ENGR 544, Life Cycle Assessment and Management

School of Engineering, Faculty of Applied Science

The University of British Columbia (Okanagan)

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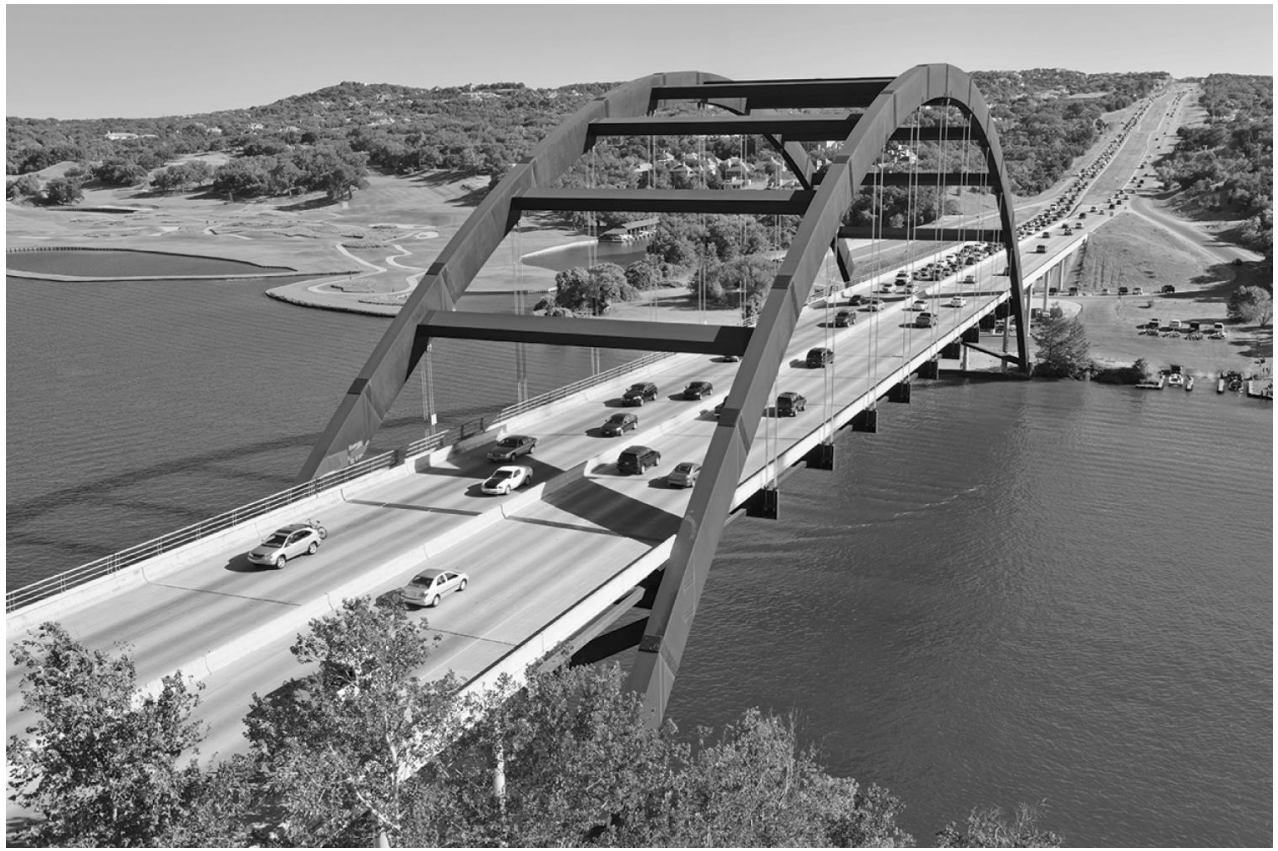
Chapter 9, Benefit/Cost Analysis and Public Sector Economics

1. Explain differences between public vs. private sector projects
2. Calculate B/C ratio for single project
3. Select better of two alternatives using B/C method
4. Select best of multiple alternatives using incremental B/C ratios
5. Describe how ethical compromise may enter public sector project analysis



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Explain Differences Between Public vs. Private Sector Projects

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Differences: Public vs. Private Projects

Public sector project is a product, service, or system used, financed, and owned by the citizens of a government level. The **project** is designed and constructed to serve citizens for the public good at no profit.

Examples: public health, criminal justice, safety, transportation, welfare, and utilities.

Characteristic	Public	Private
Size of investment	Large	Small, medium, large
Life	Long (30 – 50+ years)	Short (2 – 25 years)
Annual cash flow	No profit	Profit driven
Funding	Taxes, fees, bonds	Stocks, bonds, loans
Interest rate	Low (about 3–8%)	Medium to high
Selection criteria	Multiple criteria	Primarily ROR
Environment of the evaluation	Politically inclined	Primarily economic

More about Public Sector Projects

Terminology

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* if the alternative is implemented. Disbenefits may be indirect economic disadvantages of the alternative.

