Additional Lecture Notes
Lecture 3: Information, Options, & Costs

Overview

The purposes of this lecture are (i) to determine the value of information; (ii) to introduce real options; and (iii) begin our analysis of costs.

Notes

> The discussion of information will follow the main lecture notes (§1.4 of *Lecture Notes for 201a* by Davidoff & Hermalin). I won't repeat those notes here. I will also use the notes from §1.5.

1. Information (see §1.4 of *Lecture Notes for 201a* by Davidoff & Hermalin)
2. Real Options
   (a) Material from §1.5 of *Lecture Notes for 201a* by Davidoff & Hermalin
   (b) Capital budgeting. See Figure 1.

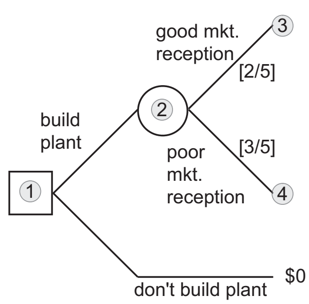


Figure 1: A decision tree for building a new plant

   i. Assumptions:
      - Costs $12 million to build
      - Annual payoff if good market reception to product is $2 million per year
      - Annual payoff if poor market reception to product is $500,000 per year
      - Annual rate of interest is 10%.

- For illustrative purposes assume plant lasts forever. NPV of terminal (payoff) node ③ is \$8 million ($2/.1 - 12$). NPV of terminal node ④ is -\$7 million ($.5/.1 - 12$).

ii. $\mathbb{E}NPV = -\$1$ million.

iii. But things don't stay constant. Assuming always good market reception ever after or always bad market reception ever after ignores possibility of change.

A. Suppose probability of continued reception at same level from year to year is 4/5 and probability of switch in reception from one year to next is 1/5.

B. Let V_g be expected value going forward when in a good state (includes this year's payoff of \$2 million). Let V_p be expected value going forward when in a bad state (includes this year's payoff of \$0.5 million.

C. Observe

$$V_g = 2 + \frac{4}{5}\frac{V_g}{1+r} + \frac{1}{5}\frac{V_p}{1+r} \text{ and}$$
$$V_p = 1/2 + \frac{4}{5}\frac{V_p}{1+r} + \frac{1}{5}\frac{V_g}{1+r}\,.$$

D. Let $\delta = 1/(1+r)$. Have

$$V_g = 2 + \frac{4}{5}\delta V_g + \frac{1}{5}\delta V_p \text{ and}$$
$$V_p = 1/2 + \frac{4}{5}\delta V_p + \frac{1}{5}\delta V_g\,.$$

E. Hence,

$$V_g = \frac{5(4-3\delta)}{2(5-3\delta)(1-\delta)} \text{ and}$$
$$V_p = \frac{5}{2(5-3\delta)(1-\delta)}\,.$$

F. If $r = .1$, then $\delta = 10/11$. Plugging in values, $V_g = \$15.4$ million and $V_p = \$12.1$ million.

G. But this reverses decision:

$$\frac{2}{5}(15.4-12) + \frac{3}{5}(12.1-12) = 1.42\,.$$

iv. Also not necessarily locked in.

A. Return to original NPVs.

B. But suppose that you can scrap factory and get back S, $0 < S < 12$.

C. Tree looks like Figure 2.

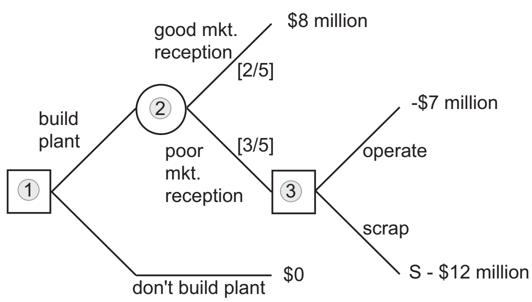


Figure 2: A decision tree for building a new plant when plant can be scrapped

D. If $S > \$5$ million, then scrap.

E. EV calculation

$$\frac{2}{5}8 + \frac{3}{5}(S - 12) = -4 + \frac{3}{5}S\,.$$

F. So, if $S > 20/3$ or $\$6\frac{2}{3}$ million, then should go ahead.

3. Costs

   (a) Arguably most important section of course

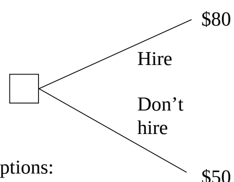
   (b) See attached slides

   (c) Computers in new classroom case

Cost

- **Fundamental Concept: *Opportunity cost***—the value of the most highly valued foregone alternative.
- *All* costs are opportunity costs.

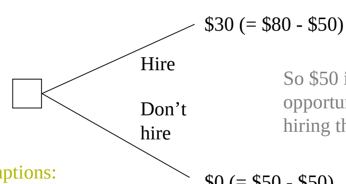
Opportunity Cost



$50 is the *opportunity cost* of hiring the assistant

Assumptions:
•benefit of hiring ass't = $80
•assistant charges me $50

An Equivalent Tree



So $50 is still the opportunity cost of hiring the ass't.

