Lecture 10: Economic Policy Analysis

TIØ4285 Production and Network Economics

Spring 2020

Norwegian University of Science and Technology

Literature

- Perman, R. et al. (2003): Natural resource and environmental economics. 3rd edition, Pearson.
  - Chapters 11 and 12

- Parissi, O.-S. et al. (2011): Integration of wind and hydrogen technologies in the power system of Corvo island, Azores: A cost-benefit analysis. Journal of Hydrogen Energy(36): 8143-8151. https://doi.org/10.1016/j.ijhydene.2010.12.074

- Journal of Benefit-Cost Analysis

Outline Cost Benefit Analysis

- Financial analysis (NPV and IRR)
- (social) CBA
- Case Study
- Valuing the environment
- Case Study

Recall TIØ4105

- commercial viability of a project
- $total\ discounted\ benefits - total\ discounted\ costs$

- NPV: present value of net cash flow

  $N_t = R_t \text{-} E_t$ E = expenditure / R = Receipts / N = net cash flow

- for project life time T present values are
  - $PV_E = E_0 + \frac{E_1}{1+i} + \frac{E_2}{(1+i)^2} + \cdots + \frac{E_T}{(1+i)^T} = \sum_0^T \frac{E_t}{(1+i)^t}$
  - $PV_R = \sum_0^T \frac{R_t}{(1+i)^t}$
  - $NPV = PV_R - PV_E = \sum_0^T \frac{R_t}{(1+i)^t} - \sum_0^T \frac{E_t}{(1+i)^t}$
  - $NPV = N_0 + \frac{N_1}{1+i} + \frac{N_2}{(1+i)^2} + \cdots + \frac{N_T}{(1+i)^T} = \sum_0^T \frac{N_t}{(1+i)^t}$

Example net cash flow

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

i) for $i = 0.05$, NPV = 4.6151

ii) for $i = 0.075$, NPV = 0

iii) for $i = 0.10$, 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.

IRR

- project should be undertaken if its IRR > rate of interest

- IRR is the rate at which its net cash flow must be discounted to produce an NPV of 0

- IRR is found by $0 = NPV$

How to deal with risk?

- imperfect knowledge of the future

- use expected value of NPV (probability weighted sum of the values of mutually exclusive outcomes)

- compute NPV for different assumptions about future expenditures and receipts to examine sensitivity of decision to assumptions built into the net cash flow projections

With 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

- 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.

CBA

- social appraisal of projects

- used for public-sector projects, incl. policies and private-sector projects with *external effects*

- corrects for market failure in assessing project's costs and benefits

- uses NPV test
  - natural extension of NPV
  - social welfare enhancement

How shall the regulator / Policy makers rank different investment projects?

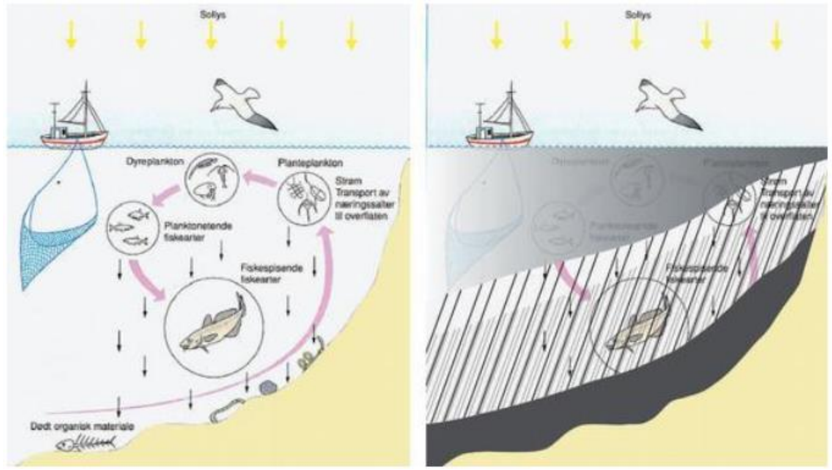
- Economist: Follow the efficiency criteria

Choose the most cost efficient project

Example: Førde fjord

Example: Mining industry

Consequences for fishing industry + local ecosystem



Source: The Norwegian Institute of Marine Research

What should the regulator do?

- Let an independent and neutral party (i.e. the analyst in the Norwegian Environemntal Agency) perform a cost-benefit analysis comparing
  - the economic benefits of establishing local industry
  - the future environmental damages to the ecosystem and biodiversity
- The decision and consideration is a political task

How to incoorporate all consequences in a CBA?

- The market does not provide any direct information about the valuation on changes in the provision of environmental goods and services.

