Chapter 9 – Benefit/Cost Analysis and Public Sector Economics

INEN 303
Sergiy Butenko
Industrial & Systems Engineering
Texas A&M University

Public Sector Projects
• Public Sector:
  • Ownership – by citizens- the public
• Public Sector Projects:
  • Provide needed services to the public at “no profit”

Types of Projects
• Hospitals
• Parks and recreation facilities
• Highways, Dams, Bridges
• Courts, prisons, schools
• Public Housing
• Many others

Characteristics compared

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Public Sector</th>
<th>Private Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of Investment</td>
<td>Larger</td>
<td>Some Large, more medium to small</td>
</tr>
<tr>
<td>Life Estimates</td>
<td>Quite Long 30 – 50 years</td>
<td>Shorter: 2-25 years</td>
</tr>
<tr>
<td>Annual Cash Flow estimates</td>
<td>No Profit: costs, benefits and disbenefits</td>
<td>Revenues – profit, cost estimates</td>
</tr>
</tbody>
</table>

Funding Sources Compared

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Public Sector</th>
<th>Private Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Funding</td>
<td>Taxes, fees, bonds, private funds</td>
<td>Sale of new stock, bonds, loans, …</td>
</tr>
<tr>
<td>Interest Rate</td>
<td>Tends to be lower</td>
<td>Higher: At market cost</td>
</tr>
</tbody>
</table>
Estimating Costs for Public Projects

- **Costs**
  - Construction, operations, maintenance less estimated salvage values
  - Initial costs fairly well known
  - Future O&M are less known and must be estimated

Estimating Benefits and Disbenefits

- **Benefits** to the owners (the public) must be estimated in terms of periodic dollar values
- **Disbenefits** are expected undesirable (negative) consequences to the owners (public)
  - May be indirect
  - Very hard to estimate and convert to $ amounts

Determination of an Interest Rate

- Determined differently than in the private sector
- Called the **social discount rate**
- Sometimes standardized by govt. agencies

Selection Process

- Not as “clear” as in the private sector i.e., not solely based on economic measures (PW or AW)
- Involves special interest and pressure groups
- Selection criteria hence need to be prioritized

Evaluation Process

- The **viewpoint** adopted (city budget, economic development, citizen welfare, environment protection) dictates the goal of the project
- Viewpoint adopted will help categorizing and estimating costs, benefits and disbenefits
- Thus, the viewpoint must be established before the economic evaluation
- See Example 9.1

B/C Analysis – Single Project

- The **conventional** B/C Ratio is:
  \[
  \text{B/C} = \frac{\text{PW(benefits)} - \text{PW(disbenefits)}}{\text{PW(costs)}}
  \]
- Equivalently, AW or FW can be used.
- Calculated at the **social discount rate** (interest rate).
**Conventions**

- Revenues and costs are assigned (+) signs, i.e., only magnitudes are considered
- Salvage values carry a negative sign and included with equivalent cost calculation (i.e. subtracted from costs)

**Decision Rule**

- If B/C ratio ≥ 1.00, "conditionally" accept the alternative
- If B/C ratio < 1.00, "conditionally" reject the alternative
- If B/C ratio "close" to 1.00 then intangible factors may sway the decision to accept or reject

**Modified B/C Ratio**

- Modified B/C subtracts the Maintenance and operations (M&O) costs in the numerator
- The modified B/C ratio
  \[
  = \left( \frac{PW(\text{benefits}) - PW(\text{disbenefits}) - PW(\text{M&O costs})}{PW(\text{initial investment})} \right)
  \]

  Note: Do not use this ratio unless you're explicitly asked to...

**Conventional vs. Modified?**

- It makes no difference which approach is used
- However, the ratio values will differ (magnitude)
- But, the accept/reject decision will be the same

**Benefit-Cost Difference**

- B-C cost difference is defined as:
  \[
  = PW(\text{Benefits}) - PW(\text{Disbenefits}) - PW(\text{Costs})
  \]
  (or AW, FW)
- Reject if B-C < 0
- Does this look familiar?

**See Example 9.2**

- Applies all three approaches to the same problem situation
  - B/C = 0.51 (reject)
  - Mod B/C = 0.39 (reject)
  - (B-C) = -$1.24 million (reject)
- Result: Same decision
Example 9.3

- Given two alternatives
  - Bypass construction
  - Upgrade construction
- Unequal lives ... use AW to compare
- discount rate is set to 8%

Example 9.3, continued

- Conventional B/C – Bypass = 1.17
- Conventional B/C – Upgrade = 1.13
- Both B/C ratios are > 1
- Both proposals are economically justified at 8%
- Which one would you select?

