Engineering Economic Analysis - Newnan, Lavelle, and Eschenbach Chapter 8

Incremental Analysis of Multiple Alternatives

A. Choices Involving Multiple Alternatives
   1. Mutually exclusive: At most, one project out of a group of alternatives may be chosen
   2. Independent: The choice of any one project is independent of the choice of any other project in the group of alternatives. Any number of projects may be chosen as long as sufficient capital is available.
   3. Contingent: The choice of a particular project is conditional on the choice of one or more of the other projects.

B. Incremental Analysis of Mutually Exclusive Alternatives with Equal Analysis Periods
   The examination of the differences between mutually exclusive alternatives is based on incremental first costs, incremental benefits and other yearly cash flows, and incremental salvage values. Complex cash flows complicate incremental rate of return (ΔROR) methods and are best done on spreadsheets.
   1. Graphical Methods (Chapters 8, 9)
      - Graphical Methods such as those illustrated in Chapter 8 and the accompanying spreadsheet analyses are generally not used to solve problems, but serve to illustrate the interrelationships between the various analysis methods. Graphical methods show how the conclusion concerning the best alternative is the same, regardless of the analysis method used.
      - If PW of Benefits is plotted against PW of Cost for all alternatives using the MARR as the interest rate, the 45 degree line where PWB = PWC at an interest rate equal to the MARR represents the NPW = 0 condition. Alternatives which plot in the lower quadrant of the graph are undesirable since they have an IRR less than the MARR. The vertical distance from the NPW = 0 line to an alternative (either positive or negative) indicates the NPW of the Alternative.
      - If several alternatives have IRR's greater than the MARR (i.e. they plot in the upper quadrant of the graph), then the best alternative is the one with the highest NPW, which is the vertical distance from the NPW = 0 line. In terms of ΔROR's, this corresponds to going along the decision tree until the highest initial cost with an incremental slope greater than unity is found. A n y incremental slope less than unity indicates an alternative which, by itself, satisfies the IRR > MARR or B/C > 1 criteria, but whose incremental cost does not justify the incremental benefit.
   2. Analytical Methods for Increments of Investment (Chapters 7, 8, 9, and 20)
      - Be sure all the alternatives and their benefits and costs are identified. Net the annual cash flows as explained in the spreadsheet material.
      - Compute the IRR for each alternative and reject any which are less than the MARR. Alternatively, a Benefit/Cost ratio > 1.0 is required to be eligible for "the final tournament". For cost only situations, this step is skipped.
      - Arrange the remaining alternatives in ascending order of initial investment for ΔROR analysis (which should correspond to ascending order of PW of cost for Benefit/Cost ratio analysis if net annual cash flows are used.)
      - Make a two alternative ΔROR analysis or ΔB/ΔC analysis
         If ΔROR ≥ MARR, or ΔB/ΔC ≥ 1.0, retain the higher cost alternative
         If ΔROR < MARR, or ΔB/ΔC < 1.0, retain the lower cost alternative
      - Continue along the decision tree until the best of the mutually exclusive multiple alternatives has been selected.
A. Future Worth Analysis

Future Worth analysis arrives at the same conclusion as net present worth analysis in comparing alternatives except the results are given in terms of future values. This may be useful in setting up savings goals and finding the future value of a long lead time plant construction project at the time it goes into operation.

B. Benefit-Cost Ratio Analysis requires a meaningful MARR and dollar values for the benefits. (Intangible benefits are a problem to analyze in cost effectiveness studies.)

\[ \text{Benefit/Cost Ratio, } B/C = \frac{\text{PW of Benefits}}{\text{PW of Costs}} \]

For a project to be considered acceptable, \( B/C \geq 1.0 \)

For mutually exclusive multiple investment alternatives, incremental analysis is required; i.e., each increment of additional cost for more expensive solutions must produce additional benefits in excess of the additional costs. One then chooses the highest cost alternative with

\[ \Delta B/\Delta C \geq 1.0 \]

Incremental Benefit/Cost Ratio analysis is easier to analyze on a hand calculator than the Incremental Rate of Return method discussed in Chapter 7. It gives the same results and uses a decision tree arranged in order of increasing present worth of costs. The absolute magnitudes of the ratio depend on whether gross or net benefits and costs are used. There is no general agreement that the "Net Annual Cash Flow" is the best method of analysis except that it must be used for "cost only" analysis and is the only way to avoid conflicting results in some situations.

C. Payback Period

- Payback period is the period of time required for the profit or other benefits from an investment to equal the cost of the investment, i.e., how quickly capital will be recovered.
- Payback period ignores useful life, salvage value and the time value of money. It should be avoided in comparing alternatives since the results of this analysis can be misleading.
- It can be found from the cumulative cash flow vs. year graph in a spreadsheet analysis.

D. Sensitivity and Breakeven Analysis

These techniques are used to see how sensitive a decision is to estimates for the various parameters.

