Lecture 9

Benefit/Cost Ratios

Judging proposed investments

- Benefit/cost ratios are frequently used for government decisions
- Costs accrue to government, but:
  - Benefits frequently accrue to others!
  - Benefits may take on non-monetary forms
  - Some benefits may not be counted!
    - E.g., profits by hospitals due to pollution
  - For some programs, costs exceed benefits!

Judging proposed investments

- For now, we will avoid some of these problems
- In particular, we will assume that:
  - All relevant costs and benefits have been put in dollar terms

Example

- Consider three choices of new highway:
  - Lifetime = 20 years for all three
  - i* = 7%

Example

- Option A:
  - Invest $110,000, no salvage value
  - Annual maintenance cost = $35,000/year
  - User "costs" (travel time) are:
    - $210,000/year in year 1
    - Increasing by $10,000/year until year 10
      - (due to increasing congestion)
    - Constant at $300,000/year until year 20

Example

- Option B:
  - Invest $700,000, salvage value = $300K
  - Annual maintenance cost = $21,000/year
  - User "costs" (travel time) are:
    - $157,500/year in year 1
    - Increasing by $7,500/year until year 10
      - (due to increasing congestion)
    - Constant at $225,000/year until year 20

Example

- Option C:
  - Invest $1,300,000, salvage value = $550K
  - Annual maintenance cost = $17,000/year
  - User "costs" (travel time) are:
    - $136,500/year in year 1
    - Increasing by $6,500/year until year 10
      - (due to increasing congestion)
    - Constant at $195,000/year until year 20

Example

- To government, option C is more costly:
  - Savings go to *someone else!*

Example

	Option A	Option B	Option C
	Present worth ($ million)		
Total	3.304	2.962	3.173
Government	0.481	0.845	1.338
User	2.823	2.117	1.835
	Equivalent annual cost ($ thousand)		
	311.9	279.7	299.5
	Incremental rate of return		
	12.8% (B-A)	3% (C-B)	

- Note that present worth and equivalent annual cost have same ratios:
  - E.g., 3.304/2.962 = 311.9/279.7 = 1.115

Note

- Benefits minus costs:
  - What is a benefit?
    - Reduction in user costs
  - Both must be in equivalent terms
    - (Either present worth or annual equivalent)

Example

- Benefits minus costs
  - A - B:
    - Benefit (reduction in user costs)
      - = \$2.823 million$_A$ - \$2.117 million$_B$ = \$706,000
    - Cost (increase in government costs)
      - = \$0.845 million$_B$ - \$0.481 million$_A$ = \$364,000
    - Net benefit = \$706,000 - \$364,000
      - = \$342,000

Example

- Benefits minus costs
  - B - C:
    - Benefit
      - = \$2.117 million$_B$ - \$1.835 million$_C$ = \$282,000
    - Cost
      - = \$1.338 million$_C$ - \$0.845 million$_B$ = \$493,000
    - Net benefit = \$282,000 - \$493,000
      - = -\$211,000

Note

- If we take *differences*,
  - It doesn't matter whether we count savings as:
    - A positive benefit

    or
    - A reduction in cost
- If the Corps of Engineers builds a dam,
  - This reduces FEMA costs (cost or benefit?)

Note

- If we take *ratios* of benefit to cost,
  - It *does* matter how we count savings:
    - A positive benefit?

    or
    - A reduction in cost?

Example

- A vs. B:
  - Benefit = $706,000
  - Cost = $364,000
    - Ratio = $706,000/$364,000 = 1.94 > 1
- B vs. C:
  - Benefit = $282,000
  - Cost = $493,000
    - Ratio = $282,000/$493,000 = 0.57 < 1

Example

- What if we consider maintenance cost reductions a benefit instead of a cost?
- In present worth terms, maintenance is:
  - $371,000 for option A
  - $223,000 for option B
  - $180,000 for option C

