

Chapter 14

Public-Sector Economic Economy

14-1

A city engineer is considering installing an irrigation system at the city park's soccer fields. He is trying to decide which one of two alternatives to select. The two alternatives have the following cash flows:

<u>Year</u>	<u>A</u>	<u>B</u>
0	-\$15,000	-\$25,000
1-10	+5,310	+7,900

If interest is 12%, which alternative should the engineer select? Assume no salvage value. Use incremental benefit/cost analysis.

Solution

	<u>A</u>	<u>B</u>
PW _{COST}	-15,000	-25,000
PW _{BENEFITS}	5,310(P/A, 12%, 10) = 30,000	7,900(P/A, 12%, 10) = 44,635
B/C ratio	30,000/15,000 = 2	44,635/25,000 = 1.79

B-A

$$\Delta\text{Cost} = -10,000$$

$$\text{PW}_{\text{COST}} = -10,000$$

$$\Delta\text{Annual Benefits} = +2,590$$

$$\text{PW}_{\text{BENEFITS}} = 2,590(P/A, 12\%, 10) = 14,634$$

$$\Delta B/C = 14,634/10,000 = 1.46$$

1.46 > 1 Therefore choose B, higher cost alternative

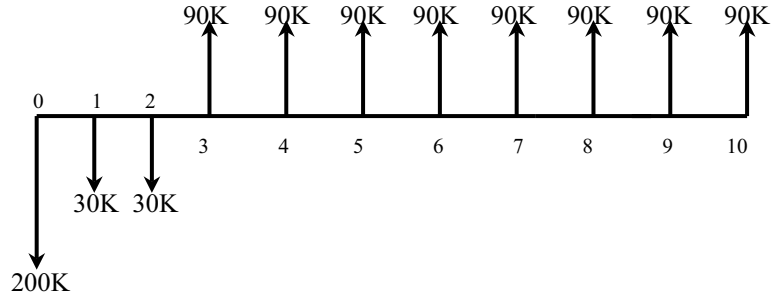
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At 10% interest, what is the benefit/cost ratio for this government project?

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Initial cost	\$2,000,000
Additional costs at end of years 1 & 2	30,000
Benefits at end of years 1 & 2	0
Annual benefits at end of years 3 - 10	90,000

Solution



$$\begin{aligned}
 PW_{\text{Cost}} &= 200K + 30K(P/A, 10\%, 2) = 252,080 \\
 PW_{\text{Benefits}} &= 90K(P/A, 10\%, 8)(P/F, 10\%, 2) = 396,800. \\
 B/C &= 396,800/252,080 \\
 &= 1.574
 \end{aligned}$$

14-3

The city of Tumbleweed has just purchased new traffic enforcement equipment for \$18,000. The equipment is anticipated to generate revenues of \$25,000 per year and expenses of \$15,000 per year in each of the five years it will be in use. The salvage value is expected to equal to removal costs. Ignoring income taxes, compute the benefit/cost ratio if $i = 10\%$.

Solution

$$\begin{aligned}
 PW_{\text{Benefits}} &= 25,000(P/A, 10\%, 5) = \$94,775 \\
 PW_{\text{Costs}} &= 15,000(P/A, 10\%, 5) + 18,000 = \$74,865 \\
 B/C &= 94,775/74,865 \\
 &= 1.2659
 \end{aligned}$$

14-4

A tax-exempt municipality is considering the construction of an impoundment for city water supplies. Two different sites have been selected as technically, politically, socially, and financially feasible. The city council has asked you to do a benefit/cost analysis of the alternatives and recommend the best site. The city uses a 6% interest rate in all analysis of this type.

<u>Year</u>	<u>Rattlesnake Canyon</u>	<u>Blue Basin</u>
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0	-\$15,000,000	-\$27,000,000
1 - 75	+2,000,000	+3,000,000

Which site should you recommend?