- Breakeven analysis is done to locate conditions under which various alternatives are equally desirable. Examples include single vs. multi-stage construction, hours of equipment utilization, production volume required, equipment replacement analysis (Chapter 12.)
- Sensitivity analysis is an examination of a range of values for some parameter to determine their effect on a particular decision. This is illustrated in a number of graphs which accompany the spreadsheets in the spreadsheet supplements.
Depreciation is a decline in market or asset value of physical properties caused by deterioration or obsolescence. It represents a legal loss of value for tax purposes. Depreciation involves a systematic allocation of the cost of an asset over its depreciable life. The annual depreciation expense is deductible for income tax calculations. However, if the asset is sold for more than its book value, the recovered depreciation is taxed as ordinary income. Depreciation thus represents tax deferral, not tax avoidance. (Note: Land is a non-depreciable asset.)

A. Definitions of Value
1. **Market Value**: Cost of a property when both buyer and seller have equal advantage and are under no compulsion to buy or sell.
2. **Use Value**: Worth of a property to its present owner because of its current use.
3. **Esteem Value**: Worth of a property to its present owner because of its qualities that make people want to possess the product.
4. **Fair Value**: Worth of a property determined by a disinterested party as fair to both buyer and seller.
5. **Salvage (resale) Value (S)**: Price that can be obtained from the sale of the property
6. **Book Value**: Original cost (P) of a property less the amounts that have been charged as depreciation expense.
7. **Adjusted Basis Value**: Book value plus the cost of improvements, additions, and other capital costs, commissions, legal fees, etc. minus certain credits. This value is essential in calculating the taxable profit or loss from the sale of property.

B. Pre-ACRS/MACRS Methods of Depreciation
1. **Asset Life**: In 1971 the U.S. Treasury Department published guidelines for about 100 classifications of depreciable asset including the concept of an Asset Depreciation Range (ADR) whose midpoint lives were somewhat shorter than the actual average useful lives.
2. **Depreciation Methods**: Although most business depreciation uses either MACRS or straight line depreciation, the other methods may still be found on the EIT examination.

- **Straight line (S.L.) Depreciation**:  
  Annual depreciation charge = (P-S)/N where N = Depreciable life  
  Book value at end of year n = P - n(P-S)/N  
  n = 1.....N

- **Sum-of-Years Digits (SOYD) Depreciation**  
  Sum-of-Years Digit = N(N+1)/2  
  SOYD depreciation for year n = (P-S)[2(N-n+1)/(N(N+1))]  
  = (P-S)(Remaining useful life at beginning of year n)/SOYD

- **Declining Balance Depreciation**  
  Double Declining Balance depreciation in any year = 2(Book Value)/N  
  = 2(Cost - Depreciation charges to date)/N  
  Book value at end of year n = P(1-2/N)  
  Implied Salvage value at the end of N years = P(1-2/N)  
  (see discussion pp. 378-379)

- **Declining Balance Depreciation with Conversion to Straight Line Dep.**  
  Rule: Switch from declining balance to S.L. whenever S.L. results in a larger depreciation charge. (Table 10-1). This is handled automatically in the spreadsheet program MACRS as illustrated in Tables 10S-1 and 10S-2.
• **Unit of Production Depreciation, Cost and Percentage Depletion**
  Depletion allowances on oil, gas, mineral, and timber properties may be based on the units of production relative to the total expected production over the lifetime of the resource or may be based on percent of gross income (up to 50% of taxable income).

  • These acts introduced the Accelerated Cost Recovery System (ACRS) as the standard depreciation method for assets placed in service after 31 December, 1980. It did not retroactively affect depreciation practices for assets placed in service prior to 1 January, 1981. ACRS allowed some of the older methods to be used in special circumstances, so these methods are still covered in the course. The Tax Reform Act of 1986 replaced the more liberal ACRS depreciation schedules with the MACRS (Modified Accelerated Cost Recovery System) which is currently in effect as modified yearly by the Congress.

2. **Principal features of the 1981 Act**
  • Depreciable life was considerably less than the useful life for most classes of assets. Real estate could be fully depreciated in 15 years.
  • Salvage value was assumed to be zero
  • Half-year ownership was assumed for non real estate property regardless of when the property is placed in service.
  • An investment tax credit of up to 10% of the value of the asset was allowed.

  • To decrease the number of "tax shelters" generated by features of the 1981 act, the depreciable lives were lengthened and the half-year convention was introduced. That is, three year property is depreciated over three and one half years and so forth as illustrated in Table 10-4.
  • Automobiles used for business were changed from three year property to five year property. Real estate was changed from 15 year property to 18 year property and then to 27.5 and 31.5 year property. Commercial real estate has recently been changed to 39 year property.
  • "Passive losses" generated by leveraged depreciation charges were outlawed for passive investors who did not have an active management role in running a limited partnership tax shelter. This combined with the lower depreciation charges for real estate essentially caused the collapse of the tax shelter business for passive investors and was a contributing factor in the collapse of many savings and loan organizations.
  • The mid-quarter convention was introduced for personal property.
  • The investment tax credit was repealed.
  • Table 10-3, lists the MACRS property classes and
  • Tables 10-4 and 10-5, list the MACRS depreciation percentages for the various classes of depreciable property.