- Projects in private sector are owned by corporations, partnerships, and individuals and used by customers.
- Projects in public sector are owned, used and financed by citizens.
- Public sector projects have a primary purpose to provide services to the citizens for the public good at no profit.
- Some public sector examples are:
  - Hospitals and clinics
  - Highways, bridges and waterways
  - Convention Centers
  - Schools, Colleges, Universities
  - Sports Arenas
- There are significant differences in the characteristics of private and public sector alternatives.

Characteristic	Public Sector	Private Sector
Size of Investment	Larger	Medium to Low
Life Estimates	Longer (30-50+ yrs)	Shorter (2-25 yrs)
Cash Flow Estimates	No Profit; cost, benefit, disbenefit	Revenues Costs
Funding	Taxes, bonds	Loans, stocks
Interest Rate	Lower	Higher
Alternative Selection Criteria	Multiple	ROR
Environment of Evaluation	Politically inclined	Economic

Cash Flow Estimates

To perform an economic analysis of public alternatives, the costs (initial and annual), the benefits, and the disbenefits must be estimated as accurately as possible in monetary units.

- Costs: Estimated expenditures to the government entity for construction, operation, and maintenance of the project, less any expected salvage value.
- Benefits: Advantages to be experienced by the owners, the public
- Disbenefits: Expected undesirable or negative consequences to the owners, the public

Interest Rate for Public Sector Projects

The interest rate for the public sector is also identified as i; to distinguish it from the private sector rate called discount rate.

- All cost, benefit and disbenefit estimates must be converted to a common equivalent monetary unit (*PW*, *AW*, or *FW*)
- B/C ratio is then calculated as:

$$B/C = \frac{\textbf{PW of benefits}}{\textbf{PW of costs}} = \frac{\textbf{AW of benefits}}{\textbf{AW of costs}} = \frac{\textbf{FW of benefits}}{\textbf{FW of costs}}$$

- *PW* and *AW* are used more frequently
- Sign convention is $+$ in B/C analysis
  - Costs are positive, salvage values are negative and subtracted from costs
  - Benefits are positive, disbenefits are negative and subtracted from benefits
- The decision guideline is:
  - If $B/C \geq 1.0$, accept the project
  - If $B/C < 1.0$, reject the project

- This ratio is called conventional B/C ratio (all terms in *PW* or *AW*):

$$B/C = \frac{Benefits - Disbenefits}{Cost - Salvage} = \frac{B - D}{C - S}$$

- The way how disbenefits handled changes the magnitude of the B/C ratio
  - Disbenefits are subtracted from benefits (correct)
  - Disbenefits are added to costs (incorrect)
- Handling the disbenefits incorrectly and adding them to costs does not alter the decision (B/C $<$ or $>$ 1)

$$\begin{aligned} B/C &= \frac{B - D}{C - S} < 1 \rightarrow B - D < C - S \\ &= B < C - S + D \rightarrow \frac{B}{C - S + D} < 1 \end{aligned}$$

- The modified B/C ratio includes maintenance and operation (M&O) costs in the numerator and treats them similar to disbenefits
- Once all terms are expressed in PW, AW, or FW terms:

$$Modified\ B/C = \frac{\textbf{Benefits - Disbenefits-M\&O costs}}{\textbf{Initial Investment-Salvage}}$$

- The modified B/C ratio yields a different cost then conventional B/C ratio
- But the decision to accept or reject is same with both ratios
- There is also the benefit and cost difference measure of worth
- Based on the difference of PW or AW of benefits and costs
  - (B-C)=Net Benefits - (Costs-Salvage)
- The decision guideline is:
  - If $(B - C) \geq 0$, accept the project
  - If $(B - C) < 0$, reject the project

In Class Work 12

The Ford Foundation expects to award $15 million today in grants to public high schools to develop new ways to teach the fundamentals of engineering that prepare students for university-level material. The grants will extend over a 10-year period and will create an estimated savings of $1.5 million per year in faculty salaries. The foundation uses a 6% discount rate for all grant awards. This grant program will share the Foundation funding with ongoing activities, so an estimated $200,000 per year will be removed from other program funding. Also $500,000 per year will be incurred as annual operation costs. Use the B/C method to determine if the grants program is economically justified using:

1. Conventional B/C analysis
2. Modified B/C ratio
3. benefit and cost difference measure of worth

Use *AW* as the common monetary equivalent:

- *AW* of investment cost $= 15,000,000(A/P, 6\%, 10) = \$2,038,050$
- *AW* of benefit = \$1,500,000
- *AW* of disbenefit = \$200,000
- *AW* of M&O cost = \$500,000

1. Conventional B/C

$$B/C = \frac{\$1,500,000 - \$200,000}{\$2,038,050 + \$500,000} = 0.51 < 1$$

2. Modified B/C

$$Modified\ B/C = \frac{\$1,500,000 - \$200,000 - \$500,000}{\$2,038,050} = 0.39 < 1$$

3. $(B - C) = (1,500,000 - 200,000) - (2,038,050 + 500,000) \leq 0$

Program is not justified.

