EVALUATION OF SAFETY ALTERNATIVES

Economic Evaluation of Alternative Projects

- Objective
  - Compare costs and benefits of projects on equivalent basis
  - Use equivalent basis of total present sum, or of uniform annual costs in same year

Economic Evaluation

- Economic evaluation is required when;
  - Costs are high
  - Countermeasures compete at one site
  - Benefits vary for various countermeasures
- FHWA requires an economic evaluation to justify the use of federal funds

Bases of Comparison for Economic Analysis

- Costs of safety improvements include;
  - Construction or implementation costs
  - Operation (of facility) costs
  - Maintenance costs
  - Salvage value (or costs)

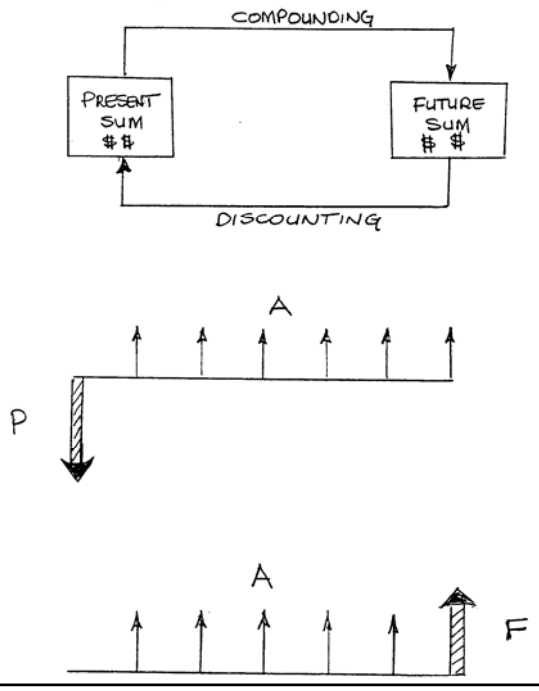
Economic Evaluation of Alternative Projects

- Safety benefits include
  - Reduction in;
    - Fatal accidents + Type A Injury
    - Injury accidents (Type B & C)
    - PDO accidents
  - Also
    - ’ Travel time
    - ’ Delay
    - ’ Operating costs

Economic Evaluation of Alternative Projects

- Equivalent basis of comparison
  - Equivalent uniform annual costs/benefits
  - Present worth of costs/benefits
  - Future worth of costs/benefits

Economic Analysis Basics



Comparison of Projects on Equivalent Uniform Annual Cost/Benefit Basis

- Definitions
  - Initial costs or benefits = P
  - Annual costs or benefits = A
  - Future costs or benefits = F

Comparison of Projects on Equivalent Uniform Annual Cost/Benefit Basis

- Method
  - Convert all benefits and costs to equivalent uniform annual amounts:
    - P →A ; A = [capital recovery factor] x (P)
    - F →A ; A = [SFF] x (F)
  - Convention
    - P →A (service life, discount rate) = capital recovery factor

      i.e., Factor to take present sum and convert to equivalent equal periodic payments

Calculations of Equivalent Uniform Annual Costs

GIVEN:

Initial cost = $1,000

Service life = 10 years

Discount rate = 10% per year

FIND:

Convert to equivalent uniform annual amount

Find tabled factor P→A (10 yrs, 10%)=0.1627

Calculate equivalent uniform annual cost

EUAC = $1,000 (0.1627)

