AAIT

School of Civil and Environmental Engineering

Engineering Economics (CEng 5211)

Chapter 4:Benefit Cost Analysis

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Benefit Cost Analysis

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4.1 Introduction

- The next step is to identify three items regarding a public project:
  - **Benefits**: are positive consequences (advantages) to the public(owner). Positive outcomes include recreation, electricity, shorter trips, fewer accidents.
  - **Costs**: are anticipated expenditures for construction, operation and maintenance, etc. Paid for construction and operation.
  - **Disbenefits**: are disadvantages to the public (owner). Reflects the loss caused to a part of the public. Negative outcomes include traffic delay during construction, neighborhood divided by new highway, etc.
- **Example**:

Item	Classification
Expenditure of 11 million dollars for a new highway	Cost
$100,000 annual income to local residents from tourists due to the construction of new highway	Benefit
$15,000 annual upkeep of highway	Cost
$250,000 annual loss to farmer due to loss of highway right of way	Disbenefit

4.1 Introduction

- A benefit cost analysis is used to compare between investment options based on a range of benefits, disbenefits, and costs to the owner.
- It is done to determine how well, or how poorly, a planned action will turn out.
- BCA has been established primarily as a tool for use by governments in making their social and economic decisions.
- It measures costs and benefits to the community of adopting a particular course of action e.g. Constructing a dam, by-pass etc.
- When an investment made commensurate with the benefit derived, it can be said that operation is positive and viable; but when benefits derived do not compensate financial investments made, it can be said that it is financially nonviable and negative.
- BCR is dollar of return per dollar of cost in the **public sector**. Similar measure is called Present worth index in the **private sector**.

4.1 Introduction

- Public projects are very different from the private ones in their nature:
- It is not the mission of the government to make money, but to bring value to the people. Therefore it is crucial to know the values associated with the alternatives.
- Since the sole monetary goal is no longer valid, it may cause conflicts among the objectives.
- There are inevitably political issues related to fairness considerations.

	Private	**Public**
Purpose	Profit	Well being of the public
Financing	Investment	Tax
Horizon	Short	Long
Benefit	Money	Value to society

- The ultimate aim of a business organization is to make profits.
- Therefore, any system in the organization must produce more benefits as compared to its costs for the organization to survive & prosper.

4.1 Introduction

- In this method all costs and benefits are **discounted to their present worth** and the ratio of benefit to cost is calculated.
- Negative flows are considered as costs and positive flows as benefits. The analysis relies on the addition of positive factors and the subtraction of negative ones to determine a net result.
- If the B/C ratio is **more than one** the project is worth undertaking.
- The BCR approach takes into account "efficiency" by comparing the benefits obtained per unit of cost. Measures the benefit per unit cost, based on the time value of money.
  - A profitability index of 1.1 implies that for every $1 of investment, we create an additional $0.10 in value.
- It is intuitively appealing to find the amount of benefit that a project produces per dollar of cost.
- Ironically, small projects with very little NPV can look comparatively attractive with the BCR.

4.2 Benefit Cost Ratio

- Items regarding a public project:
  - Benefits
  - Costs
  - Disbenefits.
- In particular, let us denote:

  B: benefits of the project; I: initial capital investment;

  CR: capital recovery; O&M: operating and maintenance costs.

- Conventional B/C ratio $= \dfrac{PW(B)}{I + PW(O\&M)}$

  or

  $= \dfrac{AW(B)}{CR + AW(O\&M)}$

Considering Disbenefit B/C ratio:

$$= \frac{AW(B) - AW(D)}{CR + AW(O\&M)}$$

or

$$= \frac{AW(B)}{CR + AW(O\&M) + AW(D)}$$

- **Modified B/C ratio** $= \dfrac{PW(B) - PW(O\&M)}{I}$

or

$$= \frac{AW(B) - AW(O\&M)}{CR}$$

4.1 Introduction

- This technique is based on the ratio of benefits to costs using either **present worth** or **annual cash flow** calculations.
- The method is graphically similar to present worth analysis. When neither input nor output is fixed, incremental benefit-cost ratio (B/C) are required. The method is similar in this respect to rate of return analysis.
- At a given MARR, we would consider an alternative acceptable, provided

  PW of benefits-PW of costs ≥ 0 or EUAB-EUAC
- Benefit-cost ratio $\frac{B}{C} = \frac{PW\_of\_benefit}{PW\_of\_cost} = \frac{EUAB}{EUAC} \geq 0$

	Situation	Criterion	
Neither input nor output fixed	Neither amount of money or other inputs nor Amount of benefits or other outputs are fixed	**Two alt.:** Compute incremental B/C ratio on the increment of investments	
		$If\ \frac{\Delta B}{\Delta C} \geq 1$	Choose higher-cost alt.; otherwise, choose lower-cost alt.
Fixed input	Amount of money or other input resources are fixed	Maximize B/C	
Fixed output	Fixed task, benefit, or other output to be accomplished	Maximize B/C	

4.2 Benefit Cost Ratio

Example: A firm is considering which of two devices to install to **reduce costs**. Both devices have useful lives of 5 years with no salvage value. **Device A** costs $1000 and can be expected to result in $ 300 saving annually. **Device B** costs $1350 and will provide cost saving of $300 the first year ; however, saving will increase $50 annually, making the second year saving $350, the third year savings $400, and so forth. With interest at 7%, which device should the firm purchase?