Solution

	<u>Rattlesnake</u>	<u>Blue Basin</u>
$\frac{\text{PW of Benefits}}{\text{PW of Cost}}$	$= \frac{2 \times 10^6 (P/A, 6\%, 75)}{15 \times 10^6}$	$= \frac{3 \times 10^6 (P/A, 6\%, 75)}{27 \times 10^6}$
$\frac{B}{C}$ ratio	$= 2.19 > 1$ (OK)	$= 1.83 > 1$ (OK)

Incremental Analysis

<u>Year</u>	<u>BB - RC</u>	
0	-12,000,000	
1 - 75	+1,000,000	
$\frac{B}{C}$	$=$	$\frac{1 \times 10^6 (P/A, 6\%, 75)}{12 \times 10^6} = 1.37 > 1$

∴ Choose higher cost alternative, Blue Basin

14-5

The city council of Arson, Michigan is debating whether to buy a new fire truck to increase protection for the city. The financial analyst has prepared the following data:

	<u>Truck A</u>	<u>Truck B</u>
First cost	\$50,000	\$60,000
Annual Maintenance	5,000	4,000
Useful Life	7 years	7 years
Salvage value	6,000	6,000
Annual Reduction in fire damage	20,000	21,000

- a) Using the modified B/C ratio method determine whether the city should buy a new truck, and which one to buy if it will be paid for with money borrowed at an interest rate 7%.
- b) How would the decision be affected if inflation were considered? Assume maintenance cost, salvage value, and fire damage are responsive to inflation.

Solution

- a) In the modified B/C ratio, all annual cash flows are placed in the numerator while first cost and salvage are placed in the denominator. Either present or uniform equivalent methods may be used to relate cash flows.

$$\left(\frac{B}{C}\right)_A = \frac{20,000 - 5,000}{50,000(A/P, 7\%, 7) - 6,000(A/F, 7\%, 7)} = 1.72 (> 1) \quad \therefore A \text{ is acceptable}$$

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$$\left(\frac{B}{C}\right)_B = \frac{21,000 - 4,000}{60,000(A/P, 7\%, 7) - 6,000(A/F, 7\%, 7)} = 1.63 (> 1) \quad \therefore B \text{ is acceptable}$$

$$\left(\frac{B}{C}\right)_{B-A} = \frac{(21,000 - 20,000) - (4,000 - 5,000)}{10,000(A/P, 7\%, 7)} = 1.08 (> 1) \quad \therefore B \text{ is better than A}$$

Truck B should be purchased

- b) Since both future costs (maintenance) and benefits (reduced damage and salvage) are responsive to inflation, the decisions are not affected by inflation.

14-6

Four mutually exclusive alternatives, each with a useful life of 20 years and no salvage value, have been presented to the city council of Anytown USA. Which alternative should be selected?

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>
PW of Costs	\$4,000	\$9,000	\$6,000	\$2,000
PW of Benefits	6,480	11,250	5,700	4,700

Solution

B/C	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>
	1.62	2.35	0.95	2.35

C < 1 ∴ eliminate

(rearrange)	<u>D</u>	<u>A</u>	<u>B</u>
PW of Cost	2,000	4,000	9,000
PW of Benefits	4,700	6,480	11,250

	<u>A - D</u>	<u>B - A</u>	
ΔB	1,780	4,770	
ΔC	2,000	5,000	
ΔB/ΔC	.89	95	≤ 1.0 ∴ Choose D least expensive

14-7

Gordon City is considering the construction of a new garbage dump on the outskirts of town. Land acquisition will cost \$85,000. Earthwork and other construction required to prepare the site will cost \$250,000. Environmental inspection prior to use will cost \$15,000. The annual upkeep and operating costs for the dump are expected to \$50,000 during its anticipated 8-year life. The new dump will result in a reduction of \$6 in the average annual garbage disposal fee for each of the 27,000 customers it will serve. (Assume the number of customers remains relatively constant during the life of the dump.) Due to the changes in the environmental conditions adjacent to the dump an annual cost to the surroundings is estimated to be \$32,000. At the end of the useful life the dump must be “capped” at a cost of \$75,000. Determine the benefit/cost ratio if Gordon City uses 4% as its cost of money.