Assumptions:
•benefit of hiring ass't = $80
•assistant charges me $50

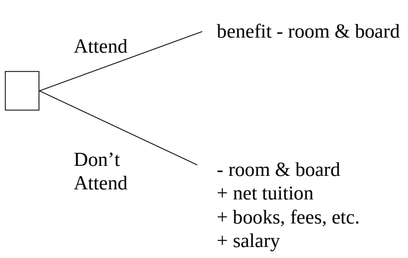
Observation

- Subtracting a *constant* amount from *all* terminal nodes cannot change an expected-value maximizer's decision.

What Does It Cost to Attend Haas?

Tuition (net aid)	
Books, fees, etc.	
Room & board	
Total	

What Does It Cost to Attend Haas?



Cost vs. Expense

Cost	Expense
Tuition	Tuition
Books, etc.	Books, etc.
Salary	—
—	Room & Board

Difference between Cost & Expense

- Salary—an example of an *imputed* cost.
- ***Imputed Cost:*** *the opportunity cost incurred when the owner of a factor employs that factor in one use rather than in its best alternative use.*
- In this case, the factor is your time.

Difference between Cost & Expense

- Room & board—an example of a *sunk expenditure*.
- ***Sunk expenditure:*** *an expenditure that will be made over the relevant decision-making horizon under both the considered course of action and the best alternative action.*

Difference between Cost & Expense

- Imputed costs *do* matter for decision making
- Sunk expenditures do *not* matter for decision making.
- **Cost = Expenditure - Sunk Expenditures + Imputed Costs**

Examples of Imputed Costs

- The cost of using a factor kept in inventory is its current market price, not its historical cost.
  - Apple Computers & memory chips.
- Wear & tear on machinery, vehicles, & other factors that reduces their resale value.

Test for Imputed Cost

If using a factor or asset changes its value, then there is an imputed cost.

Examples of Sunk Expenditures

- The non-recoverable portion of irreversible expenditures made in the past.
  - the difference between what you paid for your textbooks and the amount for which you can resell them.
- Expenditures to which you committed in the past (e.g., many debts).

Test for a Sunk Expenditure

If you can't affect an expenditure over the relevant decision-making horizon, it's a sunk expenditure.

A Cost Taxonomy

- Variable costs vs. overhead costs
- Variable costs are those that vary with each unit produced. Examples include
  - raw materials
  - direct labor

A Cost Taxonomy

- Overhead costs are costs that do ***NOT*** vary with each unit produced. Examples include:
  - – lease of machinery
  - – supervisory staff salaries
- **Caution:** some expenditures that get labeled overhead by accountants are not overhead: either they are variable costs or they are sunk expenditures.

A Cost Taxonomy

- ***Total Cost:*** *the cost of producing some number of units of output.*
- ***Marginal Cost:*** *the cost of producing the* next *unit.*
- If $C(n)$ is the total cost of producing n units, then the marginal cost of the nth unit, $MC(n)$, equals $C(n) - C(n\text{-}1)$.
- ***Average Cost:*** $C(n)/n$.

Marginal Cost: Example 1

- $10 in labor per unit and $5 in raw materials per unit.
- *MC* = $15
- *AC* = $15

Marginal Cost: Example 2

- $10 in labor per unit, $5 in raw materials per unit, $100 to rent machine for the day.
- $MC(1) = \$115$ and $MC(n) = \$15$, $n > 1$.
- **Note:** overhead increases the marginal cost of the unit that triggers the overhead expenditure.
- $AC(n) = \$15 + \$100/n > MC(n)$, $n > 1$.

Marginal Cost: Example 3

- $5 in raw materials per unit and $10 per unit in labor upto 20 units, but $15 (time & a half) per unit for all units beyond 20 units.
- $MC(n) = \$15$ if $n \leq 20$, but $MC(n) = \$20$ if $n > 20$.
- If $n > 20$, then $AC(n) = (\$300 + \$20(n\text{-}20))/n < \$20 = MC(n)$.

Marginal Cost & Average Cost

- Marginal cost will *sometimes* equal average cost (e.g., example 1)
- Marginal cost will *sometimes* be less than average cost (e.g., example 2)
- Marginal cost will *sometimes* be greater than average cost (e.g., example 3)
- **Moral:** Average cost is often a poor estimate of marginal cost.

Marginal Cost & Total Cost

- **Note:** $C(0) = \$0$—producing nothing implies that you are engaged in the best alternative.
- $C(N) = C(N) - [C(N\text{-}1) - C(N\text{-}1)] - \ldots - [C(1) - C(1)] - C(0)$

  $= [C(N) - C(N\text{-}1)] + [C(N\text{-}1) - C(N\text{-}2)] + \ldots + [C(1) - C(0)]$

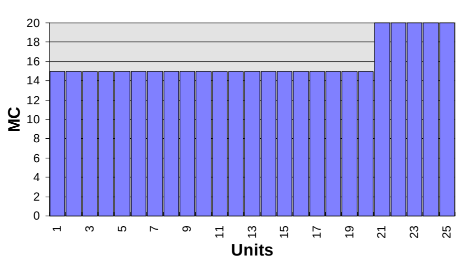
  $= MC(N) + MC(N\text{-}1) + \ldots + MC(1).$

Marginal Cost & Total Cost

- That is,

$$C(N) = \sum_{n=1}^{N} MC(n).$$

Graphically, total cost is the area beneath the marginal-cost schedule:



Going to the Continuum