

## Cost-Benefit Analysis

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## Decisions in environmental policy



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## Cost Benefit Analysis

- A *decision-making tool* to
- *evaluate and compare* projects and policies
- by *systematically*
  - *identifying,*
  - *quantifying,*
  - *valuing,*
  - and *comparing*
- the positive (*benefits*) and negative (*costs*) effects
- CBA explicitly aims to express all effects in monetary terms

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## Learning outcomes

- After this lecture and assignment, you are expected to be able to
  - Explain the overall procedure and theory behind CBA
  - Explain the main economic valuation methods
  - Explain the main reasons to discount and the main criticisms
  - Explain how CBA can deal with the distribution of costs and benefits
  - Perform a simple CBA with provided data

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## Programme

- Steps in CBA
- Distributional aspects
- CBA in policy making

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## Overall procedure of Cost-Benefit Analysis

1. Identify the policy alternatives
2. Quantify effects of the policy alternatives
3. Monetize the effects of the effects
4. Correct value of future effects for inflation and interest
5. Calculate Net Present Value

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### Identifying alternatives

- Alternatives include Business As Usual (BAU) scenario
- Objective BAU scenario:
  - Identify *incremental* effects of alternatives
- How many alternatives?
  - Zillions may theoretically be possible, but that is very impractical
  - In practice 4-5 are generally considered



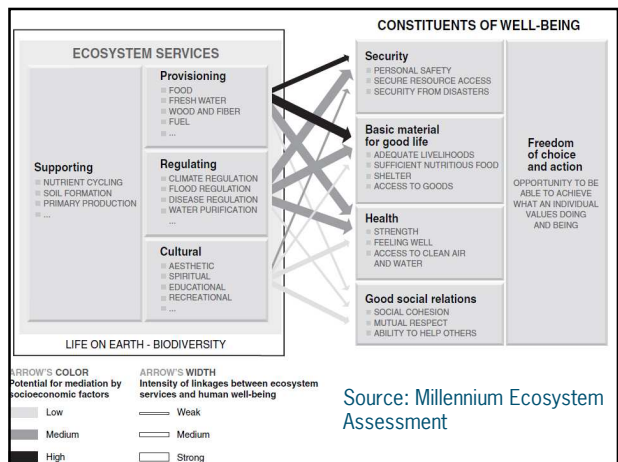
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### Effects of policy alternatives

- The obvious
  - Costs of construction material, implementation, maintenance, etc.
  - Labour (employment?)
  - Gains/losses in income for stakeholders
  - Gains/losses in tax revenue
- Environmental pollution
  - Agriculture
  - Health
- Ecosystem services



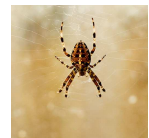
### Provisioning services

- Food
  - Fish
  - Game
- Medicine
  - E.g. rosy periwinkle
- Timber



### Regulating services

- Climate regulation
  - CO<sub>2</sub> absorption by oceans
- Water and air purification
  - Phosphorus retention by helophytes
- Pest suppression
  - Predatory birds and invertebrates
- Pollination



## Supporting services

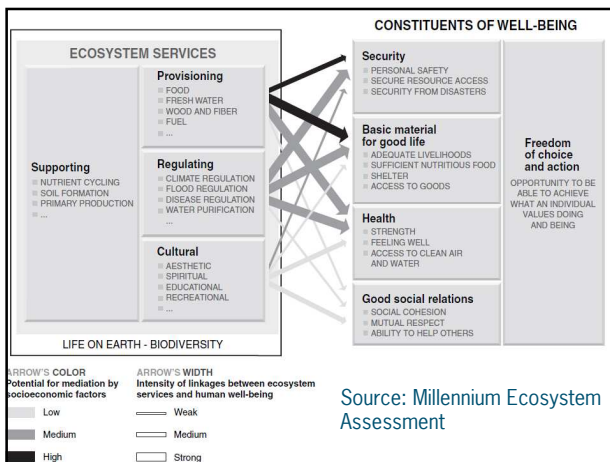
- Soil formation
- Nutrient cycling



## Spiritual/cultural services


- Tourism
- Aesthetic values
- Spiritual and religious




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## Ecosystem services and their value

