

**EE 476**

Benefit- Cost analysis

# Benefit- Cost analysis

- Environmental project feasibility study
- Costs and benefits occur at different point in time throughout the project lifetime.
- The issue of time value of money

# Time value of money

- What is the value of \$100 ten years from now?
- If interest rate is 10%

- end of year 1 ( $t = 1$ ), total amount is

$$100 + 100(0.10) = 100(1 + 0.10) = 110$$

- end of year 2 ( $t = 2$ ), total amount is

$$\begin{aligned} 110 + 110(0.10) &= 110(1 + 0.10) = 100(1 + 0.10)(1 + 0.10) \\ &= 100(1 + 0.10)^2 \end{aligned}$$

- end of year 3 ( $t=3$ ), total amount is

# Time value of money

- Principal of \$A at ( $t = 0$ ) with  $r$  % interest rate becomes  $A(1+r)^t$  at the end of year  $t$
- In other words:

$$FV = PV(1+r)^t$$

So,

$$PV = FV(1+r)^{-t}$$

# Time value of money

- In order to get \$1,000 at the end of year 10, how much money do you need now if interest rate is 5%

$$PV = 1,000(1+0.05)^{-10} = 613.90$$

# Net Present Value (NPV)

$$NPV = (B_0 - C_0) + \frac{(B_1 - C_1)}{(1+r)} + \frac{(B_2 - C_2)}{(1+r)^2} + \dots + \frac{(B_T - C_T)}{(1+r)^T}$$
$$= \sum_{t=0}^T \frac{(B_t - C_t)}{(1+r)^t}$$

- $NPV > 0 \rightarrow$  invest

# Benefit-Cost ratio (B-C ratio)

$$B - C \text{ ratio} = \frac{\sum_0^T B_t}{\sum_0^T C_t}$$

B-C ratio  $> 1 \rightarrow$  invest.

# Internal rate of return (IRR)

- Discount rate at which  $NPV = 0$
- $IRR > \text{borrowing rate} \rightarrow \text{invest}$
- $IRR < \text{borrowing rate} \rightarrow \text{do not invest}$

# Discounting

- From NPV
  - Discount rate is  $r$  :  $r$  is the market discount rate or market interest rate.
  - Discounting factor is  $\beta_t = (1 + r)^{-t}$

# Discounting

- Future does not matter very much unless  $r$  is very close to zero
- If  $r$  is 5% per year, then for  $t=100$   $\beta_t$  would be 0.0076
- You would not be willing to spend 1 Satang today to avoid 1 baht of damage in a century

# Discounting

- Market discount rate is suitable for private investment project not for public project.
- Social discount rate emerges from an ethical judgment rather than a market process.
  - reflect how we view a future generation relative to ours.

# Should we sacrifice for the future generation?

- ❑ Should we spend \$20,000,000 investing in the carbon reduction project which will increase welfare for the future generation by \$1,000,000,000 a hundred year from now?

# Thought experiment

## Which option do you choose?

- Option A: I give you 100 baht today
- Option B: I give you 100 baht 10 years from now

# Thought experiment

## If interest rate is 10%

- ❑ Argument 1 With option A, you can put \$100 in your bank account. 10 years from now, you will get \$259. (Option A is better)
  - ❑ \$259 is the future value of \$100 (amount that you get at present)
- ❑ Argument 2 With interest rate of 10%, you need \$61 today, put it in the bank and you will get \$100 after 10 years. (Option A is better)
  - ❑ \$61 is the present value of \$100 (amount that you get in the future)
- ❑ What if interest rate is 0% , will you be indifferent between option A and B? Do people have time preference?
- ❑ Same amount of money worth differently at different time → Time value of money.

# Time preference

- ❑ People have time preference which reflect in “discount rate”
- ❑ If the discount rate is high, you care relatively more about presence (value of money in the future is highly discounted i.e. low present value)
- ❑ If discount rate is low, you care relatively more about future (ex: 0 discount rate, \$ worth the same at any time)

# Should we sacrifice for the future generation?

- Should we spend \$20,000,000 investing in the carbon reduction project which will increase welfare for the future generation by \$1,000,000,000 a hundred year from now?
- We need to compare costs and benefits that realize at a different point in time.
- What is the answer?

# Implication of time preference on climate change policy

- If current generation has the discount rate of 0% , would you invest?
- If current generation has the discount rate of 4% would you invest?
  - with 4% \$1,000,000,000 a hundred year from now worth only \$19,000,000. Should we invest?
- With the discount rate of 1% would you invest?
  - with 1% \$1,000,000,000 a hundred year from now worth only \$369,000,000. Should we invest?