Example

- A vs. B:
  - Benefit = $706,000+($371,000-$223,000)
  - Cost = $364,000+($371,000-$223,000)
    - Ratio = $854,000/$512,000 = 1.67 vs. 1.94
- B vs. C:
  - Benefit = $282,000+($223,000-$180,000)
  - Cost = $493,000+($223,000-$180,000)
    - Ratio = $324,000/$536,000 = 0.61 vs. 0.57

Note

- Adding/subtracting a constant amount to the numerator and denominator:
  - Cannot change whether ratio is > 1 or < 1
    - If a/b < 1, then (a+c)/(b+c) < 1
  - But *can* change which ratio is bigger!
    - Problem unless definition of benefits is clear!!!
- This is not a problem with *differences*,
  - But benefit/cost *ratios* are more popular!

Another example

- A vs. B: Increased capital cost = $150
  - User benefit = $150
  - Reduced maintenance = $100
- A vs. C: Increased capital cost = $125
  - User benefit = $200
  - Reduced maintenance = $25

Another example

- Ratio = Benefit/(Capital-Maintenance)
  - A vs. B: $150/($150-$100) = 3
  - A vs. C: $200/($125- $25) = 2
    - Option B looks better than option C
- Ratio = (Benefit+Maintenance)/Capital
  - A vs. B: ($150+$100)/$150 = 1.67
  - A vs. C: ($200+ $25)/$125 = 1.8
    - Option C looks better than option B!!!

Another example

- What is wrong?
  - As with IRR, need to evaluate each incremental investment!
- A vs. C: Increased capital cost = $125
  - User benefit = $200
  - Reduced maintenance = $25
  - Benefit/cost ratio of 2 *or* 1.8 is > 1
    - So option C is better than option A

Another example

- Now consider the more costly option, B
- C vs. B: Increased capital cost = $25
  - *Decreased* user benefit = -$50
  - Reduced maintenance cost = $75
  - Benefit/cost ratio of ($75-$50)/($25) = 1
- So options B and C are equally desirable
  - But comparing against A can be misleading

More realistic example

- Compare three flood-control options:
  - All with 50 year lifetime

  (under the assumption of i* = 6%)
- Option C causes environmental damage
  - E.g., damage to salmon fisheries
- Is this a cost of the dam?
  - Or a reduction in its benefit???

More realistic example

	Option A	Option B	Option C
Expected annual flood damage	$480,000	$105,000	$55,000
Annual maintenance cost	$0	$35,000	$40,000
Investment	$0	$2.9 million	$5.3 million
Annual damage caused by dam	$0	$0	$38,000
Expected annual total damage	$480,000	$105,000	$55,000+$38,000 = $93,000
Equivalent annual dam cost	$0	$219,000	$376,000

More realistic example

- A vs. B:
  - Benefit = $480,000 - $105,000 = $375,000
  - Cost = $219,000
    - Net benefit = $375,000 - $219,000 = $156,000
- B vs. C:
  - Benefit = $105,000 - $93,000 = $12,000
  - Cost = $376,000 - $219,000 = $157,000
    - Net benefit = $12,000 - $157,000 = -$145,000

More realistic example

- A vs. B:
  - Benefit = $480,000 - $105,000 = $375,000
  - Cost = $219,000
    - Ratio = $375,000/$219,000 = 1.71 > 1
- B vs. C:
  - Benefit = $105,000 - $93,000 = $12,000
  - Cost = $376,000 - $219,000 = $157,000
    - Ratio = $12,000/$157,000 = 0.08 < 1

More realistic example

- What if damage to salmon fisheries is treated as a cost of the dam?
  - Instead of reduction in flood control benefit
- B vs. C:
  - Benefit = $12,000 + $38,000 = $50,000
  - Cost = $157,000 + $38,000 = $195,000
    - Ratio = $50,000/$195,000 = 0.26, *not 0.08!*
    - Still less than 1, so don't choose option C

Review

- What is the single most important pitfall to avoid when using present worth to compare projects?
- What is the single most important pitfall to avoid when using internal rate of return to compare projects?
- What is the single most important pitfall to avoid when using benefit/cost ratio to compare projects?