Solution

$$AW_C = 350,000(A/P, 4\%, 8) + 50,000 + 75,000(A/F, 4\% 8)$$

$$= \$130,000$$

$$AW_B = (6 \times 27,000) - 32,000 \quad 32,000 \text{ is considered a disbenefit (reduction in benefits)}$$

$$= \$110,112.50$$

$$B/C \text{ ratio} = 130,000/110,112.50$$

$$= 1.18$$

14-8

The local city recorder is deciding between two different phone answering systems for her office. The information concerning the two machines is presented below.

<u>Machine</u>	<u>Cost</u>	<u>Annual Savings</u>	<u>Useful Life</u>	<u>Salvage</u>
X	\$1,000	\$300	5 years	\$0
Y	1,200	325	5 years	0

With an assumed interest rate of 12%, which system would you recommend?

Solution

Machine X: $PW_C = \$1,000$
 $PW_B = \$300(P/A, 12\%, 5) = \$1,081.5$

$$B/C \text{ ratio} = 1.0815/1,000 = 1.0815$$

Machine Y: $PW_C = \$1,200$
 $PW_B = \$325(P/A, 12\%, 5) = \$1,171.63$

$$B/C \text{ ratio} = 1,171.63/1,200 = .9763$$

∴ Select machine X

14-9

A city engineer is deciding which of two bids for a new computer to accept. Using benefit/cost analysis, which alternative should be selected if the interest rate is 10% per year?

<u>Computer</u>	<u>Cost</u>	<u>Annual Benefits</u>	<u>Salvage</u>	<u>Useful life</u>
A	\$48,000	\$13,000	\$0	6 years
B	40,000	12,000	0	6 years

Solution

Alternative A:
 $PW_B = 13,000(P/A, 10\%, 6) = \$56,615$
 $PW_C = 48,000$

$$B/C = 56,615/48,000 = 1.179 \text{ (OK)}$$

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Alternative B

$$PW_B = 12,000(P/A, 10\%, 6) = \$52,260$$

$$PW_C = 40,000$$

$$B/C = 52,260 / 40,000 = 1.3065 \quad (\text{OK})$$

Incremental Analysis

$$\frac{\Delta B}{\Delta C} = \frac{56,516 - 52,260}{48,000 - 40,000} = \frac{4,355}{8,000} = .544$$

$$\frac{\Delta B}{\Delta C} < 1.0 \quad \therefore \text{select least cost alternative, B}$$

14-10

The Tennessee Department of Highways (TDOH) is considering building its first “tolled-bypass” around the town of Greenfield, Tennessee. The initial cost of the bypass is estimated to be \$5.7 million. The installation of the tollbooths along the bypass is estimated to cost \$1.3 million. The annual maintenance cost of the bypass is expected to be \$105,000 while the annual costs associated with the tollbooths are expected to be \$65,000 each year. Due to the construction of the bypass, Greenfield is expected to receive estimated tax revenues of \$225,000 per year. In addition, TDOH has projected user savings of \$100,000 each year. Each user of the bypass is will pay a toll of \$0.90. TDOH estimates that there will be a total of 500,000 users of the bypass each year. Other relevant data are summarized below.

Resurfacing cost (every 7 years)	4% of bypass initial cost
Shoulder grading/rework	90% of resurfacing cost

If the state uses an interest rate of 7%, should the “tolled-bypass” be constructed? Assume perpetual life.

Solution:

Use benefit/cost analysis. (Use AW analysis)

Benefits

Annual Tax Revenues	\$225,000.00
Bypass User Annual Savings	\$100,000.00
Tollbooth Revenue \$0.90(500,000)	<u>\$450,000.00</u>
	AW _B = \$ 775,000.00

Costs

Toll Booth First Cost \$1,300,000(A/P, 7%, ∞)	\$ 91,000.00
Bypass First Cost \$5,700,000(A/P, 7%, ∞)	\$399,000.00
Toll Booth Maintenance	\$ 65,000.00
Bypass Maintenance	\$ 105,000.00
Resurfacing 0.04(\$5,700,000(A/P, 7%, 7))	\$ 26,536.80
Shoulder Grading/Rework 0.90(0.04(\$5,700,000(A/P, 7%, 7)))	<u>\$ 23,721.12</u>
	AW _C = (\$710,257.92)

$$B/C = 775,000/710,275.92 = 1.0912$$

∴ The bypass should be constructed

14-11

The town of Oakville is evaluating a proposal that it erect and operate a structure for parking in the downtown area. Numerous design proposals were considered. Data for the two best proposals is presented below.

