SESSION 1.2

PROJECT CRITERIA:
ECONOMIC VIABILITY AND PROJECT ALTERNATIVES

Introductory Course on Economic Analysis of Investment Projects

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Discounted Cash Flow: Measures of Project Worth

- Discounting is used to compare projects with different time streams
- Discounting determines present value of cost and benefit streams
  - Future costs and impacts must be converted to present by discounting
- Discounting is the basis for arriving at common measures of project worth
  - Cost stream is subtracted year by year from the benefit stream to obtain the cash flow
  - Cash flow is used as basis to determine the net present value
  - Cash flow is also used as basis to compute for the internal rate of return
- Choice of discount rate is controversial
- Opportunity cost rate (eg 12%) normally used where the funds would otherwise be invested productively

Discounting

- Addresses value of time
- Discount factor (DF) in year t

  $DF_t = 1/(1 + i)^t$
- Reduces future values of costs and benefits
- Calculated simply in Excel

  =npv(rate, value1, value2,...)
- Different interpretations of i
- Physical quantities can be discounted

DCF Measures

- Use of spreadsheet
- Net present value (NPV)
  - A stream of values discounted at a predetermined interest (discount) rate to determine the present value
  - Formula: = NPV(interest rate, range)
- Internal rate of return (IRR)
  - The discount rate at which the NPV is zero
  - Formula: = IRR (range, guess)

Net Present Value (NPV)

$$NPV^0 = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+r)^t} + \frac{R}{(1+r)^n}$$

$$= \sum_{t=0}^{n} \frac{B_t}{(1+r)^t} - \sum_{t=0}^{n} \frac{C_t}{(1+r)^t} + \frac{R}{(1+r)^n}$$

- Do not accept projects with negative NPV.
- For mutually exclusive projects in the same time frame without cost constraints, the project with largest NPV is favored.
- NPV is sensitive to discount rate.

Internal Rate of Return (IRR)

$$r \Rightarrow NPV^0 \equiv \sum_{t=0}^{n} \frac{B_t - C_t}{(1+r)^t} + \frac{R}{(1+r)^n} = 0$$

- When only one project alternative is considered, the *IRR* can be used for project decision, i.e. only proceed with the project if the *IRR is greater* than the default discount rate.
- IRR is ratio instead of value. It should not be used to select one project from a group of candidate projects because size of the project matters.

Year	GROSS BENEFITS Non-Increm	Increm	Total Benefits	ECONOMIC COSTS Capital Investmnt	O&M	Total Cost	Net Economic Benefit
2004	0	0	0	73.2	0	73.2	-73.2
2005	0	0	0	156.6	0	156.6	-156.6
2006	0	0	0	201.7	0	201.7	-201.7
2007	0	0	0	226.3	0	226.3	-226.3
2008	0	0	0	188.0	0	188.0	-188.0
2009	1.5	36.2	37.7	106.6	2.1	108.7	-71.0
2010	10.2	243.3	253.5	7.2	14.5	21.8	231.7
2011	11.0	239.6	250.5	0	14.5	14.5	236.0
2012	11.9	239.6	251.4	0	14.5	14.5	236.9
2013	12.4	239.6	251.9	0	14.5	14.5	237.4
2014	12.4	239.6	251.9	0	13.9	13.9	238.1
2015	12.4	239.6	251.9	0	13.3	13.3	238.6
2016	12.4	239.6	251.9	0	13.3	13.3	238.6
2017	12.4	239.6	251.9	0	13.3	13.3	238.6
2018	12.4	239.6	251.9	0	18.9	18.9	233.0
2019	12.4	239.6	251.9	0	18.9	18.9	233.0
2020	12.4	239.6	251.9	0	18.9	18.9	233.0
2021	12.4	239.6	251.9	0	18.9	18.9	233.0
2022	12.4	239.6	251.9	0	13.3	13.3	238.6
2023	12.4	239.6	251.9	0	13.3	13.3	238.6
2024	12.4	239.6	251.9	0	13.3	13.3	238.6
2025	12.4	239.6	251.9	0	13.3	13.3	238.6
2026	12.4	239.6	251.9	0	13.3	13.3	238.6
2027	12.4	239.6	251.9	0	13.3	13.3	238.6
2028	12.4	239.6	251.9	0	13.3	13.3	238.6
2029	12.4	239.6	251.9	0	13.3	13.3	238.6
2030	12.4	239.6	251.9	0	13.3	13.3	238.6
2031	12.4	239.6	251.9	0	18.9	18.9	233.0
2032	12.4	239.6	251.9	0	18.9	18.9	233.0
2033	12.4	239.6	251.9	0	18.9	18.9	233.0
2034	10.3	247.6	257.9	0	18.9	18.9	239.0
NPV @	48.1	972.2	1020.3	641.6	60.3	701.9	318.4
Unit: USD million						EIRR =	16.8%