- environment is a public good without a market, i.e. there exists no market price

What is CBA?

- systematic approach to estimate short and long term consequences
- social evaluation of marginal projects correcting for potential market failure
- seeks to attach monetary values to external effects so that they can be taken account of, along with the effects of ordinary inputs and outputs

Types of CBA

- Benefit-cost-ratio
- (Incremental BCR)
- Net present value
- (The Payback Period)

B/C Ratio

- BCR = aggregated total discounted benefits of project over its entire duration / total discounted costs of the project

- BCR < 1: costs exceed benefits
- BCR = 1: costs equal benefits
- BCR > 1: benefits exceed costs

Example: Net Benefit (NB) impacts

	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_B
C	$NB_{C,0}$	$NB_{C,1}$	$NB_{C,2}$	$NB_{C,3}$	NB_C
Society	NB_0	NB_1	NB_2	NB_3	

$$\mathrm{NPV} = \mathrm{NB}_0 + \frac{\mathrm{NB}_1}{1+r} + \frac{\mathrm{NB}_2}{(1+r)^2} + \frac{\mathrm{NB}_3}{(1+r)^3}$$

For T periods:

$$\mathrm{NPV} = \sum_{t=0}^{t=T} \frac{\mathrm{NB}_t}{(1+r)^t}$$

Source: Perman et al. (2011), p.384

CBA as Pareto-improvement test

- project delivers a surplus of benefit over cost

- its existence implies that those who gain from the project could compensate those who loose and still be better off (no actual payment required)

Example: Changes in Utility

	Time period				
Individual	0	1	2	3	Overall
A	$\Delta U_{A,0}$	$\Delta U_{A,1}$	$\Delta U_{A,2}$	$\Delta U_{A,3}$	ΔU_A
B	$\Delta U_{B,0}$	$\Delta U_{B,1}$	$\Delta U_{B,2}$	$\Delta U_{B,3}$	ΔU_B
C	$\Delta U_{C,0}$	$\Delta U_{C,1}$	$\Delta U_{C,2}$	$\Delta U_{C,3}$	ΔU_C
Society	ΔU_0	ΔU_1	ΔU_2	ΔU_3	

Case 1: $$\Delta W = W(\Delta U_{A,0}, \ldots, \Delta U_{C,3})$$

Case 2: $$\Delta W = W(\Delta U_0, \Delta U_1, \Delta U_2, \Delta U_3)$$

$$\Delta W = \Delta U_0 + \frac{\Delta U_1}{1+\rho} + \frac{\Delta U_2}{(1+\rho)^2} + \frac{\Delta U_3}{(1+\rho)^3}$$

Source: Perman et al. (2011), p.385-386

CBA as welfare increasing test

- welfare is a weighted sum of consumption at different dates
- change in welfare is the same weighted sum of changes in consumption (net benefits)
- NPV test is interpreted as a test that identifies projects that yield welfare improvements
- net benefits are added over time after discounting and for $\Delta W > 0$ project should go ahead

Interim summary

- Evaluation criteria are identical, interpretation changes

financed from taxation

$$\frac{\Delta C_1}{1+r} > \Delta I_0$$

financed from borrowing

$$\frac{\Delta C_1}{1+r} > \Delta I_0 + \frac{\delta \Delta I_0}{1+r}$$

- Assumption for either: project consequences can be properly expressed in monetary equivalent terms for the affected individuals

Choice of discount rate

- Does it matter?

$$\text{NPV} = \sum_{t=0}^{t=T} \frac{\text{NB}_t}{(1+r)^t}$$

- The value of NOK100 in the future at various discount rates

r	25	50	100	200
0,5	88.28	77.93	60.73	36.88
2	60.95	37.15	13.80	1.91
3,5	42.32	17.91	3.21	1.03
7	18.43	3.40	0.12	0.0001

- Stern vs. Nordhaus

- $r = \rho + \eta g$

Case Study

Parissi, O.-S. et al. (2011): Integration of wind and hydrogen technologies in the power system of Corvo island, Azores: A cost-benefit analysis. Journal of Hydrogen Energy(36): 8143-8151.

