

Lecture 5

ECON 4910, Environmental
Economics
Spring 2008

This lecture:

Project assessment and monetary valuation

- Pareto efficient level of emissions
 - Marginal benefits of pollution = marginal damage
 - Marginal damage = aggregate marginal WTP to avoid extra pollution
 - How to measure WTP?
 - Assumption: Separability of efficiency and distribution
- Valuation methods
- Cost-benefit analysis
 - Project: Exogenous change in policy -> changes in emissions/environmental quality, costs to be paid
 - Are the benefits (WTP) worth the costs?
 - What are the implicit normative assumptions in CBA?
- Alternatives to monetary valuation

The social welfare function

- A function representing a normative view: "What is a good society?"
 - The regulator's view; an ethical observer; the analysts' ...?
 - No "neutral" aggregation is possible (Arrow's impossibility theorem)
 - Choice of SWF = choice of normative premises
- $$W = V(U_1, \dots, U_n) \quad V'_i > 0$$
- "Welfarism": Only (human) utility matters
 - not: rights, religion, animals' interests, nature as such...
 - Utilitarianism:
 - $W = U_1 + \dots + U_n$ "Unweighted" utilitarianism ($V'_i = 1$)
 - $W = \beta_1 U_1 + \dots + \beta_n U_n$ "Weighted" utilitarianism ($V'_i = \beta_i$)
 - Quasiconcave SWFs: Inequality aversion (in utilities)
 - "Rawlsian" SWF: All emphasis on the worst off person

Welfare max with public goods

- Max $W = V(U_1, \dots, U_n)$ s.t.
- (1) $U_i = u_i(x_i, E)$ Utility depends on income and environmental quality, for all i
- (2) $E = E^0 - z(\sum_k m_k)$ Environmental deterioration
- (3) $\sum_j x_j = \sum_k f_k(m_k)$ Resource constraint: production equals consumption

K firms, n individuals

Insert from (1) and use Lagrange's method:

$$L = V(u_1(x_1, E^0 - z(\sum_k m_k)), \dots, u_n(x_n, E^0 - z(\sum_k m_k))) - \lambda(\sum_k f_k(m_k) - \sum_j x_j)$$

Get 1.o.c. by differentiating wrt $x_1, \dots, x_n, m_1, \dots, m_K$:

$$V'_i u'_{ix} = \lambda \quad \text{for each } i$$

$$\sum_j V'_j u'_{jE} z' = \lambda f'_k \quad \text{for each } k$$

i.e.:

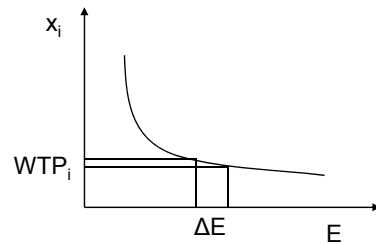
$$f'_k = z' (\sum_j V'_j u'_{jE}) / (V'_i u'_{ix}) \quad \text{for each } i \text{ and } k$$

Since in welfare max, the *welfare weights* $V'_i u'_{ix}$ must be equal for all i , this is equivalent to the criterion for Pareto optimality:

$$f'_k = z' \sum_j (V'_j u'_{jE} / V'_i u'_{ix}) = \sum_j \text{MWTP}$$

Willingness to pay

- Consider a project that increases the supply of a pure public good E (e.g., air quality) by ΔE .
- What is the amount of money (x) that can be taken away from individual i , leaving her just as well off?



- WTP_i : Money measure of i 's benefits from ΔE
- WTP_i : not necessarily equal to what i *actually* pays
- i 's *net* benefits: Gross benefits (WTP_i) minus the payment she must actually make (call this C_i): $NWTP_i = WTP_i - C_i$

Utility changes: Marginal project

- The utility function:

$$U_i = u_i(x_i, E)$$
- Utility change for a marginal project:

$$dU_i = u'_{ix} dx_i + u'_{iE} dE$$
 Dividing by u'_{ix} :

$$dU_i / u'_{ix} = dx_i + (u'_{iE} / u'_{ix}) dE = -C_i + WTP_i = NWTP_i$$
 (net willingness to pay)
- Utility change is *proportional* to NWTP
- Proportionality factor: Marginal utility of income
- Can we aggregate this benefit measure across individuals?