EUAC = $163

7% INTEREST FACTORS FOR ANNUAL COMPOUNDING INTEREST

YEAR	SINGLE PAYMENT: COMPOUND AMOUNT FACTOR P→F	SINGLE PAYMENT: PRESENT WORTH FACTOR F→P	EQUAL PAYMENT SERIES: COMPOUND AMOUNT FACTOR A→F	EQUAL PAYMENT SERIES: SINKING FUND FACTOR F→A	EQUAL PAYMENT SERIES: PRESENT WORTH FACTOR A→P	EQUAL PAYMENT SERIES: CAPITAL RECOVERY FACTOR P→A
1	1.070	0.9346	1.000	1.0000	0.9346	1.0700
2	1.145	0.8734	2.070	0.4831	1.8080	0.5531
3	1.225	0.8163	3.215	0.3111	2.6243	0.3811
4	1.311	0.7629	4.440	0.2252	3.3872	0.2952
5	1.403	0.7130	5.751	0.1739	4.1002	0.2439
6	1.501	0.6663	7.153	0.1398	4.7665	0.2098
7	1.606	0.6227	8.654	0.1156	5.3893	0.1856
8	1.718	0.5820	10.260	0.0975	5.9713	0.1675
9	1.838	0.5439	11.978	0.0835	6.5152	0.1535
10	1.967	0.5083	13.816	0.0724	7.0236	0.1424
11	2.105	0.4751	15.784	0.0634	7.4987	0.1334
12	2.252	0.4440	17.888	0.0559	7.9427	0.1259
13	2.410	0.4150	20.141	0.0497	8.3577	0.1197
14	2.579	0.3878	22.550	0.0443	8.7455	0.1143
15	2.759	0.3624	25.129	0.0398	9.1079	0.1098
16	2.952	0.3387	27.888	0.0359	9.4466	0.1059
17	3.159	0.3166	30.840	0.0324	9.7632	0.1024
18	3.380	0.2959	33.999	0.0294	10.0591	0.0994
19	3.617	0.2765	37.379	0.0268	10.3356	0.0968
20	3.870	0.2584	40.995	0.0244	10.5940	0.0944

Source: LHSS Users Guide, pp C-10

10% INTEREST FACTORS FOR ANNUAL COMPOUNDING INTEREST

YEAR	SINGLE PAYMENT: COMPOUND AMOUNT FACTOR P→F	SINGLE PAYMENT: PRESENT WORTH FACTOR F→P	EQUAL PAYMENT SERIES: COMPOUND AMOUNT FACTOR A→F	EQUAL PAYMENT SERIES: SINKING FUND FACTOR F→A	EQUAL PAYMENT SERIES: PRESENT WORTH FACTOR A→P	EQUAL PAYMENT SERIES: CAPITAL RECOVERY FACTOR P→A
1	1.100	0.9091	1.000	1.0000	0.9091	1.1000
2	1.210	0.8264	2.100	0.4762	1.7355	0.5762
3	1.331	0.7513	3.310	0.3021	2.4869	0.4021
4	1.464	0.6830	4.641	0.2155	3.1699	0.3155
5	1.611	0.6209	6.105	0.1638	3.7908	0.2638
6	1.772	0.5645	7.716	0.1296	4.3553	0.2296
7	1.949	0.5132	9.487	0.1054	4.8684	0.2054
8	2.144	0.4665	11.436	0.0874	5.3349	0.1874
9	2.358	0.4241	13.579	0.0736	5.7590	0.1736
10	2.594	0.3855	15.937	0.0627	6.1446	0.1627
11	2.853	0.3505	18.531	0.0540	6.4951	0.1540
12	3.138	0.3186	21.384	0.0468	6.8137	0.1468
13	3.452	0.2897	24.523	0.0408	7.1034	0.1408
14	3.797	0.2633	27.975	0.0357	7.3667	0.1357
15	4.177	0.2394	31.772	0.0315	7.6061	0.1315
16	4.595	0.2176	35.950	0.0278	7.8237	0.1278
17	5.054	0.1978	40.545	0.0247	8.0216	0.1247
18	5.560	0.1799	45.599	0.0219	8.2014	0.1219
19	6.116	0.1635	51.159	0.0195	8.3649	0.1195
20	6.727	0.1486	57.275	0.0175	8.5136	0.1175

Source: LHSS Users Guide, pp C-13

Information Needed for Economic Evaluation

- Construction / installation costs
- Operation and maintenance costs
- Anticipated safety benefits

Economic Evaluation Process

- Estimate accident reduction potential
- Estimate the safety benefits;

  Safety benefits = $\pm$fatal acc. x $fatal + $\pm$injury acc. x $injury + $\pm$PDO's x $PDO

- Determine construction / installation / operation / maintenance costs
- Put all costs/benefits on a common economic basis
  - Equivalent uniform annual costs/benefits
  - Present worth of costs/benefits
- Compare benefits and costs

Implementation Costs

- Include all costs incidental to;
  - Construct
  - Install
  - Operate
  - Maintain

Other Information Needed for Economic Evaluation

- Service life
- Interest rate (vest charge rate)
- Salvage value

Service Life

- Service life is that time that a countermeasure serves in a fully functional manner as originally intended.

