Comparing Alternatives

CE 215

Comparing Alternatives

- A basic part of engineering is choosing between alternative designs.
- Economic comparisons are tremendously important in our society, and are usually used to select between alternatives.
- We will discuss the tools available for making economic comparisons between alternatives.

Other Comparisons

- Comparisons between alternatives can also be based on:
  - Social value
  - Aesthetics
  - Environmental values
  - But these are difficult to quantify and agree upon.
  - Or a decision may involve several bases of comparison.
- These non-economic concerns are often reduced to economic comparisons, as well.

Methods of Economic Comparison

- Patterns of investment, revenue, saving, cash flow can vary widely.
- There is no single method for making all economic comparisons.
- We will describe three equivalent worth methods for comparing alternatives:
  - Present worth
  - Annual worth
  - Future worth

Other Economic Comparison

- In Engineering Economics, you will also discuss economic comparisons based on rate of return.
  - I.e., an annual rate of profit or savings on one's investment.
- Rate of return comparisons can be made based on:
  - Internal rate of return
  - External rate of return
  - Explicit reinvestment rate of return,
    - Which differ depending on the interest rate available for the profits or savings.

Equivalence between Methods

- All of these methods result in the same decision (i.e., they select the same alternative) as long as the inherent assumptions underlying each method are applicable.

Other Methods

- Economic comparisons can also be based on:
  - “Payback period” - the time required to earn back the original investment.
    - This method typically ignores the time value of money, and will not always be consistent with the previous methods
  - Benefit-cost ratios.
    - This method is often used for public sector economy studies.

Interest Rates

- When a business or government agency decides to invest in a project, they have to weigh:
  - The amount they expect to earn from the project against,
  - The amount they could earn by investing the money elsewhere.
    - Economists refer to this as an “opportunity cost.”
- In order to invest in a project, it must provide a minimum attractive rate of return (M.A.R.R.)

M.A.R.R.

- The minimum attractive rate of return depends on the amount of risk the investor is willing to accept.
  - It can vary significantly, depending on the investors’ objectives.
- The minimum attractive rate of return becomes the interest rate used in the time value of money calculations.

Taxes

- Taxes are a substantial cost of doing business.
  - Most corporations pay about one-half of their gross profits in state and federal income taxes.
- Obviously they will have a significant impact on actual profits or costs of any project.
  - Unfortunately, they can be extremely complicated.

Taxes (cont.)

- However, many projects will pay the same tax rates for any of the alternatives under consideration.
- If this is true, comparisons can be made without considering taxes.
  - I.e., the same decision will be reached with or without including taxes in the calculations.
- If alternatives result in different tax rates, taxes must be considered in the calculations.

Present Worth Comparisons

- The present worth of an alternative is the amount of money that would have to be set aside now to provide for all future expenditures.
- All alternatives are compared on the basis of their present worth.

Time Span

- All alternatives should be compared over the same length of time.
- Using the "repeatability" approach, we
  - Choose a study period that is the least common multiple of the lives for the alternatives, and
  - Assume that whatever happens during an alternative's initial life span will happen in all subsequent life spans.

Present Worth Example

- Two structures are being considered.
  - Both structures generate the same revenue, so direct revenues are not considered in the comparisons.

	Structure M	Structure N
First cost	$12,000	$40,000
Useful Life (years)	10	25
Salvage Value at end of life	$0	$10,000
Annual Cost (O&M)	$2,200	$1,000

  - I.e., structure N costs more to build, but lasts longer and is cheaper to maintain.

Time Span & M.A.R.R.

- The least common multiple of both structure's life span is 50 years.
  - Structure M will be built once and replaced four times.
  - Structure N will be built once and replaced once.
- The costs will be the same for each replacement.
- The minimum attractive rate of return for the investors is 15%.

Structure M

Present Worth of Costs	Structure M
Original Investment	$12,000
First replacement $12,000(P/F, 15%, 10)	$2,966
Second replacement $12,000(P/F, 15%, 20)	$733
Third replacement $12,000(P/F, 15%, 30)	$181
Fourth replacement $12,000(P/F, 15%, 40)	$45
Annual O&M costs $2,200(P/A, 15%,50)	$14,653
Total Present Worth - Costs	$30,579

Structure N

Present Worth of Costs	Structure N
Original Investment	$40,000
First replacement ($40,000-10,000)(P/F, 15%, 25)	$911
Final Salvage $10,000(P/F, 15%, 50)	($9)
Annual O&M costs $1,000(P/A, 15%,50)	$6,661
Total Present Worth - Costs	$47,563

- Note that the final salvage value is a revenue rather than a cost.

Comparison

- Structure M is the preferred alternative, since it has the lower present value of costs.
- The lower cost is a function of the interest rate.
  - If the example is redone with a M.A.R.R. of 5%, Structure N is preferred.
- Since money is fairly expensive, it is cheaper to save on initial costs rather than on long term costs.
  - This is a fairly common result.

Annual Cost Method

Annual Costs	Structure M	Structure N
Operations and Maintenance	$2,200	$1,000
Capital Recovery Costs		
$12,000(A/P, 15%, 10)	$2,391	
$40,000(A/P, 15%, 25)		$6,188
$10,000(A/F, 15%, 25)		($47)
Total Annual Cost	$4,591	$7,141

- Note that the salvage value is a revenue

- Again, Structure M is the preferred alternative for this minimum attractive rate of return.

Inflation

- Inflation significantly affects the time value of money.
  - It is an annual rate of change in the value of money.
- E.g., if the annual rate of inflation is 5%, everything will cost 5% more at the end of the year.
  - The rate of inflation compounds, just like investments.

Example with Inflation

- Consider the previous example with a 5% annual rate of inflation applied to the replacement costs, salvage value, and operating costs
  - The first replacement cost for Structure M at 10 years is thus

$$\text{First Replacement} = \$12{,}000(F/P,\ 5\%,\ 10) = \$19{,}547$$

  - And the salvage value for Structure N at 25 years is

$$\text{Salvage} = \$10{,}000(F/P,\ 5\%,\ 25) = \$33{,}864$$

Structure M

Present Worth of Costs	Structure M
Original Investment	$12,000
First replacement $19,547(P/F, 15%, 10)	$4,832
Second replacement $31,840(P/F, 15%, 20)	$1,945
Third replacement $51,863(P/F, 15%, 30)	$783
Fourth replacement $84,480(P/F, 15%, 40)	$315
Annual O&M costs $2,200(P/A, 15%-5%,50)	$21,813
Total Present Worth - Costs	$41,688

- Note that the operating costs increase at the *net* interest rate (interest less inflation).
  - Inflation reduces the amount of interest we're earning on the monies we set aside (now) to cover the annual O&M costs

Structure N

Present Worth of Costs	Structure N
Original Investment	$40,000
First replacement ($135,454-33,864)(P/F, 15%, 25)	$3,086
Final Salvage $114,674(P/F, 15%, 50)	($106)
Annual O&M costs $1,000(P/A, 15%-5%,50)	$9,915
Total Present Worth - Costs	$52,895

- Structure M remains the preferred alternative, but the margin between the two has narrowed.

Summary

- Economic comparisons can be made if costs and revenues are reduced to a common basis, such as present worth, annual worth, or future worth.
  - All three methods select the same alternative if the underlying assumptions are satisfied.
- Comparisons are sensitive to the interest rate, which is based on the M.A.R.R.
- Comparisons are also sensitive to the inflation rate.