CIEG 125 Introduction to Civil Engineering Fall 2005

Engineering Economics
Lecture 11

Outline

- Example
- What is Economic Analysis
- Time and Risk
- The Concept of Interest: The Cost of Money
- Methods of Calculating Interest
- Economic Equivalence
- Summary

Example Project

A car manufacturer plans to invest $27 million to expand production facilities. Two different proposals are being considered. The first proposal is to expand a current mid-western assembly plant. This will allow the manufacturer to produce an additional 50,000 cars per year at an average net profit of $200 per car. The second proposal is to build a new assembly plant on the west coast. The facility will have an annual output of only 40,000 cars per year, but the profit is expected to be $350 per car.

The mid western plant can begin production during the first year (I.e. the same year that the investment is mad). However, the west coast plan requires a 1 year start up so that production cannot begin until the second year. For planning purposes, the company is assuming that each assembly plant has a lifetime of 5 years of actual production.

Which option should we take?

- The example problem is a typical use of engineering economics
- Typically, you will be presented with different projects with different investment and different revenues and you will have to decide among them.

The Role of Engineers in the Public Sector

- Engineers in the public sector also have to:
  - » acquire equipment (inspection truck)
  - » allocate resources to acquire assets (bridge)
  - » allocate resources to maintain assets
  - » evaluate competing proposals for projects and
  - » determine where costs can be reduced

All require engineering economic analysis

Three Possible Investments

- For a $20,000 investment now:
  - » Option 1: you get $25,000 at the end of 5 years
  - » Option 2: you get $1,000 at the end of each of the next five years, and $20,000 at the end of year 5.
  - » Option 3: you get $1500 at the end of each of the next five years and $17,500 at the end of year 5.

Three New Possible Investments

- For a $20,000 investment now:
  - » Option 1: You definitely get $1,000 at the end of each of the next 5 years, and $20,000 at the end of year 5.
  - » Option 2: You get anywhere from $800 to $1400 at the end of each of 5 years, and $20,000 at the end of year 5.
  - » Option 3: You get anywhere from $0 to $3,000 at the end of each of 5 years, and $20,000 at the end of year 5.

Time and Risk

- All investments have aspects of time and risk.
- The first three options gave you back different amounts over time, they are different options.
- They are based on your time value of money.
- The second three options had different amounts of risk - different expected values and variances.

Time Value of Money

- If I were to give you $1000, what would you do with that money?
- You could
  - » spend it
  - » deposit it in the bank
  - » invest in stocks and bonds
  - » lend it to someone else

Time Value of Money .... cont.

- Assume inflation is 0%

That is, I can buy exactly the same in the future as I can now.

- If I invest the $1000 now, I can buy more in the future.
- Why?..... the time value of money.

Time Value of Money .... cont.

- Which would you rather have?
  - » $1000 given to you now
  - » $1000 given to you one year from now
- Getting the $1000 now is worth more to you than $1000 in the future as you have the money to invest.
- Getting money sooner is better than later.

The Concept of Interest

- When we lend someone the use of money, we expect to be paid interest
- When we borrow money, we expect to pay interest.
- Interest represents the cost of money.
- If you borrow my money (or your parents money), I (they) could have been doing something else with that money to make more money.

The Concept of Interest....cont.

- The cost of money is related to
  - » the amount of money
  - » how long you keep it
- Interest is described in terms of a percentage per time period, for example, 5% annual percentage rate (APR).

Methods of Calculating Interest

- Simple interest - interest earned only on principal

$I = iPN$

$F = P+I = P(I+iN)$

- Compound interest - interest on principal and interest

$P\&I_1 = P(1+i)$

$P\&I_2 = P\&I_1 (1+i) = P(1+i)^2$

$P\&I_N = F = P\&I_{N-1} (1+i) = P(1+i)^N$

Elements of Transactions

- Principal (P) - amount being lent or borrowed
- Interest rate per period (i)
- Interest period (n) e.g. month, quarter
- Number of interest periods (N)
- Plan for receipts or disbursements (A_n)
- Future amount of money (F)
- End of period convention

Examples of Interest Calculations

- Given P = $5000, annual interest rate of 8% compounded semi annually for 2 years

n	Simple	I	Compound	I
0	$5,000		$5,000	
1	$5,200	200	$5,200	200
2	$5,400	200	$5,408	208
3	$5,600	200	$5,624	216
4	$5,800	200	$5,849	225

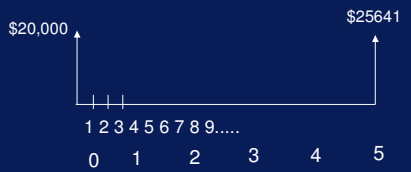
Cash Flow Diagram

P= $20,000,
5% annual interest rate, compounded annually
i = 5% , n = 1 year, N = 5

