
    - Keep open: $\frac{50(198-230)}{1.05}+\frac{0.5\times 362+0.5\times(-500)}{1.05}=-1{,}590$
    - Close it: $-500+\frac{0.5\times 0+0.5\times 0}{1.05}=\boxed{-500}$
    - Close it
  - If mine is closed
    - Open it: $-500+(-1{,}590)=-2{,}090$
    - Keep closed: $\boxed{0}$
    - Keep closed
- Node 0:
  - Mine <u>is</u> closed
    - Open it:
    - Keep closed:
    - ?
- NPV: