Engineering Economics

Lecture 10

Er. Sushant Raj Giri
B.E. (Industrial Engineering), MBA
Lecturer
Department of Industrial Engineering

Chapter 17
Economic Analysis in the Public Sector

- Framework of Benefit-Cost Analysis
- Valuation of Benefits and Costs
- Benefit-Cost Ratios
- Analysis of Public Projects Based on Cost-Effectiveness

Benefit-Cost Analysis

- Benefit-cost analysis is commonly used to evaluate public projects.
- Benefits of a nonmonetary nature can be quantified and factored into the analysis.
- A broad range of project users distinct from the sponsor should be considered—benefits and disbenefits to all these users can (and should) be taken into account,

Framework of Benefit-Cost Analysis

1) Identifying all the users and sponsors of the project.
2) Identifying all the benefits and disbenefits of the project.
3) Quantifying all benefits and disbenefits in dollars or some other unit of measure.
4) Selecting an appropriate interest rate at which to discount benefits and costs to a present value.

Benefit-Cost Ratio Criterion

$$\text{Benefit - Cost Ratio} = \frac{\text{Equivalent Users' Net Benefits}}{\text{Equivalent Sponsor's Net Cost}}$$

If this BC ratio exceeds 1, the project can be justified

Definition of Benefit-Cost Ratio

$$B = \sum_{n=0}^{N} b_n (1+i)^{-n}$$

$$C = \sum_{n=0}^{N} c_n (1+i)^{-n}$$

b_n=Benefit at the end of period n, $b_n \geq 0$
c_n=Expense at the end of period n, $c_n \geq 0$
$A_n = b_n - c_n$
N = Project life
i =Sponsor's interest rate (discount rate)

$$I = \sum_{n=0}^{K} c_n (1+i)^{-n}$$ Equivalent capital investment

$$C = \sum_{n=K+1}^{N} c_n (1+i)^{-n}$$ Equivalent O&M costs

$$BC(i) = \frac{B}{C} = \frac{B}{I+C}, \quad I + C > 0$$

Example 17.1 BC Analysis

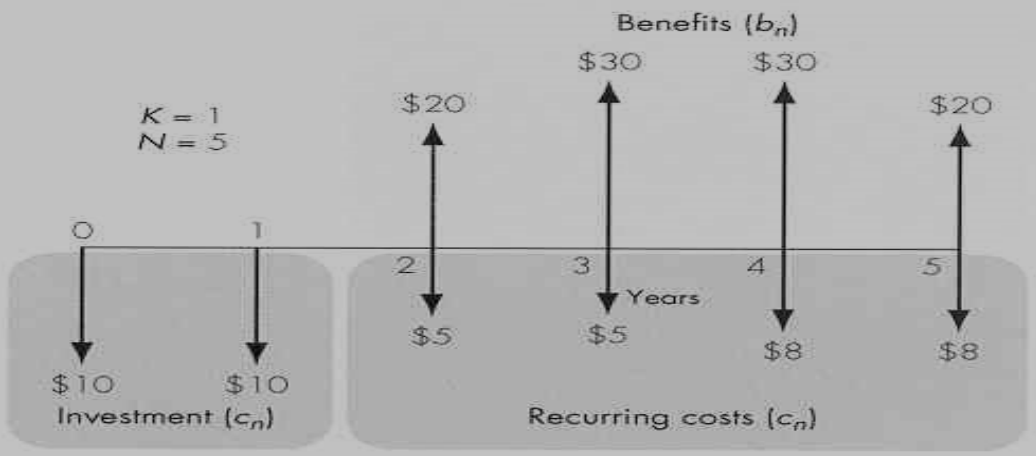


Figure 17.1 Classification of a project's cash flow elements (Example 17.1)

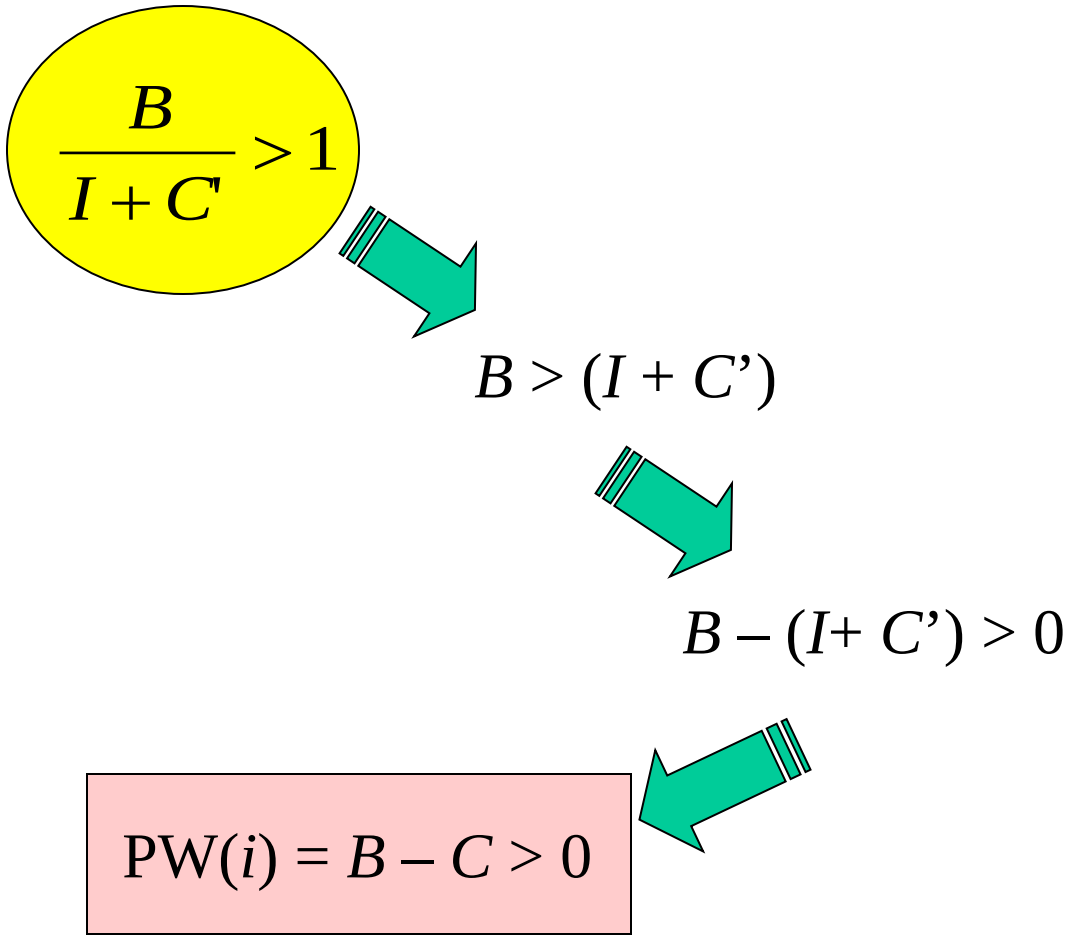
n	b_n	c_n	A_n
0		$10	–$10
1		10	–10
2	$20	5	15
3	30	5	25
4	30	8	22
5	20	8	12

$$B = \$20(P/F, 10\%, 2) + \$30(P/F, 1\%, 3)$$
$$+\$30(P/F, 10\%, 4) + \$20(P/F, 10\%, 5)$$
$$= \$71.98$$

$$C = \$10 + \$10(P/F, 10\%, 1) + \$5(P/F, 10\%, 2) + \$5(P/F, 10\%, 3)$$
$$+ \$8(P/F, 10\%, 4) + \$8(P/F, 10\%, 5)$$
$$= \$37.41$$
$$I = \$10 + \$10(P/F, 10\%, 1)$$
$$= \$19.09$$
$$C' = C - I$$
$$= \$18.3$$

$$BC(10\%) = \frac{71.98}{\$19.09 + \$18.32} = 1.92 > 1, \text{ Accept the project.}$$