Vest Charge Rate

- Interest rate (time value of money) must be applied consistently for all competing countermeasures.

Salvage Value

- Net value at end of service life
- Often zero
- May be negative, if no value, but costs to remove

Anticipated Benefits

- Accident reduction
- Reduced travel time
- Reduced delays
- Reduced fuel consumption

Source of Accident Reduction Factors

- Agency studies
- Caltrans
- ODOT
- Missouri DOT
- Washington DOT
- Current literature
- Federal Highway Administration

Established Dollar Value of Accident Costs

- NSC
- NHTSA / FHWA
- Agency policy

Traffic Crash Costs:

AIS Level Severity	Descriptor		Cost Per Injury (Dollars)
Property Damage Only			65,000
AIS 3	Serious Injury	(C)	175,000
AIS 4	Severe	(B)	565,000
AIS 5	Critical	(A)	2,290,000
AIS 6	Fatal		3,000,000

2-30

Source: NHI, 2005

FHWA Costs per Accident

Accident Type	
PDO	2,300
Type C Injury	22,000
Type B Injury	42,000
Type A Injury	208,000
Fatal	3,000,000

Source: Highway Safety Manual

Economic Evaluation Methods

- Total cost
- Net benefits
- Cost effectiveness
- Benefit cost ratio

Appropriateness of Total Cost Method

- Total cost may be used only when benefits are equal for all alternatives

Total Cost = Safety Costs + Implementation

Appropriateness of Net Benefit Method

- Net benefit method may be used only when implementation costs are equal for all alternatives

Net Benefit = Safety Benefit – Implementation Costs

Comparison of Net Benefits and Benefit/Cost Ratios

Annual Costs	Existing	Project A	Project B
Construction cost	0	$9,000	$85,000
Operation cost	$3,000	0	0
Maintenance cost	$2,000	$1,000	$20,000
Safety costs	$150,000	$140,000	$45,000

Comparison of Net Benefits and Benefit/Cost Ratios

Net Ben_A = \$10,000 - \$5,000 = \$5,000

Net Ben_B = \$105,000 - \$100,000 = \$5,000

$BCR_A = \frac{\$1000}{\$5000} = 2$ $BCR_B = \frac{\$105{,}000}{\$100{,}000} = 1.05$

Appropriateness of Cost Effectiveness

- Cost effectiveness may be used when implementation costs are known and magnitude of effects can be quantified for alternatives

$$\text{Cost Effectiveness} = \frac{\text{Diff. in Costs}}{\text{Diff. in Effects}}$$

Cost Effectiveness

$$\text{CE Ratio} = \frac{\text{Cost}_{\text{New}} - \text{Cost}_{\text{Current}}}{\text{Effect}_{\text{New}} - \text{Effect}_{\text{Current}}}$$

For example -

Dollar cost to reduce fatal accidents by one

Benefit Cost Ratio Method

- Benefits and costs must be quantified for each alternative

$$B/C = \frac{\text{Safety Benefits}}{\text{Implementation Cost}}$$

Example: Benefit-Cost Analysis

- Given information
  - Initial implementation cost = $100,000
  - Additional O&M cost = $4,000/yr
  - Accident reduction (annual) from improvement
    - 1 injury accident
    - 12 PDO accidents

Example: Benefit-Cost Analysis

  - Accident costs
    - Injury accident: $200,000
    - PDO accident: $4,000
  - Salvage value = 0
  - Service life = 10 yrs
  - Discount rate = 10% p.a.

Example: Benefit-Cost Analysis

- Calculations solution
  - Annual safety benefits ($ saved)
    1 x $200,000 = $200,000
    12 x $4,000 = $48,000
    Total = $248,000
  - Equivalent uniform annual cost (EUAC)
    = $200,000 (CRF) + $24,000
    = $200,000 (0.1424) + $24,000
    = $52,480
  - B/C = 248,000 / 52,480 = 4.7

Appropriateness of Countermeasure Selected

- Evaluate benefits versus costs
- Result depends on;
  - Service life identified
  - Values of accidents assumed
  - Vest charge selected
  - Costs of construction, operation, maintenance