Comparison of DCF Measures

Item	NPV	IRR
Selection criterion	Accept all independent projects of 0 or greater NPV discounted at opportunity cost of capital	Accept all independent projects with IRR equal to or greater than opportunity cost of capital
Ranking	Gives no ranking for order of implementation	May give incorrect ranking among independent projects
Mutually exclusive alternatives	Accept alternative with largest NPV when discounted at opportunity cost of capital	Cannot be used directly
Discount rate	Must determine a suitable discount rate, generally the opportunity cost of capital	Determined internally; must determine opportunity cost of capital to use as the cut-off rate

Project Decisions

- Choosing between alternatives when benefits are not the same and can be valued
  - Select the one with the highest, positive NPV at the chosen discount rate.
  - IRR is not the right indicator because it does not reflect project size.
  - Pay attention to the underlying assumptions: a) alternatives are within budget; b) alternatives have the same time frames (otherwise add terminal value to longer life alternative)
- Determining economic viability of the single alternative
  - IRR> default discount rate or NPV>0

Project Alternatives

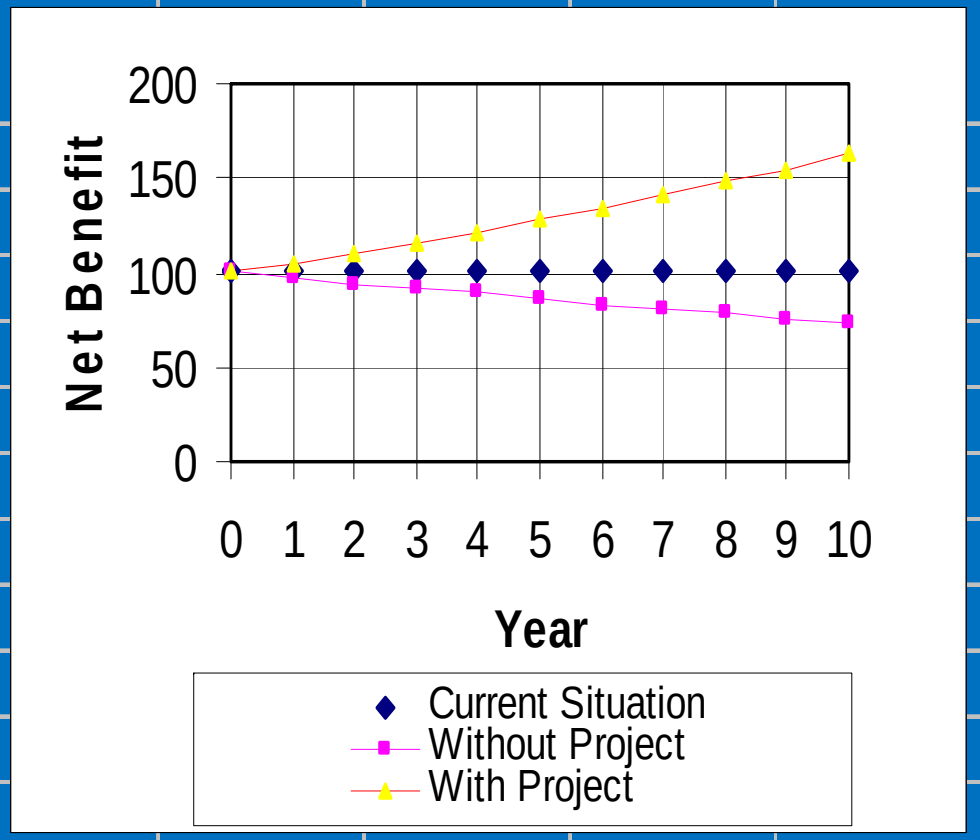
- Comparison of mutually exclusive project options - key reason for economic analysis
- Identification of problem, intervention rationale and set of alternative solutions
- Alternative solutions may not all be economically feasible
- Economic analysis helps identify alternative that meets demand in least-cost way