Relationship between B/C Ratio and NPW



Incremental Analysis Based on *BC*(*i*)

$$\Delta B = B_k - B_j$$

$$\Delta I = I_k - I_J$$

$$\Delta C' = C'_k - C'_j$$

$$BC(i)_{k-j} = \frac{\Delta B}{\Delta I + \Delta C'}$$

Example 17.2 Incremental Benefit-Cost Ratios

	A1	A2	A3
I	$5,000	$20,000	$14,000
B	12,000	35,000	21,000
C'	4,000	8,000	1,000
PW(*i*)	$3,000	$7,000	$6,000

Solution

	A1	A2	A3
$BC(i)$	1.33	1.25	1.40

Ranking Base	A1	A3	A2
$I + C'$	\$9,000	\$15,000	\$28,000

$$BC(i)_{2-1} = \frac{\$21{,}000 - \$12{,}000}{(\$14{,}000 - \$5{,}000) + (\$1{,}000 - \$4{,}000)}$$

$$= 1.5 > 1, \text{ select A2.}$$

$$BC(i)_{2-3} = \frac{\$35{,}000 - \$21{,}000}{(\$20{,}000 - \$14{,}000) + (\$8{,}000 - \$1{,}000)}$$

$$= 1.08 > 1, \text{ select A2.}$$

General Procedure for Cost-Effectiveness Studies

- Step 1: Establish the goals to be achieved by the analysis.
- Step 2: Identify the imposed restrictions on achieving the goals, such as budget or weight.
- Step 3: Identify all the feasible alternatives to achieve the goals.
- Step 4: Identify the social interest rate to use in the analysis.
- Step 5: Determine the equivalent life-cycle cost of each alternative, including research and development, testing, capital investment, annual operating and maintenance costs, and salvage value.

- Step 6: Determine the basis for developing the cost-effectiveness index. Two approaches may be used;
  - (1) the fixed-cost approach and
  - (2) the fixed-effectiveness approach.
  - If the fixed-cost approach is used, determine the amount of effectiveness obtained at a given cost.
  - If the fixed-effectiveness approach is used, determine the cost to obtain the predetermined level of effectiveness.
- Step 7: Compute the cost-effectiveness ratio for each alternative based on the selected criterion in Step 6.
- Step 8: Select the alternative with the maximum cost-effective index.

Cost-Effectiveness Decision Criterion

- Fixed Cost Approach

Maximize Effectiveness

Subject to:

Budget Constraint

- Fixed Effectiveness Approach

Minimize Cost

Subject to:

Must meet the minimum effectiveness

Case Study - Selecting an Weapon System

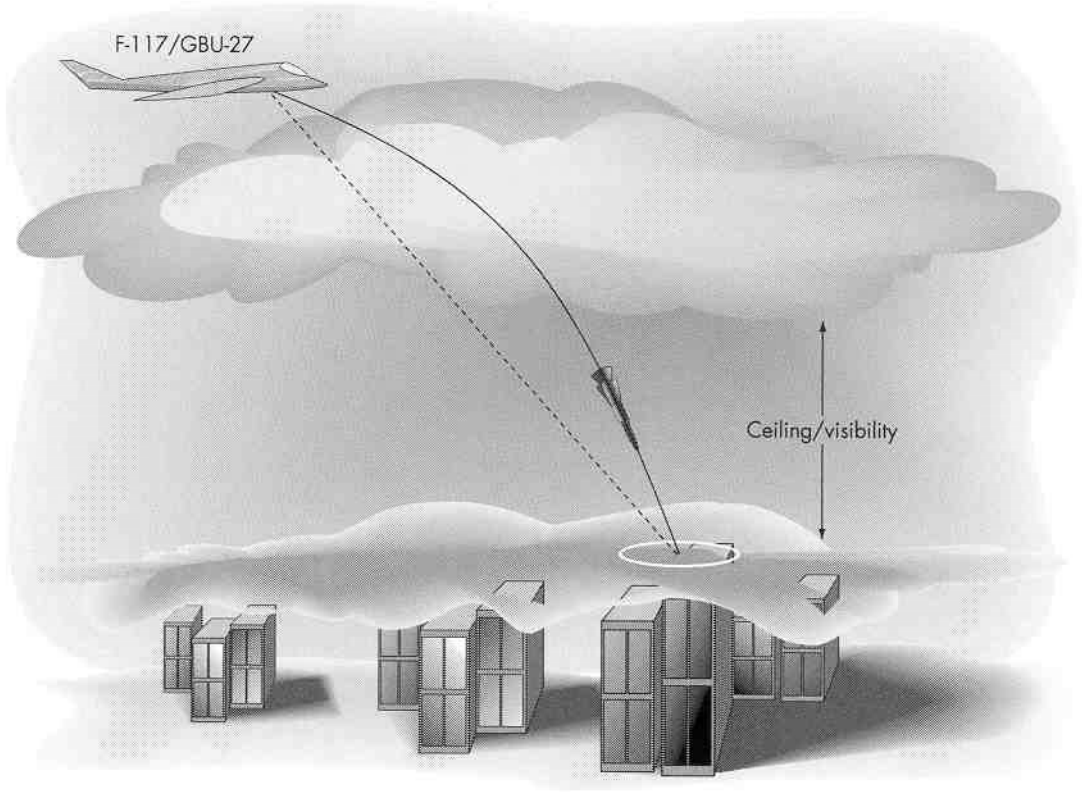


Figure 17.2 Conceptual use of an adverse weather guidance weapon by an aircraft

Weapon System Alternatives

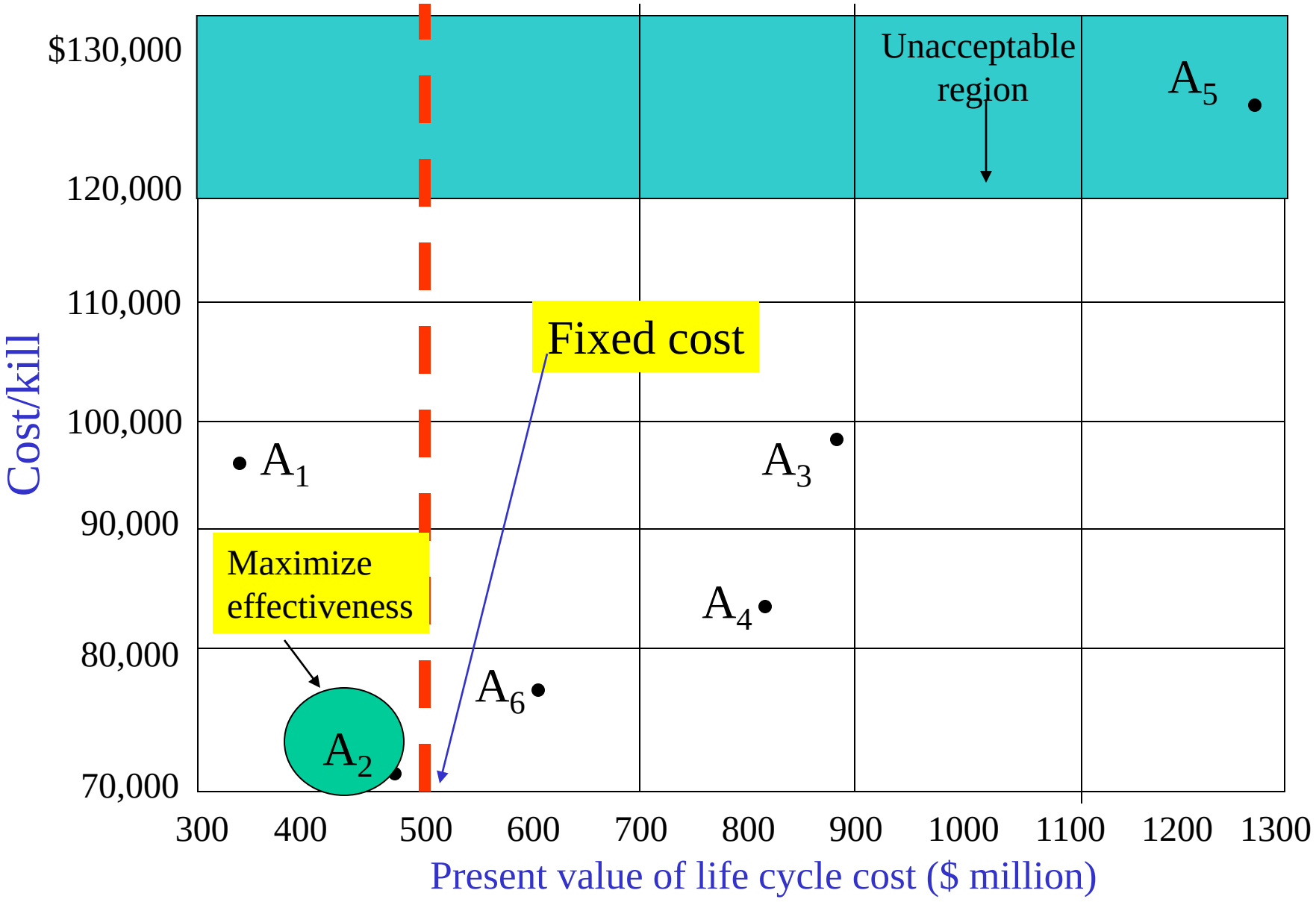
Alternative A_j	Advantage	Disadvantage	Probability of Kill
A1: Inertial navigation system	Low cost, mature technology.	Accuracy, target recognition	0.33
A2: Inertial navigation system: Global positioning system	Moderate cost, nature technology	Target recognition	0.70
A3: Imaging infrared (I^2R)	Accurate, target recognition	High cost, bunkered target detection	0.90
A4: Synthetic aperture radar	Accurate, target recognition	High cost	0.99
A5: Laser detection/ranging	Accurate, target recognition	High cost, technical maturity	0.99
A6: Millimeter wave (MMW)	Moderate cost, accurate	Target recognition	0.80