Welfare changes

- Assume that we know WTP_i and C_i for every i .
- Does i 's utility increase?
 - YES if $WTP_i > C_i$
 - NO if $WTP_i < C_i$
 - If YES for all \rightarrow Project is a Pareto improvement
 - If NO for all \rightarrow Project is welfare reducing
- If some YES and some NO: How can we know if winners' gain outweigh losers' loss?
- With costless redistribution: Can focus on Pareto efficiency
- Otherwise: Comparison of utility between individuals

Cardinal and ordinal utility

- Ordinal utility: The consumer can rank alternatives, but we do not know the *strength* of this preference:
 - A is better than B; C is better than D
 - "I prefer soccer to ballet."
 - Not: "- but it doesn't matter much, I like both quite well."
- Cardinal utility: Utility change can be measured
 - $u_i(A) - u_i(B) > u_i(C) - u_i(D)$
 - "I *strongly* prefer soccer to ballet".
- Cardinal and interpersonally comparable utility:
 - $u_i(A) - u_i(B) > u_i(C) - u_i(D)$
 - "It is more important for *me* than for *you* to watch the game."
 - "It is more important for Anne to get well than for Carl to watch the game."
- To calculate NWTP for one person, only ordinal utility is needed
- To calculate social benefits, one needs cardinal, interpersonally comparable utility.

Welfare changes

$$\begin{aligned}
 W &= V(u_1(x_1, E), \dots, u_n(x_n, E)) \\
 dW &= \sum_i [V'_i (-u'_{ix} C_i + u'_{iE} dE)] \\
 &= \sum_i [V'_i u'_{ix} (-C_i + (u'_{iE} / u'_{ix}) dE)] \\
 &= \sum_i [V'_i u'_{ix} (NWTP_i)]
 \end{aligned}$$

- Change in social welfare: A *weighted* sum of everyone's net willingness to pay.
- This holds regardless of the choice of (welfaristic & continuously differentiable) social welfare function.
- *Welfare weights*: $V'_i u'_{ix}$
- Optimal income distribution: Equal welfare weights

Cost-benefit analysis

- Measures aggregate net willingness to pay for projects
- Generally (dynamic analysis, see Perman Ch. 11): Aggregate net present value
- Here, simplification:
 - Static analysis; disregard dynamics and discounting
 - Disregard uncertainty
- Standard cost-benefit analysis:
 - Project is socially efficient if $\sum_j WTP_i - \sum_j C_i > 0$
 - Equivalent: Socially efficient if $\sum_j NWTP_i > 0$
- Implicit assumption
 - Initial income distribution is optimal, or
 - government can use other instruments to redistribute.
- In principle: Can use different welfare weights for different individuals
 - e.g. higher weights for the poor, or children
 - rarely done in practice

On welfare weights

$$dW = \sum_i V'_i u'_{ix} (\text{NWTP}_i)$$

V'_i is *purely normative*: How much emphasis should society put on person i 's utility?

Economic theory provides little guidance; must be discussed on a normative (ethical/political) basis.

u'_{ix} (marginal utility of income) is a descriptive, but cardinal concept.

No generally accepted methodology exist to measure and compare u'_{ix} between individuals.

- If $V'_i u'_{ix}$ is equal for all, dW is the sum of NWTP.
- **This assumption is not empirically verifiable.**

Optimal income distribution

$$dW = \sum_i [V'_i u'_{ix} (\text{NBV}_i)]$$

- Implicit assumption in CBA: $V'_i u'_{ix} = 1$ (or: equal for all)
- $V'_i u'_{ix} = 1$ implies either
 - $V'_i = u'_{ix} = 1$
 - unweighted utilitarianism, *and* everybody has the same marginal utility of income
- or, the marginal utility of income may differ, but
 - $V'_i = 1/u'_{ix}$
 - that is: we put *most* emphasis on the interests of those who have the *least* marginal utility of income.
 - if the poor have lower marginal utility of income than the rich: The interests of the rich should be given systematically more weight than the interests of the poor.