# Debate in climate change policy

Sir Nicholas Stern of LSE: The Stern Review on the Economics of Climate Change (2006)



Low discount rate (0.1%) → urgent action against global warming to prevent economic damage.

William D. Nordhaus of Yale



High discount rate (3%) → act slowly

# Cost Benefit Analysis (CBA)

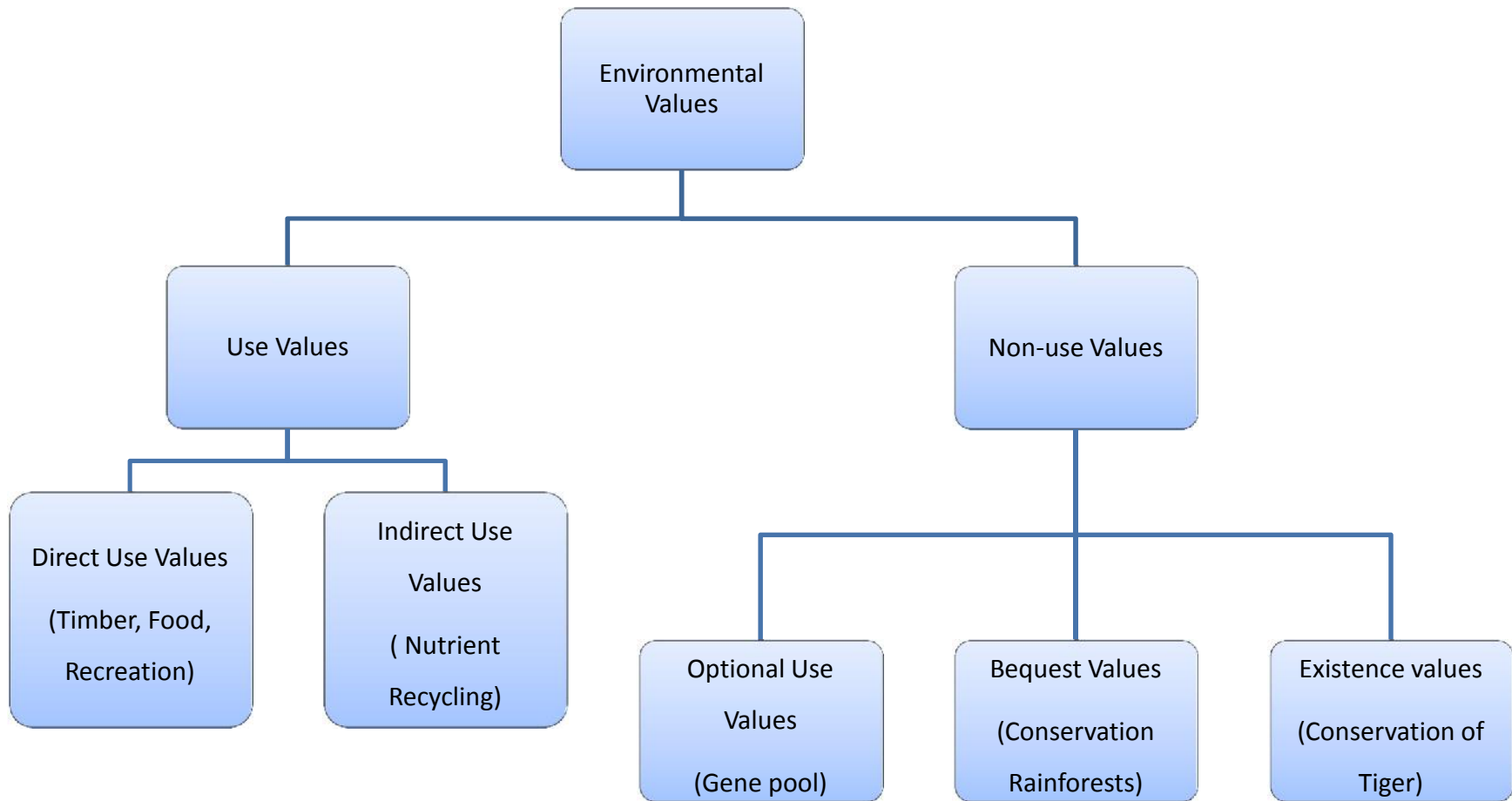
- CBA aims to value the effects of a project as they would be valued in money terms by individuals affected.
- 2 steps,
  - List all parties affected by the project
  - Value the effects on their welfare as it would be valued in money terms by them.