The technique to compare two mutually exclusive alternatives using B/C ratio is the incremental B/C analysis. The procedure for incremental B/C is given as (equivalent values can be in *PW* or *AW*):

1. Determine the total equivalent costs for both alternatives
2. Order the alternatives by the total equivalent cost, smaller first. Calculate the incremental cost (ΔC) for the larger-cost alternative over the smaller-cost alternative.
3. Calculate the total equivalent benefits and disbenefits for both alternatives. Calculate incremental net benefits ($\Delta(B - D)$) for the larger-cost alternative over the smaller-cost alternative.
4. Calculate the incremental B/C ratio

$$\Delta B/C = \frac{\Delta(B - D)}{\Delta C}$$

5. Select the higher-cost alternative if $\Delta B/C \geq 1$

Cautions in using Incremental B/C Analysis

1. Each alternative included in the incremental B/C analysis must have a B/C ratio ≥ 1.
2. Ordering of alternatives is done on the basis of total cost not initial cost
3. Like all methods considered so far, incremental B/C analysis requires equal-service comparison of alternatives.
   - Usually the alternatives have very long lives, so alternatives have equal lives
   - When alternatives do have unequal lives, LCM of lives must be used
   - Use *AW* equivalency of costs and benefits whenever alternatives have unequal lives

In Class Work 13

The city of Garden Ridge, Florida, has received designs for a new patient room wing to the municipal hospital from two architectural consultants. The three financial estimates are given as:

	Design A	Design B
Construction Cost, $	$1,000,000	$1,500,000
Building maintenance cost, $ per year	35,000	55,000
Savings in operation, $ per year	200,000	450,000

The discount rate is 5%, and the life of the building is estimated as 30 years. Use conventional B/C ratio analysis to select design A or B.

Use *AW* equivalency:

1. *AW* of costs is the sum of construction and building maintenance costs

$$AW_A = 1,000,000(A/P,5\%,30) + 35,000 = \$100,050$$
$$AW_B = 1,500,000(A/P,5\%,30) + 55,000 = \$152,575$$

2. Design B is the alternative with the larger total cost, so it is the alternative to be incrementally justified.

$$\Delta C = 152,575 - 100,050 = \$52,525$$

3. Savings in operation are the benefits:

$$\Delta B = 450,000 - 200,000 = \$250,000$$

4. The incremental B/C ratio is calculated as:

$$\Delta B/C = \frac{\$250,000}{\$52,525}$$

5. The incremental B/C is larger than 1, Therefore design B is selected.

1. Determine the the total equivalent costs for all alternatives (Use PW or AW)
2. Order the alternatives by the total equivalent cost, smaller first
3. Calculate the total equivalent benefits and disbenefits for each alternative
4. Direct benefit estimation only: Determine the B/C for all alternatives and retain the ones with $B/C \geq 1$
5. Calculate the incremental costs (ΔC) and benefits ($\Delta(B-D)$):
   - $\Delta C =$ challenger cost - defender cost
   - $\Delta(B-D) =$ challenger benefits - defender benefits
   - if relative usage costs are estimated for each alternative, rather than direct benefits:
     - $\Delta(B-D) =$ defender usage cost - challenger usage cost
6. Calculate the incremental B/C for the first challenger compared to the defender
   - if $\Delta B/C \geq 1$, eliminate the defender, challenger becomes new defender
   - if $\Delta B/C < 1$, eliminate the challenger
7. Repeat steps 5 and 6 until only one alternative remains

Example

A municipal is seeking a developer that will place a major water park in the city area. Financial incentives will be awarded to the developers depending on their investment size. The developers will get reductions in property tax for 8 years. Each proposal includes a provision that residents of the county will benefit from reduced entrance fees when using the park. This reduction will be effective for 8 years. The annual total entrance fees with the reduction are estimated. The discount rate is 7 %. Which proposal should be selected?

	Proposal 1	Proposal 2	Proposal 3
Initial Incentive, $	$250,000	$350,000	500,000
Tax Incentive cost, $ per year	25,000	35,000	50,000
Entrance fees, $ per year	500,000	450,000	425,000
Extra sales tax, $ per year	310,00	320,000	320,000
Study period, years	8	8	8

- AW of costs is the sum of incentive cost and the annual cost of initial incentive.

$$\begin{aligned} AW_{C1} &= 250,000(A/P,7\%,8) + 25,000 = \$66,867 \\ AW_{C2} &= 350,000(A/P,7\%,8) + 35,000 = \$93,614 \\ AW_{C3} &= 500,000(A/P,7\%,8) + 50,000 = \$133,735 \end{aligned}$$

Alternatives are ordered as 1,2,3.

- The annual benefits are the incremental benefit from the decrease in entrance fees and increase in sales taxes.

$$\begin{aligned} \Delta B_{2-1} &= 50,000 + 10,000 = \$60,000 \\ \Delta B_{3-2} &= 25,000 + 0 = \$25,000 \end{aligned}$$

The first defender is alternative 1.

- For 2-1 comparison:

$$\Delta B/C = \frac{\Delta B}{\Delta C} = \frac{\$60,000}{93,614 - 66,867} > 1$$

Alternative 2 is incrementally justified. Alternative 1 is eliminated, 2 is the new defender.

- For 3-2 comparison:

$$\Delta B/C = \frac{\Delta B}{\Delta C} = \frac{\$25,000}{133,735 - 93,614} < 1$$

Alternative 3 is incrementally not justified. Alternative 3 is eliminated, Alternative 2 is the selection.