Life-Cycle Costs for Weapon Development Alternative

Expenditures in Million Dollars							
Phase	Year	A1*	A2	A3	A4	A5	A6
FSD	0	$15	$19	$50	$40	$75	$28
	1	18	23	65	45	75	32
	2	19	22	65	45	75	33
	3	15	17	50	40	75	27
	4	90	140	200	200	300	150
	5	95	150	270	250	360	180
IOC	6	95	160	280	275	370	200
	7	90	150	250	275	340	200
	8	80	140	200	200	330	170
PW(10%)		$315.92	$492.22	$884.27	$829.64	$1,227.23	$612.70

Cost-Effectiveness Index

Type	Cost/Unit	Probability of Kill	Cost/Kill	Kill/Cost
A1	$31,592	0.33	$95,733	0.0000104
A2	49,220	0.70	70,314	0.0000142
A3	88,427	0.90	98,252	0.0000102
A4	82,964	0.90	83,802	0.0000119
A5	122,723	0.99	123,963	0.0000081
A6	61,370	0.80	76,713	0.0000130


$130,000
120,000
110,000
100,000
90,000
80,000
70,000
Cost/kill
Unacceptable region
A5
Fixed cost
A1
A3
Maximize effectiveness
A4
A6
A2
300
400
500
600
700
800
900
1000
1100
1200
1300
Present value of life cycle cost ($ million)

Summary

- Benefit-cost analysis is commonly used to evaluate public projects:
- Difficulties involved in public project analysis include the following:

1) Identifying all the users who can benefit from the project.
2) Identifying all the benefits and disbenefits of the project.
3) Quantifying all benefits and disbenefits in dollars or some other unit of measure.
4) Selecting an appropriate interest rate at which to discount benefits and costs to a present value.

- The B/C ratio is defined as:

$$BC(i) = \frac{B}{C} = \frac{B}{I + C'}, I + C' > 0$$

The decision rule is if BC(i) > 1, the project is acceptable.

- The net B/C ratio is defined as

$$B / C(i) = \frac{B - C'}{I} = \frac{B'}{I'}, I > 0$$

The net B/C ratio expresses the net benefit expected per dollar invested. The same decision rule applies as for the B/C ratio.

- The cost-effectiveness method allows us to compare projects on the basis of cost and nonmonetary effectiveness measures.
- We may either maximize effectiveness for a given cost criterion or minimize cost for a given effectiveness criterion.

End of Lecture 10

Notice!!!

Internal Assessment

Date: September 1, 2015 11:00 AM

Examination Pattern

Phase I: Objective Round

10 Questions (1 marks for correct answer, -0.2 for each incorrect one)

Phase II: Subjective Round

2 Short Questions (5 marks each)

1 Long Question (10 marks)

Scheme for Internal Evaluation

Assessment:	50%
Assignments:	50%
Total Internal Evaluation:	100%

Chance
Assignment

Chapter 8 (Page 383)	8.1, 8.4, 8.8, 8.12, 8.16, 8.21, 8.26, 8.32, 8.35
Chapter 9 (Page 436)	9.1, 9.5, 9.7, 9.10, 9.12, 9.16, 9.21, 9.25, 9.28

Submission Deadline:

September 1, 2015
(Tuesday)