	<u>Design A</u>	<u>Design B</u>
Cost of site and construction	\$2,220,000	\$1,850,000
Annual revenue from parking fees	765,000	575,000
Annual maintenance cost	410,000	295,000
Service life	20 years	20 years

At the end of each five year period the parking facility will require a maintenance overhaul. The cost for design A is estimated to be \$650,000 and for design B, \$375,000. At the end of the service life the facility will be torn down and the land sold. Demolition costs and proceeds from the sale of the land are presented below.

Demolition costs	\$530,000	\$550,000
Proceeds from sale of land	530,000	530,000

If the city's interest rate is 10%, determine the B/C ratio of each design proposal.

Solution

Design A

$$PW_B = 765,000(P/A, 10\%, 20) = \$6,513,210$$

$$PW_C = 2,220,000 + 410,000(P/A, 10\%, 20) + 650,000(P/F, 10\%, 5, 10, \text{ and } 15) = \$6,500,510$$

$$\frac{B}{C} = \frac{\$6,513,210}{\$6,500,510} = 1.001$$

(Note: Demolition and proceeds from sale net to \$0)

Design B

$$PW_B = 575,000 + 530,000(P/F, 10\%, 20) = \$4,974,308$$

$$PW_C = 1,850,000 + 295,000(P/A, 10\%, 20) + 375,000(P/F, 10\%, 5, 10, \text{ and } 15) + 550,000(P/F, 10\%, 20) = \$4,910,535$$

$$\frac{B}{C} = \frac{\$4,974,308}{\$4,910,535} = 1.013$$

14-12

A new water treatment plant will cost the city of Frogjump \$2,000,000 dollars to build and \$100,000 per year to operate for its 20-year life. At the end of 20 yrs, the salvage value will be 0. Due to more efficient operation of the water plant, it is expected to lower the cost of utility bills for each customer \$50 per year. There are 6,000 customers that are billed in Frogjump. The plant will reduce air quality by an estimated \$5 per resident per year. The population of Frogjump is currently 18,000 and is expected to remain relatively constant over the life of the plant. If 3% is used for the evaluation of public works projects, should the water treatment plant be built?

Solution

First Cost: \$2,000,000
 Annual Operating Cost: \$100,000/yr
 Air Quality Annual Cost: \$5/year × 18,000 residents = \$90,000/year (considered a disbenefit)
 Annual Benefits: \$50/year × 6,000 customers = \$300,000/year

Using B/C ratio AW_B/AW_C should be greater than or equal to 1

$$AW_B = \$300,000 - 90,000 = 210,000$$

$$AW_C = \$2,000,000(A/P, 3\%, 20) + 100,000 = \$234,400 \quad .8974$$

$$B/C = 300,000/342,000 = .8772$$

∴ New Water Treatment Plant should not be built

14-13

A new electric generation plant is expected to cost \$43,250,000 to complete. The revenues generated by the new plant are expected to be \$3,875,000 per year while operational expenses are estimated to \$2,000,000 per year. If the plant is expected to last forty years and the electric authority uses 3% as its cost of capital, determine if the plant should be built.