Viewpoint or Perspective

The **viewpoint of a public sector analysis** must be determined before cost, benefit, and disbenefit estimates are made and before the evaluation is formulated and performed. There are several viewpoints for any situation, and the different perspectives may alter how a cash flow estimate is classified.

Examples: job creation and retention; economic development potential

Types of Contracts

Traditional: Contractor does not share in project risk

Fixed price - lump-sum payment

Cost reimbursable - Cost plus, as negotiated

- A **government** unit took responsibility for **funding** and the **design elements**, and later all operation activities, while the contractor did not share in the risks involved (e.g., natural disasters and funding shortfalls).

More recently: Contractor shares in project risk

Public-private partnerships (PPP)

- Design-build projects - Contractors take on more of the functions from **design stage to operations stage**.
- Design-build-finance-maintain-operate (DBFMO) projects - **It requires the contractor(s)** to perform all the DBFMO activities with collaboration and approval of the owner (i.e., the government unit).

Calculate B/C Ratio for Single Project

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Calculating the B/C Ratio

- Determine the viewpoint of the analysis.
- Identify each cash flow as either benefit, disbenefit, or cost.
- Do not use minus sign ahead of costs.
- Savings and revenues to government, and any salvage value, are subtracted from costs.
- All B, C, and D terms have a common equivalency unit (PW, AW, or FW) determined at the rate i.
- Calculation of the B/C ratio uses one of these equivalency formats

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

- PW and AW equivalencies are more commonly used.

B/C Analysis of a Single Project

Conventional B/C ratio is most commonly calculated as

Conventional B/C ratio = (B – D) / C

Modified B/C ratio places equivalent initial cost (and any salvage) in the denominator

Modified B/C ratio = (B – D – M&O costs) / Initial investment

Decision guideline

- If B/C ≥ 1.0, project is economically justified
- If B/C < 1.0, project is not acceptable

Example: B/C Analysis – Single Project

A flood control project will require investment of $1.4 million and annual M&O costs of $40,000 over a 10 year life. Reduced flood damage is expected to amount of $175,000 per year. Lost income to area farmers is estimated to be $25,000 per year. Apply a conventional B/C analysis at a rate of 6% per year to determine if the project is economically justified.

Solution:

Express all values in AW terms and calculate B/C ratio

B = $175,000

D = $25,000

C = 1,400,000(A/P, 6%, 10) + 40,000 = $230,215

$$B/C = (B - D) / C = (175{,}000 - 25{,}000) / 230{,}215 = 0.65 < 1.0$$

Economically, do not build the project

Class Participation 27, Calculate B/C Ratio for Single Project

Officials from the City of Galveston and State of Texas gathered to celebrate the start of a beach restoration project that involves dumping sand and adding anti-erosion structures. The first cost of the project is $30 million with annual maintenance estimated at $340,000. If the restored/expanded beaches attract visitors who will spend $6.2 million per year, what is the conventional B/C ratio at the social discount rate of 8% per year? Assume the State wants to recover the investment in 20 years.

Select Better of Two Alternatives Using B/C Method

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Incremental B/C Analysis: Two ME Alternatives

General approach: Incremental B/C analysis is virtually the same as incremental ROR analysis. A significant difference is in the ordering of alternatives for evaluation:

Alternatives are ordered by increasing equivalent total costs

Errors in B/C can occur if alternatives are ordered by first cost or initial investment only, thus rejecting an acceptable higher-cost alternative

Procedure for Two Alternatives – X and Y

1. Determine the equivalent total costs for both alternatives.
2. Order the alternatives by equivalent total cost: first smaller, then larger. Calculate the incremental cost (ΔC) for the larger-cost alternative. This is the denominator in $\Delta B/C$.
3. Calculate the equivalent total benefits and any disbenefits estimated for both alternatives. Calculate the incremental benefits (ΔB) for the larger-cost alternative. This is $\Delta\,(B - D)$ if disbenefits are considered.
4. Calculate the ΔB/C ratio
5. Use the selection guideline to select the higher-cost alternative if $\Delta B/C \geq 1.0$.

Example: Incremental B/C Analysis

Compare two alternatives: i = 10%; AW basis; conventional B/C ratio

Alternative	X	Y
First cost, $	350,000	540,000
M&O costs, $/year	45,000	35,000
Benefits, $/year	110,000	150,000
Disbenefits, $/year	20,000	45,000
Life, years	10	20

Solution: First, calculate equivalent AW of total costs

AW of $costs_X$ = 350,000 (A/P, 10%, 10) + 45,000 = $101,961

AW of $costs_Y$ = 540,000 (A/P, 10%, 20) + 35,000 = $98,428

Order of analysis: Y, then X (first smaller, then larger)

X vs. Y: $\Delta(B - D/C) = \frac{-40{,}000 - (-25{,}000)}{3533} = -4.25$ Eliminate X

Select Y

Class Participation 28, Two-Alternative Comparison

One of two alternatives will be selected to reduce flood damage in a rural community in central Arizona. The estimates associated with each alternative are available. Use B/C analysis at a discount rate of 8% per year over a 20-year study period to determine which alternative should be selected. For analysis purposes only, assume the flood damage would be prevented in years 3, 9, and 18 of the study period. (Note: PW basis for comparing two alternatives).