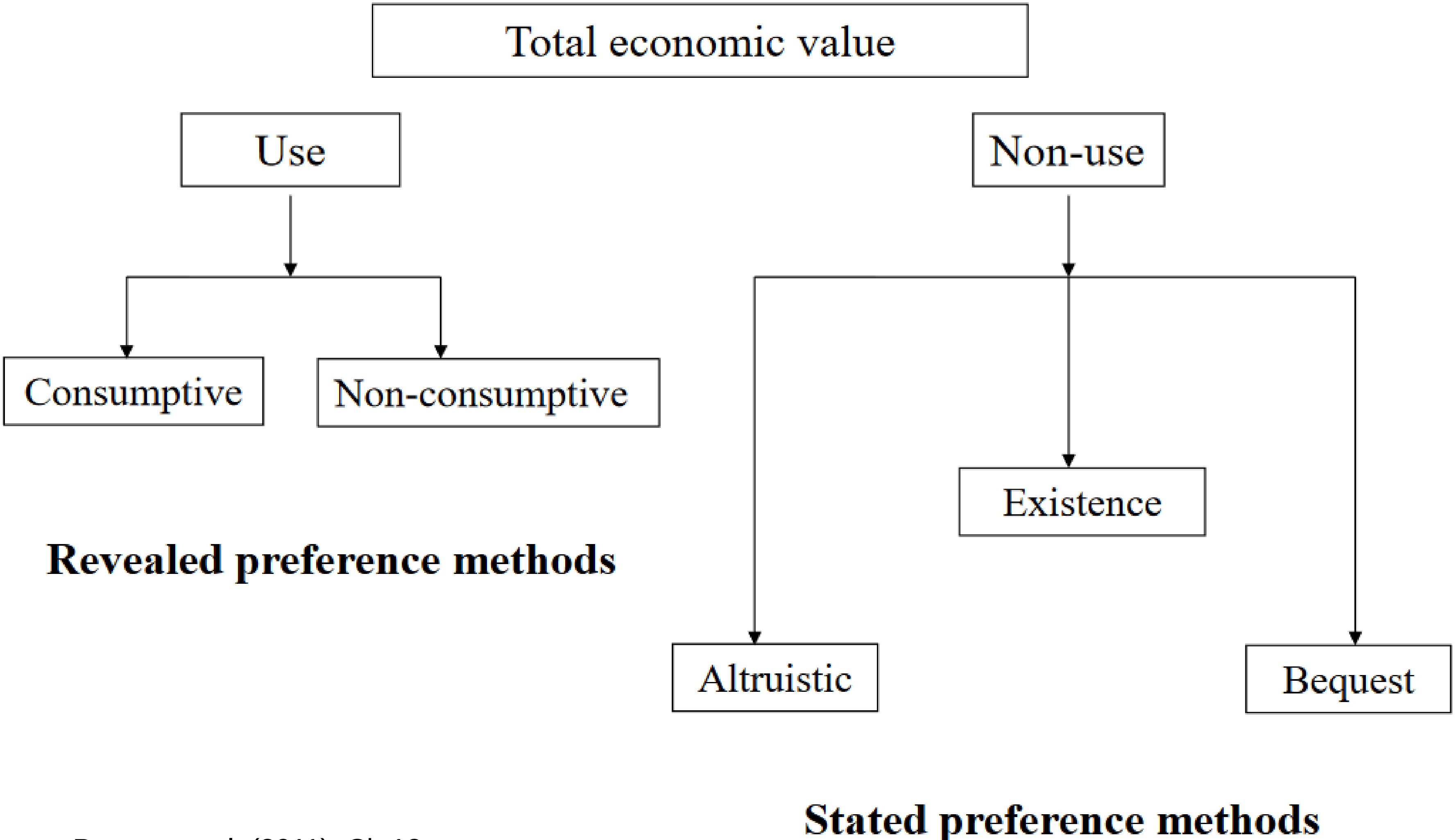
Summary

- Intertempporal efficiency
- Intertemporal optimality
- Mrktes and intertemporal allocation
- Project appraisal using CBA
- Choice of disscount rate
- Environmental CBA
- Alternatives to environmental CBA

Valuing the environment

- Theory of environmental evaluation
- Environmental benefits/damages should be valued as the marginal willingness to pay (WTP) or the marginal willingness to accept (WTA)