Solution

$$AW_{\text{BENEFITS}} = \$3,875,000$$

$$AW_{\text{COSTS}} = 43,500,000(A/P, 3\%, 40) + 2,000,000 = \$3,872,725$$

$$B/C = \frac{AW_{\text{BENEFITS}}}{AW_{\text{COSTS}}} = \frac{3,875,000}{3,872,725} = 1 \quad \therefore \text{Build Plant}$$

14-14

Mathis City is considering the construction of a municipal park. Land required for the park will be bought in two transactions, the initial purchase and a second purchase for expansion five years later. The first land purchase will cost \$62,000. The second land purchase will cost \$24,000. Construction of the park will take two years. Each year of construction the city is anticipating spending \$250,000. When the park is expanded in year six (after the second land purchase at the end of year five) the cost is expected to be \$80,000.

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Various activities at the park, for instance putt-putt golf will require fee payment by the user. These activities are expected to generate revenue of \$35,000 per year. The monetary value to the citizens of the city due to the enjoyment of the park is calculated to be \$26,000 per year. Maintenance and upkeep will be contracted out at a cost of \$12,000 per year. The park is expected to be used indefinitely and Mathis City has a cost of money of 8%. Determine the B/C ratio of the planned park.

Solution

$$AW_B = 35,000 + 26,000 \\ = \$61,000$$

$$AW_C = 574,550(A/P, 8\%, \infty) + 12,000 \\ = \$57,964$$

$$PW_C = 62,000 + 24,000(P/F, 8\%, 5) + 250,000(P/F, 8\%, 1) + 250,000(P/F, 8\%, 2) \\ + 80,000(P/F, 8\%, 6) \\ = \$574,550$$

$$B/C = 61,000/57,964 = 1.0524$$

14-15

The expansion of the hotel and conference center at Wicker Valley State Park is under study. The initial investment and annual operating benefits and costs are very different due to the differing magnitudes of the projects under consideration. These can be summarized as follows:

	<u>Alternative A</u>	<u>Alternative B</u>	<u>Alternative C</u>
Investment cost	\$180,000	\$100,000	\$280,000
Annual operating costs	16,000	12,000	28,000
Annual benefits	53,000	35,000	77,000

Using a MARR of 10%, which alternative should be selected if all alternatives have a ten-year useful life? Use benefit/cost ratio analysis.

Solution

- B/C ratios of individual alternatives.

$$\left(\frac{B}{C}\right)_A = \frac{AW_B}{AW_C} = \frac{53,000}{180,000(A/P, 10\%, 10) + 16,000} = 1.17 (> 1)$$

$$\left(\frac{B}{C}\right)_B = \frac{AW_B}{AW_C} = \frac{35,000}{100,000(A/P, 10\%, 10) + 12,000} = 1.24 (> 1)$$

$$\left(\frac{B}{C}\right)_C = \frac{AW_B}{AW_C} = \frac{77,000}{280,000(A/P, 10\%, 10) + 28,000} = 1.05 (> 1)$$

∴ All economically attractive

- Incremental B/C Analysis

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$$\Delta \text{Benefits} = 53,000 - 35,000 = 18,000$$

$$\Delta \text{Costs} = (180,000 - 1000,000)(A/P, 10\%, 10) + (16,000 - 12,000) = 17,016$$

$$\left(\frac{B}{C}\right)_{A-B} = \frac{18,000}{17,016} = 1.06 (> 1) \quad \therefore \text{Choose A}$$

C - A

$$\Delta \text{Benefits} = 77,000 - 53,000 = 24,000$$

$$\Delta \text{Costs} = (280,000 - 180,000)(A/P, 10\%, 10) + (28,000 - 16,000) = 28,270$$

$$\left(\frac{B}{C}\right)_{C-A} = \frac{24,000}{28,270} = 0.85 (< 1) \quad \therefore \text{Choose A}$$

Select Alternative A. (If we consider the operating costs as a reduction to the annual benefits a different numerical value for the B/C ratio might be found. The decision of which alternative is best will, however, be the same.)

14-16

Using benefit/cost ratio analysis, determine which one of the following alternatives should be selected. Each alternative has a six-year useful life. Assume a 10% MARR.