Select Best of Multiple Alternatives Using Incremental B/C Ratios

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Incremental B/C Procedure for > 2 ME Alternatives

1. Determine equivalent total cost for each alternative using PW, AW or FW equivalencies
2. Order alternatives by increasing equivalent total cost (smallest first).
3. Determine B and D for each alternative for direct benefits
4. Only if direct benefits are estimated: Calculate B/C for each alternative and eliminate all with B/C < 1.0
5. Calculate ΔC, ΔB and ΔD between two ordered alternatives
6. Calculate $\Delta B/C$; if $\Delta B/C \geq 1.0$, higher-cost alternative becomes defender to a new challenger
7. Repeat steps 5 and 6 until only one alternative remains. Select it.

Example: Multiple Alternative Evaluation using ΔB/C (1)

Use a spreadsheet, ΔB/C analysis, AW equivalencies, a discount rate of 6% per year, and a 40-year study period to select one Internet security system from four proposals. Monetary values are all in $ million units.

	1	2	3	4
First cost, $	58	76	2	48
M&O costs, $/yr	5.5	5.3	2.1	4.4
Benefits, $/yr	11.1	12.0	2.7	8.3

Calculate AW of total costs and reorder, if necessary

Spreadsheet function for AW of total costs:

= PMT(6%, 40, -first_cost) + M&O costs

Example: Multiple Alternative Evaluation using ΔB/C (2)

	A	B	C	D	E
1		1	2	3	4
2	First cost, $	58	76	4	48
3	M&O, $/yr	5.5	5.3	2.1	4.4
4	Benefits, $/yr	11.1	12	2.7	8.3
5	AW of total costs, $/yr	9.35	10.35	2.37	7.59
6	AW of benefits, $/yr	11.1	12.0	2.7	8.3
7	Reorder by increasing costs	3	4	1	2
8	AW of total costs, $/yr	2.37	7.59	9.35	10.35
9	AW of benefits, $/yr	2.7	8.3	11.1	12.0
10	ΔC, $/yr	2.37	5.22	1.76	1.00
11	ΔB, $/yr	2.7	5.6	2.8	0.9
12	ΔB/C	1.14	1.07	1.59	0.90
13	Increment justified?	Yes	Yes	Yes	No
14	Selection	3	4	1	1

5.5 + 58 (A/P, 6%, 40) = 9.35

= PMT(6%, 40, -first_cost) + M&O costs

It is necessary to reorder proposals based on AW of total costs

7.59 – 2.37 = 5.22

8.3 – 2.7 = 5.6

Select proposal 1; it is incrementally justified

Class Participation 29, Multiple (More than Two) Alternatives

In order to safeguard the public health, environment, public beaches, water quality, and economy of south San Diego County, California, and Tijuana, Mexico, federal agencies in the United States and Mexico developed four alternatives for treating wastewater prior to discharge into the ocean. The project will minimize untreated wastewater flows that have caused chronic and substantial pollution in the Tijuana River Valley, the Tijuana River National Estuarine Research Reserve, coastal areas used for agriculture and public recreation, and areas designated as critical habitat for federal- and state-listed endangered species. For the costs and benefits estimated, which alternative should be selected on the basis of a B/C analysis at 6% per year and a 40-year project period? All monetary amounts are in $ million units.

	Pond System	Expand Plant	Advanced Primary	Partial Secondary
Capital cost, $	58	76	2	48
M&O cost, $/year	5.5	5.3	2.1	4.4
Benefits, $/year	11.1	12.0	2.7	8.3

Class Participation 29, Multiple (More than Two) Alternatives

	Pond System	Expand Plant	Advanced Primary	Partial Secondary
Capital cost, $	58	76	2	48
M&O cost, $/year	5.5	5.3	2.1	4.4
Benefits, $/year	11.1	12.0	2.7	8.3

Calculate AW of total cost (in $ millions), then rank according to increasing AW value

Chapter Summary

1. B/C method is used in public sector project evaluation.
2. Can use PW, A W, or FW for incremental B/C analysis, but must be consistent with units for B,C, and D estimates.
3. Making accurate estimates of benefits is difficult for public sector project analysis.
4. For multiple mutually exclusive alternatives, compare two at a time using incremental analysis (ΔB/C), eliminating alternatives until only one remains.
5. For independent projects with no budget limit, compare each against DN and select all that have B/C $\geq$ 1.0.
6. Ethical dilemmas are especially prevalent in public sector projects.

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