- Moral value vs economic value
- Use value
  - Direct use value
  - Indirect use value
  - Option value
- Nonuse value
  - Bequest value
  - Existence value



## Valuation methods

- Market prices
- Replacement cost method
- Expected damage
- Revealed preference methods: *real* choices
  - Hedonic Pricing Method: e.g. housing prices
  - Travel Cost Method: e.g. tourism
  - Averting Expenditures Method: e.g. insulation against noise
- Stated preference methods: *hypothetical* choices
  - Contingent Valuation Method
  - Choice Experiments



## Market prices

- Input prices
  - Labour, building material, expertise, etc
- Output prices
  - Fish, wood, tourist lodging
- Market distortions
  - Monopolies
  - Externalities
  - Taxes
  - Subsidies
- Do prices reflect welfare?
  - Consumer surplus



## Expected damage

- Expected damage is the product of
  - The probability of, say, a flood event
  - The damage suffered when a flood event occurs
- Valuing mortality risk
  - Not: "What is the value of a human being?"
  - But: "How do individuals value a change in mortality risk?"
  - People make such choices everyday



## Hedonic pricing method

- Housing prices depend on many factors
- One of them may be environmental factors
- Method:
  - Regress house price on all factors
  - Estimate change in house price due to change in environment
- What do you measure?
  - Use value of a nice living environment
- Complications
  - Have we included all relevant variables?
  - Do people have all information?
  - How well does the housing market work?



## Travel cost method

- People make expenses to go a park
- Method:
  - Regress number of trips on travel costs
  - Estimate consumer surplus
- What do you measure?
  - Recreation value of the park
- Complications
  - Do people visit often because it is close by or do they live close by because they like visiting?
  - Is this the only purpose of the journey?
  - Is the journey really a cost?



## Averting expenditures method

- Examples
  - Insulation against noise
  - (Extra) expenses for water purification
- Method
  - Take expenditure as estimate of value of environmental effect
- What do you measure?
  - Use value of noise, water purity, etc.
- Complications
  - Not all environmental effects mitigated
  - Sometimes other effects
  - Can all afford the expenditure?



## Stated preference methods

- Surveys
- Contingent Valuation Method
  - 'What are you willing to pay for this improvement in environmental quality?'
  - 'How much should you be paid for you to accept this deterioration in environmental quality?'
  - Open question, yes/no, iterative questions
  - One good or service
- Choice experiments
  - Show a number of alternatives to respondent
  - 'Please choose the alternative that you prefer'
  - Several goods or services



### Example choice experiment question

- Given the following choice, which option do you prefer?

	0	1	2
Number of pandas	0	20	10
Length of hiking trails	100 km	90 km	150 km
Extra income tax	€0	€20	€30
Your choice	0	0	0



### Stated preference methods

- Methods
  - Contingent Valuation Method
  - Choice Experiments
- What do you measure?
  - Hypothetical WTP or WTA the good in question
- Complications
  - Hypothetical bias
  - Information bias
  - Payment vehicle bias
  - Framing effects, scaling effects, starting point bias, etc.



### Revealed preference versus stated preference

Revealed preference	Stated preference
Real choices	Hypothetical choices
Specific for some particular use	Broadly applicable
Estimate use values only	Can estimate use and nonuse values



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### Time in Cost-Benefit Analysis

- Inflation
  - Prices rise (value of money declines)
  - Correct for future price rises through inflation rate
- Interest
  - People are impatient
  - Opportunity cost of capital
  - Correct for time preference through discount rate



### Inflation in Cost-Benefit Analysis

- How to deal with future prices rise?
  - Expected inflation rate  $\delta$
- Suppose price €1 at 5% inflation:

