Chapter 5 Present Worth (Value) Analysis

• Introduction
  ➢ Given a set of “feasible” alternatives, engineering economy attempts to identify the “best” (most viable) alternative(s) from an economic perspective.
  ➢ Economic perspective requires a quantitative criteria for decision making.
  ➢ In this chapter, we study the present worth criteria.

• Types of economic projects
  ➢ Mutually exclusive alternatives
    o From a set of feasible alternatives, pick only one. E.g., which car to buy.
    o Mutually exclusive alternatives “compete” with each other.
  ➢ Independent projects
    o From a set of feasible alternatives select as many as possible to meet the economic criteria the most. E.g., where to invest money?
    o In the absence of a budget constraint, choose all alternatives that do better than the “do nothing” alternative.
• Do nothing (status-quo) alternative
  ➢ This is the alternative of not changing the current situation. E.g., keep money in a saving account, rather than in stocks.

• Cash flow types for projects
  ➢ Revenue – each alternative generates costs and revenues over the life of the project. E.g., what product to introduce?
    o Criteria: Select the alternative that maximizes the economic measure of merit, which is profit-based.
  ➢ Service – each alternative has only cost cash flows. Revenues are the same for all alternatives. E.g., which 100-seat plane to buy?
    o Criteria: Select the alternative that minimizes the economic measure of merit, which is cost-based.

• Present Worth (PW) analysis
  ➢ This is the process of obtaining the equivalent worth of future cash flows at present time.
  ➢ That is, finding PW of cash flows.
  ➢ We say that future cash flows are “discounted” to time 0.
  ➢ The higher the PW, the better
  ➢ PW is evaluate based on an interest rate, which is equal to the organization’s MARR.
• PW analysis of equal-life alternatives
  ➢ Mutually exclusive projects
    o For one project, it is financially viable if \( PW \geq 0 \).
    o For 2 or more alternatives, select the one with the (numerically) largest PW value.
  ➢ Independent Projects
    o Select all projects with \( PW \geq 0 \)
    o However, in practice a budget limit exists (see Ch. 12)

• PW analysis of different-life alternatives
  ➢ For alternatives with unequal lives the rule is
    \( PW \) must be compared over the same number of years.
  ➢ This is called “equal service” requirement
  ➢ Equal service requirement can be met in two ways
    o LCM
      ▪ Evaluate alternatives over the lowest common multiple of lives. E.g., lives of 4 and 6, use \( n = 12 \).
      ▪ Assume reinvestment at same cash flow estimates in each life cycle of the LCM planning horizon.
    o Study period
      ▪ Assume a fixed planning horizon and evaluate the alternatives over it.
      ▪ Ignore cash flows beyond the planning horizon.
• **LCM assumptions**
  - The service provided is needed for LCM years or more.
  - The selected alternative is repeated over each the life cycle of the LCM in exactly the same manner.
  - Cash flow estimates are the same in every life cycle.

• **Study period and alternative life**
  - Depending on the life of an alternative, three cases could occur when adopting the study period approach.
    1. *Alternative life equal to the study period.* No adjustment to the cash flow is required.
    2. *Alternative life longer than the study period.* An implied salvage value must be added to the alternative at the end of the study period.
       - The salvage value may be estimated based on the *market value* of the asset generating the cash flows.
       - It may be also based on the PW of remaining cash flows (i.e., *book value*).
    3. *Alternative life shorter than the study period.* Assumptions must be made on what happens in the additional years between end of life and end of study period.
       - For service (cost) alternatives, one can estimate the costs of continuing service over the additional years.
       - For revenue alternatives, one may assume that the net receipts are invested at MARR for the additional years.
• **Future worth (FW) analysis**
  
  - Similar to PW analysis but uses future instead of present values. (MARR is also used to find future values.)
  - Utilized when
    - A prime goal is to maximize future wealth of stockholders.
    - Asset may be sold after some time of startup (e.g., buy a company and sell it in three years).
    - Projects will not “come online” until end of investment period (e.g., construction projects).
  - FW and PW criteria are equivalent in comparing alternatives.

• **Capitalized Cost (CC) analysis**
  
  - Capitalized cost is the present worth of a project that lasts forever.
  - This occurs
    - Public Sector Projects. E.g., roads, bridges, dam.
    - Not-for-profit organization endowments.
  - For these projects, the life cycle, $n$, is either very long, indefinite, or infinity.
  - The CC for an infinite uniform series of cash flows (with annuity $A$) is
    \[
    CC = \lim_{n \to \infty} \frac{A}{i} \left[1 - \frac{1}{(1+i)^n}\right] = \frac{A}{i}.
    \]
➢ To evaluate CC for any cash flow, do the following.
  o For nonrecurring (one-time only) cash flows
    ▪ The CC of the cash flows is their PW.
  o For a recurring cash flow of value $R$, that repeats every $n_R$ years
    ▪ Find equivalent uniform annual worth through one life cycle of recurring amounts, $A_R = R(A/F, i, n_R)$.
    ▪ Find equivalent CC for the AR series, $CC_R = A_R / i$.

➢ Alternatives that have infinite lives can be compared on the basis of CC, which is equivalent to PW criteria.
➢ When an alternative with a finite life is to be compared with another having infinite life, the guidelines for alternatives with life shorter than study period (here infinity) are applied.
• **Payback period analysis**
  - Payback period is the estimated time it will take for the revenues of a project to recover the initial investment.
  - The payback period, $n_p$, is such that
    \[
    0 = -P + \sum_{t=1}^{n_p} NCF_t(P / F, i, t),
    \]
    where $P$ is the initial investment and $NCF_t$ is the net cash flow at time $t$.
  - This equation can be solved using trial an error or using a computer package (e.g., Excel solver.)
  - If $i = 0\%$, $0 = -P + \sum_{t=1}^{n_p} NCF_t$. If, in addition, $NCF_t = NCF$ for all $t$, $n_p = P / NCF$.
  - This method estimate of $n_p$ is often used in practice for quick initial screening.
  - Payback period analysis should not be used as the primary means of making an accept/reject decision on an alternative.
  - E.g., one reason for caution with payback analysis is that it ignores cash flows after time $n_p$. 

• Life-Cycle costs
  ➢ Engineering projects costs are accrued in two main phases: acquisition and operations.
  ➢ The acquisition phase includes requirement definition, preliminary design (includes feasibility study), and detailed design stage.
  ➢ The operations phase includes construction and implementation, usage, and phaseout/disposal.
  ➢ Commonly 75-85% of the cost is in acquisition phase.
  ➢ Therefore, the potential for significantly reducing costs is primarily during early stages.