Real and potential Pareto improvements

- Real Pareto improvements: If $NWTP_i \geq 0$ for all i , then $dW \geq 0$
 - We don't need to know the welfare weights
- Potential Pareto improvements (Hicks-Kaldor criterion): *We could have had* $NWTP_i \geq 0$, if redistribution had taken place – although it did not take place
 - Winners could have compensated losers
 - Can restructure the project (e.g.: combine it with appropriate compensations) to *make it* a Pareto improvement.
 - If this is impossible: Hicks-Kaldor must be interpreted as a normative criterion: Winners' gain is more important than losers' loss.

Cost-benefit analysis and public decision-making

- **Purpose 1:** Ranking projects
 - If not Pareto improvement: Conflicts of interests
 - Normative premises must be chosen: How to balance between these conflicts?
 - To give an explicit answer: All relevant concerns must be valued in monetary terms.
- **Purpose 2:** Providing factual input to a (democratic) debate between decision-makers with different normative views (SWFs)
 - Requires distinction facts/normative assessment
 - Does not require final answers
 - Requires that information is presented in a way which can be used as *input* in the decision-maker's own SWF

Handling normative disagreements

- Explicit welfare weights:
 - Purpose 1: Find the right weights.
 - Purpose 2: Different decision-makers need different weights
- Assuming initially optimal income distribution
 - Purpose 1: The government has already redistributed as desired
 - Purpose 2: Will *all* decision-makers agree that the income distribution is optimal?
- Lumpsum transfers
 - Purpose 1: If lumpsum transfers are available: Distribution and efficiency can be separated. But: Information asymmetry, costly transfers
 - Purpose 2: Will *all* decision-makers agree on the ex post redistribution?

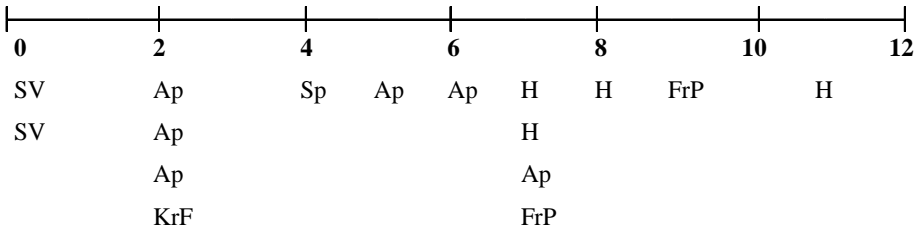
Environmental indicators in physical units

$$dW = \sum_i [V'_i u'_{ix} (C_i + (u'_{iE} / u'_{ix}) dE)]$$

- Disregard costs, consider only benefits ($C_i = 0$)
- This gives $dW = dE \sum_i (V'_i u'_{iE})$
- That is, if decision makers can judge *average social benefit* of the environmental change (average environmental welfare weight), they need only information about dE , measured in physical units.
- Monetary valuation: Requires judgement of $V'_i u'_{ix}$ for all i (by the analyst)
- Physical units: Requires judgement of $\sum_i (V'_i u'_{iE})$ by decision-maker
- Both are subjective
- Which judgement is easiest?

Political parties and CBA

An index for attitudes towards use of CBA as policy tool. Higher number means more positive attitude (Source: Nyborg 1998, Nyborg and Spangen 1996)



Applied project evaluations: What should be valued in monetary terms?

- Purpose 1 (ranking) : *Everything*
- Purpose 2 (input to debate):
 - "When considering this, one must keep the main goal of the analysis in mind: Clarifying and visualizing the consequences of a policy change. Sometimes, valuing something in monetary terms can be confusing rather than illuminating, e.g. if the effect under consideration is closely linked to ethically complex questions. One criterion for when we should value in money terms, is thus that the valuation should give the decision-makers a better and more complete picture of the effects of the policy change." (NOU 1998:16, s. 12)

Different types of project evaluations

- **Full CBA:**
 - Value everything
 - When conflicts of interest are not strong
 - When the project is very complex
 - As supplement to descriptive/detailed information
- **Cost-effectiveness analysis:**
 - Value costs, not benefits
 - When alternatives produce exactly the same benefit
- **Cost-effect analysis:**
 - Value costs, describe benefits in non-monetary terms
 - When alternatives produce different benefits
 - When non-monetary descriptions are easier to understand than money values