Year	1	2	3	4	5
Price	€1	€1.05	€1.10	€1.16	€1.22

- Two ways of dealing with this
  1. CBA in nominal terms: estimate future nominal prices and use nominal discount rate
  2. CBA in real terms: use current prices and real discount rate



### CBA in nominal terms

- Under 5% inflation and 10% nominal discount rate:

Year	1	2	3	4	5
Nominal price	€1	€1.05	€1.10	€1.16	€1.22
Nominal discount factor	1	$1.1^{-1} = 0.91$	$1.1^{-2} = 0.83$	0.75	0.68
PV(price)	€1	€0.95	€0.91	€0.87	€0.83



### CBA in real terms

- Under 5% inflation and 10% nominal discount rate
- Real discount rate  $\approx 10\% - 5\% = 5\%$

Year	1	2	3	4	5
Real price	€1	€1	€1	€1	€1
Real discount factor	1	$1.05^{-1} = 0.95$	$1.05^{-2} = 0.91$	0.86	0.82
PV(price)	€1	€0.95	€0.91	€0.86	€0.82



### What should be the discount rate?

- Market interest rate? (possibly minus inflation)
  - After all, this reflects the marginal value of saving and borrowing
  - Moreover, interest reflects productivity growth
- Zero?
  - Why should future generations be worth less?
- High for the near future but low for the distant future?
  - This is what people tend to do on an individual level
  - But: is time-inconsistent (but then again, people are time-inconsistent)



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### Net Present Value

- NPV = Difference between discounted benefits and discounted costs

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Benefits	0	25	25	25	25	100
Costs	55	10	10	10	10	95
Netto						5

- Present value at real interest rate of 5%:

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Benefits	0	23.81	22.68	21.60	20.57	88.65
Costs	55	9.52	9.07	8.64	8.23	90.46
NPV						-1.81



### Programme

- Steps in CBA
- Distributional aspects
- CBA in policy making



## Distributional aspects of CBA

- 'Creating jobs'
  - How do we deal with unemployment?
- Poverty alleviation
  - €1 means more to a poor person than to a rich person
- Democracy
  - Does 'One person one vote' still hold if rich people have a larger WTP because they can afford to pay more?

## Unemployment

- Rule of thumb:
  - Value goods by their opportunity costs
- Transfers
  - One party (e.g. the government) loses
  - Another party (e.g. an unemployed person) gains
  - The net effect may be zero

## Unemployment

- Full employment:
  - Hiring a worker reduces production elsewhere
  - Opportunity costs are reflected in his/her wage
- Unemployment:
  - Hiring a worker does not reduce production elsewhere
  - Opportunity costs are zero or even negative

## Distributional issues in economics

- Pigou
  - Maximize total utility
- Pareto
  - A change in allocation is a Pareto improvement if it makes at least one agent better off without reducing the others' situation
  - An allocation is Pareto efficient if no Pareto improvements are possible
- Kaldor-Hicks
  - A change in allocation improves welfare if the winners could compensate the losers and still be better off than before the change

## Addressing distributional issues in CBA

- Identify winners and losers
- Apply rules of thumb
  - "Nobody should be worse off *at all*"
  - "Nobody should lose >x% of current welfare"
  - "Nobody should have welfare <€x per month"
- Apply weighting
  - Higher incomes are weighted less

## Example distributional weights

- E.g. weight = population median income / subgroup median income

Income group	Median income	Net effect	Net effect (weighted)
Bottom	€20,000	- €500	- €750
Middle	€30,000	€100	€100
Top	€60,000	€500	€250
NPV		€100	- €400

## Role of CBA in policy

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- What is the proper role of CBA in environmental policy?
- Example: USA
  - Regulation must pass CBA test
  - Criticism: CBA misused to stop environmental legislation
- Example: European Union
  - No legal obligation on decision-makers
  - Criticism: wasteful projects may still be endorsed
- In practice, CBA is often a tool to get the debate going