Project Alternatives

- Comparing with & without project situation:
- Without: what will happen in the absence of a project intervention – counterfactual analysis
- With: identifying costs and benefits that are incremental, non-incremental (cost-saving, efficiency improving)

With and Without Project Comparison

Year	Current Situation	Without Project	With Project
0	100	100	100
1	100	97	105
2	100	94	110
3	100	91	116
4	100	89	122
5	100	86	128
6	100	83	134
7	100	81	141
8	100	78	148
9	100	76	155
10	100	74	163



Project Alternatives

- Considering alternative designs:
  - Scale, beneficiaries, technology, outputs, sequencing, private vs public sector delivery
  - Where outcomes of alternatives not identical, factors other than least-cost exist – state extra costs and reasons

Least Cost Analysis

1. LCA is an appraisal and program monitoring technique used primarily in social programs and projects

   Example: Health, nutrition, and education where identification and quantification of benefits in money terms is not straightforward.

2. The objective is to compare costs per unit of outcome of two programs for purposes of capital budgeting

3. Approach is very useful where aim is to choose from a set of alternative technologies and approaches that will provide the same service

4. When two project alternatives produce the same benefit, choose the one with the least cost.
   - Choosing from two school systems that give same educational benefits
     - Centralized schools that require bus transportation and more expensive smaller schools to which students can walk
   - Two systems of electricity generation
     - Thermal versus hydro
   - Choosing amongst alternative ways of supplying potable water to communities
   - Two or more kinds of health treatment to save lives

Least Cost Analysis

Method 1: Constant Effects

- Uses least-cost analysis to determine the lowest cost alternative for meeting the same level of benefits.
- Example:
  - choosing from two water pipes of different sizes that yield the same quality of water per day (smaller pipe has lower investment cost but higher operating or pumping costs)
  - Selecting from two alternatives for generating the same amount of electricity (thermal and hydro generation units, the former with a lower investment and higher operating cost compared to the latter)

Case 1: Least Cost Method
Drinking Water: Alternative Delivery System

	(All figures in '000)					
Alternative A						
Years	0	1	2	3	4	5
Installation Cost	3,000					
Operating Cost		700	700	700	700	700
Total Cost	3,000	700	700	700	700	700
PV of Total Cost (at 12%)	***$4,932***					
Alternative B						
Years	0	1	2	3	4	5
Installation Cost	4,200					
Operating Cost		400	400	400	400	400
Total Cost	4,200	400	400	400	400	400
PV of Total Cost (at 12%)	***$5,037***					

Discounting Quantities

- Where output levels for alternatives differ it is necessary to discount physical units to make comparison
- Argument of cost of waiting still applies as funds committed to project would have generated returns given by discount rate

Least Cost Analysis

Method 2: Cost-Effectiveness Analysis

- involves a series of steps similar to those of a normal investment appraisal except that the benefits are not measured as monetary values, but as quantitative impacts.
- focus is on evaluating the costs of the alternatives
- comparison of economic costs of alternatives - cost per unit outcome of a program
- Calculates the cost per unit of benefit

Example:

Benefits are simply measured as effectiveness (the number of Premature Deaths Prevented)

- Two different health programs: DPT-BCG vaccination campaign for children or AIDS treatment program.
- The cost per child vaccination and per patient will be computed in this case. Here the purpose is to see which programs yield more value per dollar of expenditure

Cost per Health Impact

For Example:

Benefits are measured as effectiveness (the number of Premature Deaths Prevented)

- Two different health programs: DPT-BCG vaccination
- campaign for children or AIDS treatment program both save lives.
- The cost per child vaccination and per patient will be computed in this case. Here the purpose is to see which programs yield more value per dollar of expenditure

Cost of health Project: Immunization Against DPT and BCG

Year	2000	2001	2002	2003	2004	2005
Premature Deaths Prevented	-	8000	12000	18000	25000	30000
Capital Costs						
Facilities	2500					
Equipments	8500					
Vehicles	5000					
Training	2000					
TA	6000					
Recurrent Costs						
Personnel		10000	16000	25000	36000	42500
Supplies		15000	24000	37500	55000	64000
Training		500	800	1250	1800	2100
Maintenance		2000	3200	4500	7200	8000
Others		3300	5500	8200	12000	14500
Total Costs	24000	30800	49500	76450	112000	131100
PV of Total Benefits	12%	$62,431.99				
PV of Total Costs	12%	$259,771.77				
Cost per unit of Premature Deaths Prevented			**$4.16**			

Cost of Health Project: AIDS Program

Year	2000	2001	2002	2003	2004	2005
Premature Deaths Prevented	-	8000	12000	18000	25000	30000
Capital Costs						
Facilities	200					
Equipments	1000					
Vehicles	300					
Training	500					
TA	1500					
Recurrent Costs						
Personnel		2000	2500	4000	5000	6000
Supplies		40000	65000	90000	120000	150000
Training		100	100	100	100	100
Maintenance		250	300	450	600	800
Others		300	500	800	1250	1500
Total Costs	3500	42650	68400	95350	126950	158400
PV of Total Benefits	12%	$62,431.99				
PV of Total Costs	12%	$298,692.95				
Cost per unit of Deaths Prevented			**$4.78**			

Incremental (or Marginal) Cost-Effectiveness Ratio

- The decision makers need to compute marginal cost-effectiveness ratios when a new larger alternative is compared with existing situation.
- The numerator now contains the difference between the cost of the new and old alternatives, and the denominator is also the difference between the effectiveness of the new and old alternatives:

$$\text{Marginal CE}_{\text{i}} = \frac{C_i - C_0}{E_i - E_0}$$

- This ratio in discounted present values can be interpreted as the incremental cost per unit of effectiveness. When there are several alternatives available, the marginal cost-effectiveness ratio can be used to rank the new measures versus the existing one.

Marginal Cost-Effectiveness Ratios in Prevention of Traffic Fatalities

	Policy Measures	Total Lives Saved	Incremental Effective-ness (Deaths Prevented in a Year)	Total Cost (M $)	Incremental Cost (Rand per Year) (M $)	Marginal CE Ratios ($)	Ranking
A	Existing	500		20.0		40,000	
B	Existing plus Enforcement	600	100	25.5	5.5	55,000	2
C	Existing plus Road Safety	1000	500	31.5	11.5	23,000	1
D	Existing plus Public Campaign	585	85	25.0	5.0	58,824	3

Limitations of Cost Effectiveness

- Does not measure Benefits in monetary terms, unless benefits are treated as costs avoided.
- Has to assume the activity is desirable and suggests how it can be delivered at the lowest unit cost
- Often analyses exclude externalities, on both cost and benefit side

Limitations of Cost Effectiveness

- Does not always account for difference in scale of project and scale difference may distort the choice
- A project with smaller size but higher efficiency level may get accepted, while another project may provide more quantity of output at a reasonable cost.
- Ranking by CE only strictly correct where activities are divisible so more than one small cheaper alternative can produce the same output as one larger more expensive one.

Scale and Implicit Valuation

- Lack of perfect divisibility can lead to unacceptable valuations
- For example, alternative A costs $1 million, saves 10 lives
- Alternative B costs $ 0.4 million, saves 5 lives
  - A = $0.1 mill/life and B = 0.08 mill/life
  - But accepting B means saving $0.6 million at cost of 5 lives or $0.12 million per life
  - Thus, caution is required as valuation may be contentious

Thank you.