Device A

AW_A= -1000(A/P, 7%, 5)+300 = -1000(0.2439)+300

= $ 56.11

Device B

AW_B= -1350 (A/P, 7%, 5)+300 + 50(A/G, 7%, 5)

=-1350(0.2439) +300+ 50(1.865)=$ 64

Installing Device B results larger benefit.

$$(A/P, 7\%, 5) = \frac{0.07(1.07)^5}{(1.07)^5 - 1} = 0.2439$$

$$(A/G, 7\%, 5) = \frac{(1.07)^5 - (1+5*0.07)}{0.07[(1.07)^5 - 1]} = 1.865$$

	Device A	Device B
Installation cost	1000	1350
Annual saving	300	300 Increasing gradient series with G=50
EUAW	56.11	64

4.2 Benefit Cost Ratio

Example: Which device should the firm purchase?

	Device A	Device B
Installation cost	1000	1350
Annual saving	300	300 Increasing gradient series with G=50
EUAW	56.11	64

	Device A	Device B	Incremental B-A
Installation cost	1000	1350	350
	= 243.9	**= 329.26**	**= 85.36**
Annual saving	300	300 & Increasing gradient series (G=5)	50(A/G, 7%, 5) =93.25
B/C= $\frac{EUAB}{EUAC}$	=300/243.9 =1.23	=393.25/329.26 =1.19	=93.25/85.36 **=1.09**

Maximizing B/C ratio results wrong indication(Device A). Must use incremental analysis.

4.2 Benefit Cost Ratio

- **Examples:** Consider three investment projects A_1, A_2, and A_3. Each project has the same service life, and the present worth of each component value (B,I,C') is computed at 10% as follows:

(a). If all three projects are independent, which project would be selected based on BC (i)?

(b). If the three projects are mutually exclusive, which project would be the best alternative? Use the B/C ratio on incremental investment.

	Project A_1	**Project A_2**	**Project A_3**
Initial cost (I)	5,000	20,000	14,000
Revenue (B)	12,000	35,000	21,000
Operation cost(C')	4,000	8,000	1,000
PW(i)	3,000	7,000	6,000

4.2 Benefit Cost Ratio

- **Examples: (a).** If all three projects are independent, which project would be selected based on BC (i)?

  All projects would be considered as all the PW's are positive.

	A_1	A_2	A_3
B/C= $\frac{B}{I+C'}$	=12,000/9000 =1.33	=35,000/28000 =1.25	=21,000/15000 =1.40

(b) If these projects are a mutually exclusive, we must use the principle of incremental analysis.

- First arrange the projects by increasing order of their denominator (I+C')

  A_1 =5,000+4,000=9000

  A_2 =20,000+8,000=28,000

  A_3 =14,000+1,000=15,000 → **$A_1 > A_3 > A_2$**

4.2 Benefit Cost Ratio

- **Examples:** If the three projects are mutually exclusive, which project would be the best alternative? Use the B/C ratio on incremental investment.

	A_1	A_3	A_2	B/C_{3-1}	B/C_{2-3}
I+C'	9,000	15,000	28,000	6,000	13,000
B	12,000	21,000	35,000	9,000	14,000
B/C $= \frac{B}{I+C'}$				**1.50**	**1.08**

→ **B/C_{3-1}**>1, We prefer **A_3** over **A_1**: **A_3** ***current best alternative***

→ **B/C_{2-3}**>1, We prefer **A_2** over **A_3**: with no further project to consider *becomes* ***best choice.***

4.2 Benefit Cost Ratio

- The Benefit-Cost Ratio Method is very popular in practice. However, it has several drawbacks as well.
  - The required data might be hard to quantify;
  - It disregards the problem of economic inequalities, i.e., one part of the population benefits at the expense of the other part;
  - It takes no notice to any qualitative information.
- Extra care should be taken in the evaluation of the economic decisions in the public sector.

Summary

Evaluation Method	Inputs	Decision	
	For Calculation	Accept	Reject
Net present Value(NPV)	• Cash flows •Cost of Capital(k)	NPV > 0	NPV < 0
Profitability Index (PI)	•Cash flows •Cost of capital(k)	PI > 1	PI < 1
Internal Rate of return(IRR)	• Cash flows	IRR > k	IRR < k
Discounted Payback period(DPP)	•Cash flows •Cost of capital (k)	DPP < cutoff period	DPP > cutoff period
Payback period(PP)	•Cash flows	PP < cutoff period	PP > cutoff period

Thank You