$F = (P+I)^N = \$20,000\ (1.05)^5 = \$25,525$

$P = (F+I)^{-N} = \$25,525\ (1.05)^{-5} = \$20,000$

Cash Flow Diagram... cont



P= $20,000,
5% annual interest rate, compounded quarterly
i = 1.25%, n = 1/4 year, N = 20

$F = P(i+I)^N = \$20,000\ (1.0125)^{20} = \$25,641$

$P = F(i+I)^{-N} = \$25,641\ (1.0125)^{-20} = \$20,000$

Economic Equivalence

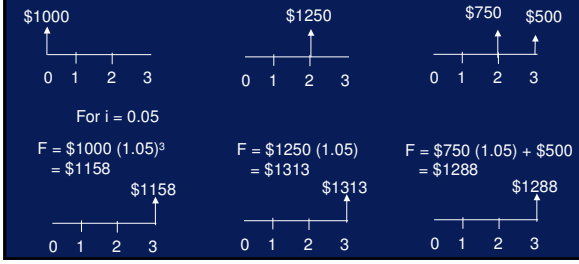
- How do we measure and compare various cash flows?
- The time value of money complicates this.
- Would you prefer:
  - » $1000 now
  - » $1250 2 years from now
  - » $750 2 years from now and $500 3 years from now

Economic Equivalence.... cont.

- Two cash flows are **economically equivalent** if:
  - » they have the same future value (economic effect)
  - » they can be traded for one another w/o economic effect
- To determine if two cash flows are equivalent, we must convert each cash flow to an equivalent payment at any point in time.

Economic Equivalence.... cont.

- To convert a cash flow to a specific point in time, you use the compound interest formula for each payment.



General Observations

- common time basis
- Equivalence depends on interest rate
- conversion of multiple payment cash flows to a single cash flow
- independent of point of view (point in time)

Example Project

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- The mid western plant can begin production during the first year (I.e. the same year that the investment is mad). However, the west coast plan requires a 1 year start up so that production cannot begin until the second year. For planning purposes, the company is assuming that each assembly plant has a lifetime of 5 years of actual production.

Process of analysis

- Establish the cash flows of the projects
- Establish the interest rate to be used
- Compute the economically equivalent value of each project at a point in time
- Compare the computed project values
- Note that you may choose not to do any project

Project cash flows

- When analyzing competing projects, you need to establish the net cash flows for each period.
- This needs to be done in a systematic manner.

Year (n)	Cash Inflow	Cash Outflow	Net Cash Flow
0		$27m	-$27 m
1	$10 m		+$10 m
2	$10 m		+$10 m
3…..			

Project cash flows for example

Midwestern expansion option:

Year (n)	Cash Inflow	Cash Outflow	Net Cash Flow
0		$27m	-$27 m
1	$10 m		+$10 m
2	$10 m		+$10 m
3	$10 m		+$10 m
4	$10 m		+$10 m
5	$10 m		+$10 m

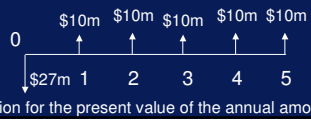
Project cash flows for example

Western plant option:

Year (n)	Cash Inflow	Cash Outflow	Net Cash Flow
0		$27m	-$27 m
1			$0
2	$14 m		+$14 m
3	$14 m		+$14 m
4	$14 m		+$14 m
5	$14 m		+$14 m

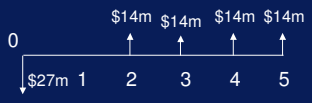
Revisit Manufacturing Example - Option 1.

- Assume the minimum attractive rate of return is 8%
- NPV = $10M (P/A,8%,5)* - $27M
  =$10M (4.9937 -27M
  = $12.9M



* Short hand notation for the present value of the annual amount

Revisit Manufacturing Example - Option 2.



- Assume MARR = 8%
- NPV = $14m (P/A, 8%,4) (P/F,8%,1) - $27m
  = $14m(3.3121)(0.9259) - $27m
  = $42.9m - $27m
  = $15.9m
- Thus, option 2 is better for the company than option 1

Summary

- Money can make more money over time
- Money costs money to borrow - interest
- Different cash flows may occur at different times and in different amounts
- To compare cash flows, they must be converted to a specific point in time using the same interest rate.

Summary

- All investments have time and risk aspects
- Major types of engineering economic decisions:
  - » Material and process selection
  - » Equipment replacement
  - » New product and product expansion
  - » Cost reduction
  - » Service improvement