# Project benefits

- Use and Non-use values
- Use values = all use benefits to man
- Non-use values =

Direct or Indirect use benefits + option values  
+ existence values

# Environmental values



# Option values

- Risk is attached to all decisions
- Uncertainty about demand and supply in future
- Pay more to insure demand or supply
- Option value =  
value that an individual is willing to pay in excess  
to expected use value to preserve an asset

# Existence values

- Amount that people would pay to preserve the natural environment or a species above any use benefits

# Secondary benefits

- Result from primary benefits of the project
- e.g. project > higher wages to employees > higher expenditure > improve quality of life
- Not included in CBA
- Viewed as transfer between communities rather than net addition to community income

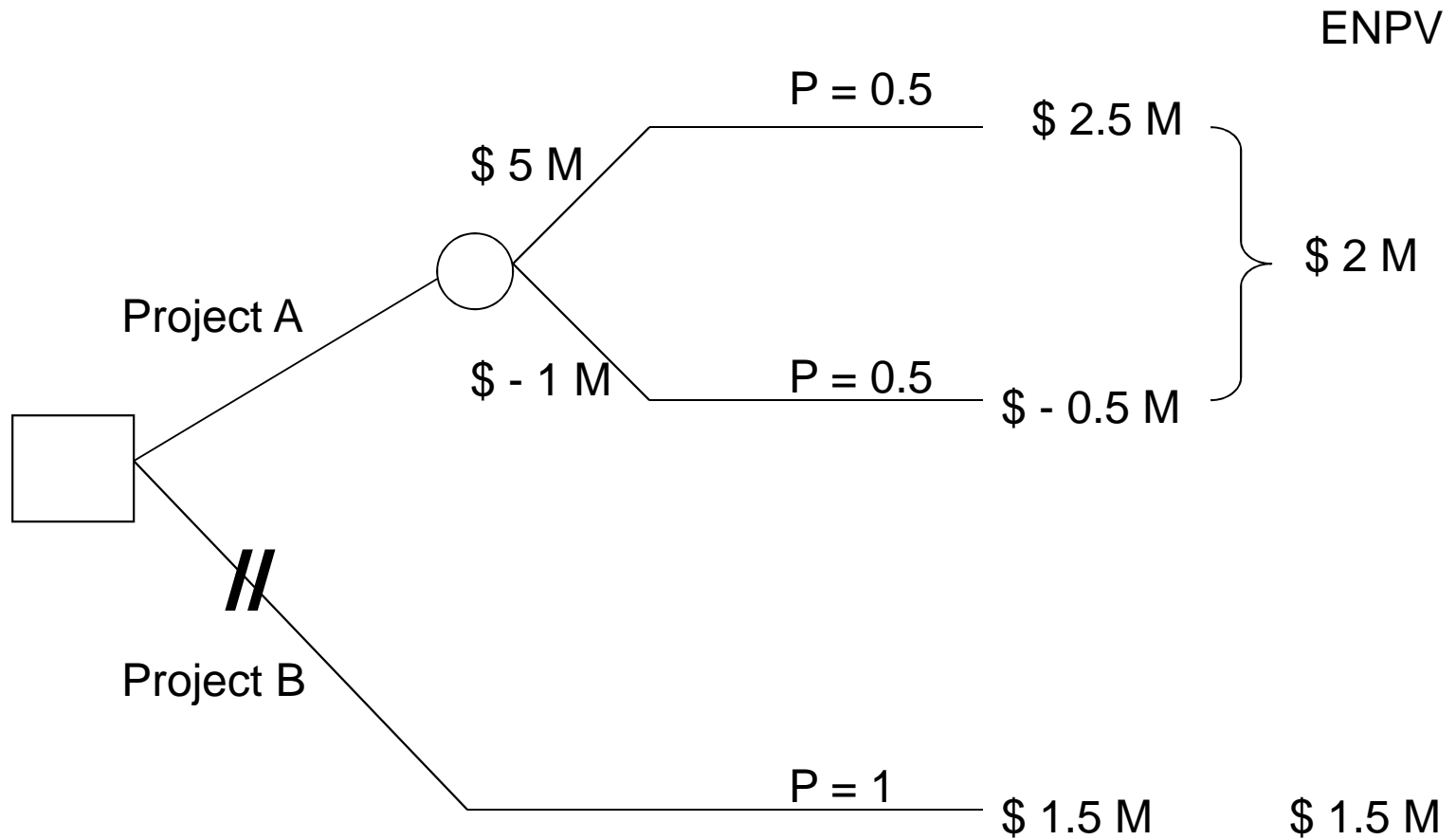
# Uncertainty

- Quantified and Unquantified impacts
- Need to reduce risk of wild exaggerations
- Expected value approach

- $$\text{ENPV} = \sum_{t=1}^n \frac{(E_b - E_c)_t}{(1 + r)^t}$$

- In risk- neutral case, project with highest ENPV should be preferred.