Categories of environmental benefits



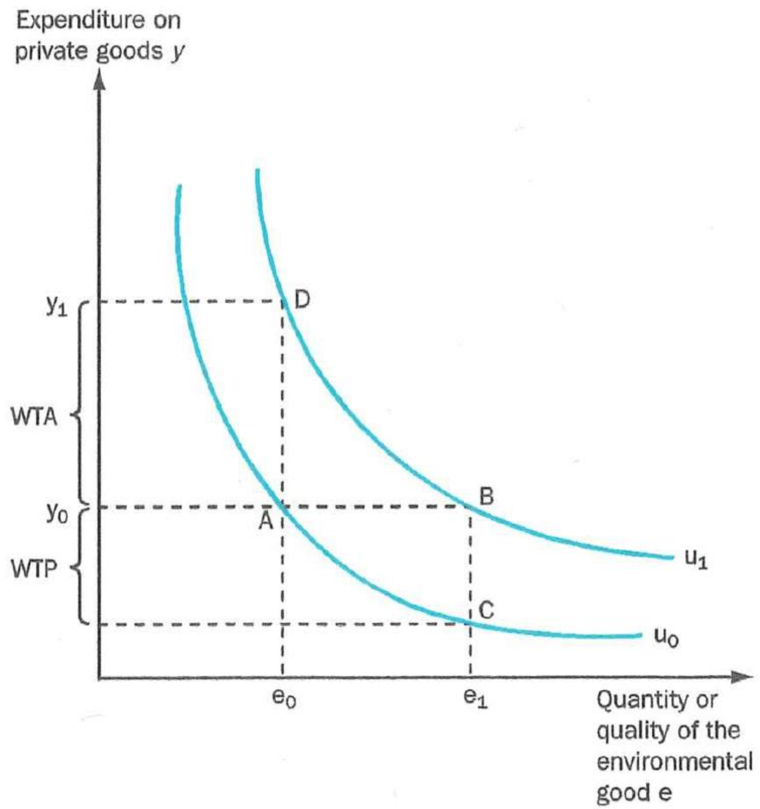
Source: Perman et al. (2011), Ch 12

Finding monetary measures

- WTP
  - amount one is willing to pay for an improvement in environmental quality
- WTA
  - compensation one accepts for a reduction in environmental quality
- WTP is constrained by individual's budget; WTA not bounded by income

- Assume well-behaved utility function $u = u(y, e)$ where (y) is income and environmental quality (e) cannot be chosen by individuals

NTNU



$e_0 \longrightarrow e_1$

at A, WTP for e improvement = *BC* is Compensating Surplus, CS

at A, WTA in lieu of e improvement = *DA* is Equivalent Surplus, ES

$e_1 \longrightarrow e_0$

at B, WTP to avoid deterioration = *BC* is Equivalent Surplus, ES

at B, WTA compensation for deterioration = *DA*, Compensating Surplus, CS

	CS	**ES**
Improvement	WTP for the change occuring	WTA compensation for the change not occuring
Deterioration	WTA compensation for the change occuring	WTP for the change not to occur

Source: Perman et al. (2011), p. 414

Contingent valuation

- survey stated preference technique
- can measure both Use and Non-use values
- provides theoretically correct WTP and WTA measures of utility change
- the most widely used valuation technique
- hundreds of applications
  - air and water quality improvement, preservation benefits of wilderness, benefits of outdoor recreation opportunities, benefits of reduced transport risks, benefits of improvements in public utility reliability, environmental damages

Steps involved for CV

1. Creating a survey instrument (i.e. questionnaire); can itself be broken down into a number of tasks.
2. Choosing an appropriate survey technique.
3. Identifying the population of interest and developing a sampling strategy.
4. Analysing the responses to the survey.
5. Aggregating the WTP or WTA responses over the population of interest
6. Evaluating ex-post the success (or otherwise) of the CV exercise.

Example: Exxon Valdez oil spill in 1989 in the coast of Alaska

- US District Court settled compensation to ~$1 billion in damages, and $2 billion in restoration efforts.
- In anticipation of legal action against the ship's owners, the Government of Alaska commissioned a team of economists to conduct a CV study to estimate the damages from the oil spill.
  - Carson et al. (1995) estimated total WTP for the escort ship programme of $2.75 billion.
  - The damage was estimated to be $4.9 billion in lost economic value of non-users, survey non-Alaskans
  - Hausman et. al (1995) estimated the recreation damages to be $3.8 million, the economic loss of actual visiting the area
- Key explanation for the thousand-fold difference: Inclusion of non-use values
- Stated preference methods came under intense examination
- When pricing wilderness areas non-use values may be the largest component
- Accounting only direct impacts (lost production, health effects, damaged fisheries, displaced recreation) may result in comparatively small losses.

Choice Experiments (stated preferences)

- respondents are presented with a number of discrete alternatives – in terms of a set of attributes - and asked to state which they prefer
- growing in popularity because
  - can deal with non-use values
  - control of the experimental design is with the researcher
  - avoids yea and nay-saying
  - monetary values implicit – no WTP question
  - can calculate WTP even if attribute levels change
  - WTP values can be transferred across project analyses

Revealed preferences methods

- The travel cost method (Hotelling, 1947)
- Hedonic pricing (Rosen, 1974)
  - Widely used to value household preferences for noise nuisance, air quality
  - Describes the price of a quality-differentiated commodity in terms of its quality attributes
- Production function-based techniques