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>
First cost	\$880	\$560	\$700	\$900
Annual benefit	240	130	110	250
Annual cost	80	20	0	40
Salvage value	300	200	440	110

SolutionA

$$AW_{\text{BENEFITS}} = 240 + 300(A/F, 10\%, 6) = 278$$

$$AW_{\text{COSTS}} = 880(A/P, 10\%, 6) + 80 = 282$$

$$B/C = .98 (< 1, \text{ so, eliminate})$$

B

$$AW_{\text{BENEFITS}} = 130 + 200(A/F, 10\%, 6) = 155.9$$

$$AW_{\text{COSTS}} = 560(A/P, 10\%, 6) + 20 = 148.57$$

$$B/C = 1.04$$

C

$$AW_{\text{BENEFITS}} = 110 + 440(A/F, 10\%, 6) = 167$$

$$AW_{\text{COSTS}} = 700(A/P, 10\%, 6) + 0 = 160$$

$$B/C = 1.04$$

D

$$AW_{\text{BENEFITS}} = 250 + 110(A/F, 10\%, 6) = 264$$

$$AW_{\text{COSTS}} = 900(A/P, 10\%, 6) + 40 = 246$$

$$B/C = 1.07$$

D-C

$$AW_{\text{BENEFITS}} = (250 - 110) + (110 - 440)(A/F, 10\%, 6) = 97$$

$$AW_{\text{COSTS}} = (900 - 700)(A/P, 10\%, 6) + (40 - 0) = 85$$

$$B/C = 1.14 \rightarrow \text{Choose D}$$

D-B

$$AW_{\text{BENEFITS}} = (250 - 130) + (110 - 200)(A/F, 10\%, 6) = 108$$

$$AW_{\text{COSTS}} = (900 - 560)(A/P, 10\%, 6) + (40 - 20) = 98$$

$$B/C = 1.10 \rightarrow \text{Choose D}$$

14-17

Froggy University is considering the purchase of a new garbage incinerator. The “best” alternative costs \$55,000 and is expected to save Froggy U. \$6,000 in garbage fees the first year with the savings increasing by \$750 each year thereafter. The incinerator will result in a decrease of the air quality around campus which is estimated to be worth \$1,000 per year. The incinerator will have no salvage value at the end of its 10-year useful life. If Froggy U. evaluates all capital outlays with a 6% interest and requires B/C analysis what would you recommend?

Solution

Consider the air quality value is a disbenefit.

$$\frac{B}{C} = \frac{6,000 + 750(A/G, 6\%, 10) - 1,000}{55,000(A/P, 6\%, 10)} = 1.07 (> 1) \quad \therefore \text{Purchase the incinerator}$$

6-18

Drygulch is considering damming the nearby Twisted River to create a recreational lake for the community. The earthen dam under consideration has an anticipated cost of \$1,000,000. Every ten years the lake will require draining and the dam reworked at an estimated cost of \$100,000. The annual expense of operating the lake and surrounding area is estimated to be \$20,000. Drygulch has forecast that the lake will be used by an average of 8,000 persons annually. The monetary benefit to each user has been calculated to be \$7.75. Boat launching fees of \$6.00/launching will be charged the estimated annual 1,200 boats that launch into the lake. At an interest rate of 4%, determine if Drygulch should build the dam.

Solution

$$AW_B = (8,000 \times 7.75) + (1,200 \times 6.00)$$

$$= \$69,200$$

$$AW_C = 1,000,000(A/P, 4\%, \infty) + 100,000(A/F, 4\%, 10) + 20,000$$

$$= \$68,330$$

$$B/C = 69,200/68,330$$

$$= 1.01 \quad \therefore \text{Build the dam}$$

6-19

Two different water delivery methods are available to supply the town of Dry-Hole with much needed water. Each method is summarized in the table below. Using an interest rate of 6% and the appropriate analysis for public projects, which method should be chosen?

Deep-well

Canal

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First Cost	\$435,000	\$345,000
Annual M & O Costs	18,000	25,500
Life	20 years	20 years

Solution

$$\left(\frac{B}{C}\right)_{\text{DW-C}} = \frac{7,500(P/A, 6\%, 20)}{90,000} = .96 (< 1) \quad \therefore \text{Build the canal}$$