# Uncertainty continued ...



# Distributional Issues

- Fiscal policies fail to distribute income fairly
- WTP values > rich get the edge over poor
- Sustainable development principle
- Need to identify social groups
- Converting WTP values into utility values by use of weights

# Discount Rates

- People require reward for forgoing consumption now
- Positive real rate of return
- Present value of future money
- Example,

Accept \$ 100 today or \$ 110 next year

If accepted \$ 110 – we forgo \$ 100 today

We say that the discount rate is 10%.

# Private project appraisal – the Net Present Value test 1

The present value of expenditures E is

$$\begin{aligned} PV_E &= E_0 + \frac{E_1}{1+i} + \frac{E_2}{(1+i)^2} + \dots + \frac{E_T}{(1+i)^T} \\ &= \sum_0^T \frac{E_t}{(1+i)^t} \end{aligned} \quad (11.14)$$

The present value of receipts R is

$$\begin{aligned} PV_R &= R_0 + \frac{R_1}{1+i} + \frac{R_2}{(1+i)^2} + \dots + \frac{R_T}{(1+i)^T} \\ &= \sum_0^T \frac{R_t}{(1+i)^t} \end{aligned} \quad (11.15)$$

The present value of the project is

$$NPV = PV_R - PV_E = \sum_0^T \frac{R_t}{(1+i)^t} - \sum_0^T \frac{E_t}{(1+i)^t} \quad (11.16)$$

Which for  $N = R - E$  is

$$\begin{aligned} NPV &= N_0 + \frac{N_1}{1+i} + \frac{N_2}{(1+i)^2} + \dots + \frac{N_T}{(1+i)^T} \\ &= \sum_0^T \frac{N_t}{(1+i)^t} \end{aligned} \quad (11.17)$$

The project should go ahead iff  $NPV \geq 0$

## Private project appraisal – the Net Present Value

Year	Expenditure	Receipts	Net cash flow
0	100	0	-100
1	10	50	40
2	10	50	40
3	10	45.005	35.005
4	0	0	0

Example net cash flow

at  $i = 0.05$ , NPV = £4.6151

at  $i = 0.075$ , NPV = £0

at  $i = 0.10$ , NPV = -£4.27874

**The NPV of a project is the amount by which it increases the firm's net worth. It is the present value of the surplus, after financing the project, at the end of the project lifetime.**

## Private project appraisal - risk

Year	Net cash flow 1 Probability 0.6	Net cash flow 2 Probability 0.4
0	-100	-100
1	40	35
2	40	35
3	35.005	25
4	0	0

One project, two possible cash flows

Year	Expected net cash flow	Present value of expected cash flow
0	$-(0.6 \times 100) + \{-(0.4 \times 100)\} = -100$	-100
1	$(0.6 \times 40) + (0.4 \times 35) = 38$	$38/1.075 = 35.35$
2	$(0.6 \times 40) + (0.4 \times 35) = 38$	$38/1.075^2 = 32.88$
3	$(0.6 \times 35.005) + (0.4 \times 25) = 31.003$	$31.003/1.075^3 = 24.96$
4	$(0.6 \times 0) + (0.4 \times 0) = 0$	
Expected NPV		-6.81

Calculation of expected NPV

Where the firm is prepared to assign probabilities, the criterion for going ahead with the project is the expected NPV – the probability weighted sum of the mutually exclusive cash flow outcomes.

**This assumes that the decision maker is risk-neutral**

# Social project appraisal

CBA is the social appraisal of projects

CBA uses the NPV test

## **CBA can be approached in two ways**

As an extension of private appraisal where externalities are taken into account

In terms of social welfare enhancement

The first stages of CBA are

proper project/policy identification

forecasting all of the consequences of the project/policy for all of the affected individuals in each year of the project/policy lifetime

Then

expressing consequences in terms of monetary gains/losses for aggregation to an NPV number

## Social appraisal: an illustrative project

	Time period				
Individual	0	1	2	3	Overall
A	$NB_{A,0}$	$NB_{A,1}$	$NB_{A,2}$	$NB_{A,3}$	$NB_A$
B	$NB_{B,0}$	$NB_{B,1}$	$NB_{B,2}$	$NB_{B,3}$	$NB_{BB}$
C	$NB_{C,0}$	$NB_{C,1}$	$NB_{C,2}$	$NB_{C,3}$	$NB_C$
Society	$NB_0$	$NB_1$	$NB_2$	$NB_3$	

Net benefit (NB) impacts consequent upon an illustrative project

$$NPV = NB_0 + \frac{NB_1}{1+r} + \frac{NB_2}{(1+r)^2} + \frac{NB_3}{(1+r)^3}$$

Generally, go ahead if

$$NPV = \sum_{t=0}^{t=T} \frac{NB_t}{(1+r)^t} > 0 \quad (11.19)$$