Alternative Selection using Incremental Analysis: 2 Alternatives

- This approach is similar to the material in Chapter 8
- Requires a proper ordering of the alternatives
- Order alternatives on the basis of Total Equivalent Costs

Rank on Total Costs - Rules

1. Determine total equivalent costs, benefits and disbenefits (PW, AW or FW) for both alternatives- AW is preferred as one can compare unequal life alt. (under repeatability assumptions as before)
2. Order by total costs: Smaller AW(cost) first (defender) then larger AW(cost) (challenger)
   Note: This ranking is based not just on initial cost – it is on total equivalent cost!

Incremental B/C Approach

3. Calculate the incremental equivalent C,B,D:
   - $\Delta C = AW(\text{challenger costs}) - AW(\text{defender cost})$
     - should be > 0 and is the denominator in the B/C ratio
   - $\Delta B = AW(\text{challenger benefits}) - AW(\text{defender benefits})$
   - $\Delta D = AW(\text{challenger disbenefits}) - AW(\text{defender disbenefits})$
4. Calculate the $\Delta B/C$ ratio: $(\Delta B - \Delta D)/\Delta C$

Incremental B/C Approach

5. If $\Delta B/C \geq 1.00$ go with the challenger alternative
   else,
   Go with defender alternative!
An Important Point

• If one is using a PW to determine equivalent B, D, C, then you must have an equal life model or lowest common multiple of lives.
• Or, apply the annual worth on a typical cycle for the alternatives and the *repeatability assumption* applies.

Example 9.4

<table>
<thead>
<tr>
<th></th>
<th>Design A</th>
<th>Design B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction cost, $</td>
<td>10,000,000</td>
<td>15,000,000</td>
</tr>
<tr>
<td>Building Maintenance cost, $/year</td>
<td>35,000</td>
<td>55,000</td>
</tr>
<tr>
<td>Patient usage cost, $/year</td>
<td>450,000</td>
<td>200,000</td>
</tr>
</tbody>
</table>

Patient usage cost is the amount paid by patients over the insurance coverage. Discount rate is 5% and life is 30 years

Example 9.4

- There are no individual benefits – benefit to the patient exists when switching from lower cost A to higher cost B (equiv. costs on next slide)
- So A is the defender and B is the challenger
- Treat usage cost as a disbenefit
- Calculate $\Delta B$, $\Delta D$ and $\Delta C$ as challenger equiv. – defender equiv.,

Example 9.4, -contd

$AW_A = 10,000,000(A/P, 5\%, 30) + 35,000 = 685,500$
$AW_B = 15,000,000(A/P, 5\%, 30) + 55,000 = 1,030,750$
$\Delta C = AW_B - AW_A = 345,250$
$\Delta D = usage(B-A) = 200,000 - 450,000 = -250,000$
$\Delta B = 0$
$(\Delta B - \Delta D)/\Delta C = 0.72$

Incremental B/C for Multiple Projects

- Select from three or more mutually exclusive alternatives
- Same approach as that in Chapter 8, Section 8.6
- Remember, the *Do Nothing* if acceptable, should be evaluated as an alternative.

Steps for Multiple Incremental Analysis

1. Using either PW or AW determine the total equivalent cost for all options. If unequal lives, apply AW
2. Create the rankings based upon lowest to highest total equivalent cost of the alternatives
3. Determine the total equivalent benefits for each alternative
Steps - continued

4. The lowest cost option is the first Defender and the next higher cost alternative is the first challenger
   Compute the B/C ratio on the increment
   If B/C < 1, eliminate the Challenger else eliminate the Defender.
   Current winner becomes new Defender

Multiple Alternatives….

5. Compare the new defender to the next higher cost challenger and repeat the analysis.
6. Continue through the alternative until there are no more challengers.
7. The last “champion” is the winner

See Example 9.5

- 4 Alternatives { 1,2,3, and 4}
- Ranked on total cost as shown
- Analysis Summary:
  - (2-1) B/C = 2.24 …Go with {2}
  - (3-2) B/C = 0.62…Reject 3, stay with {2}
  - (4-2) B/C = 1.83 Go with 4, final winner

Chapter 9 Summary

- B/C is primarily a public sector analysis technique
- Uses PW or AW with a social cost of capital interest rate (specified before the analysis is conducted)
- B/C ratio greater than 1 indicates economic desirability of an alternative

Chapter 9 Summary cont.

- Very difficult to estimate $ values for benefits and disbenefits
- Results may depend upon viewpoints that define costs and benefits
- Selection from multiple alternatives is based on a ranking followed by a pair-wise comparison-elimination procedure