On valuation of environmental goods

- **Motives:**
 - *Use value*: WTP to go fishing, hiking etc
 - *Existence value*: WTP to know that the environmental good exists, even if one never plans to use it. E.g.: The pleasure of knowing that pristine wilderness exists
 - *Option value*: WTP for the option to use the good later (or having the option than others can use it later)
- **Methodes for measurement of WTP**
 - Direct methods: Surveys, voting
 - Indirect methods: Use of market prices/revealed preferences
 - Indirect methods can only capture use values

Contingent valuation: Interview surveys

- «How much would you be willing to pay to improve air quality in Oslo by x pst.?»
- Controversies (*Exxon Valdez*)
- Practical problems:
 - Strategic reporting? (freeriding/ increase value estimates)
 - Misperceptions (what does «improve air quality by x pst.» mean?)
 - Inexperience: Anchoring effects, framing effects
- Existence values can only be estimated using direct valuation methods (asking directly)

Contingent valuation

- Substantial improvements in methodology
- NOAA-panel
- Open vs. closed questions
- Great flexibility when formulating questions (ref. experiments)
- Are survey data generally less interesting than market data?
- Good CVM studies: Costly

Political or private values?

- Perception of CVM question: Political/ethical question, not question about own benefits
- "How much do you think everyone should be willing to pay for dE?"
- "How much would you be willing to pay for dE, if your payment were the only way to realize this change?"
- "What are you willing to pay to keep your self-image as an environmentally responsible person?"
- Characteristics of respondents' subjective SWFs or utility?
- Do not know their interpretation
- Could be like adding apples and oranges

Indirect methods

- Even if no markets for environmental goods: Market goods may be closely tied to the *use* of environmental goods
- By making appropriate assumptions about the relationship between the market good and the environmental good, use value of environmental good can be estimated.
- Some goods are *complementary* to E:
 - Fishing rod/clean water
 - Bus tickets to a national park
- Some goods are *substitutes* to E:
 - Bottled drinking water/ clean tap water
 - Noise isolating window glass / quiet outdoors environment
- Most used indirect methods: travel cost method, property prices

Travel cost method

- Estimating WTP for environmental goods one must travel to: National parks, skiing amenities etc.
- Travelling costs: «Price» to visit the amenity – expression of (lower limit) of WTP to visit
 - Travel costs: Train/bus tickets, gas, car expenses
 - Entrance fees, fishing permits etc.
 - Time costs: Alternative use of time (e.g. working, earning money)

«Hedonic prices»

- Some goods are heterogeneous; different units have different characteristics
 - Two houses have different # of rooms, different location, different exposure to noise
 - Two jobs may have different exposure to hazardous substances
- «Hedonic pricing»: Use of econometric techniques to estimate e.g. expected price increase if a house becomes marginally less exposed to noise, or how much higher wages workers would require to accept marginally higher health risk (everything else fixed)

Laboratory experiments

- Choices in the lab: Real choices, real payments
 - E.g.: Give subjects a sum of money and auction a product between subjects. Does WTP vary with info on whether product is genetically modified?
- Great control of experimental design
 - Issue to be valued
 - What to control for (stakes, information, etc)
- External validity: Would people behave correspondingly outside the lab?

Valuation of CO₂ emissions in CBA

- Climate issue is global
- Project assessment: Usually natural to assume national population as the relevant population
- For countries participating in a well-functioning permit market: The permit price provides a measure of alternative value
- Corresponds to a shadow price on the political obligation (Kyoto)

Physical unit indicators

- Applied policy analysis: Physical unit indicators much more used than WTP
- Examples:
 - Square kilometers wilderness
 - Number of wolves
 - Relative change in population of wild salmon
 - Number of persons exposed to noise exceeding recommended limits
 - Ambient NO_x concentration in urban areas
- Does monetary valuation facilitate understanding of the effects – their nature, their importance?
- A note on discounting

Alternative quantification of environmental changes: An example

- Environmental effect of a road project: Reduced bird population in protected bird reserve area.
- Indicator 1: Total WTP to keep the previous bird population level
- Indicator 2: WTP in groups of the population
- Indicator 3: Number of birds before and after road construction
- Which information provides the best understanding of the environmental effect and its importance?

Complex projects

- Have assumed a very simple project: Environmental effect dE
- In practice:
 - Many different environmental goods
 - Not necessarily pure public goods
 - Time dimension
- Trade-off complexity vs. neutrality:
 - The more aggregation, the more information disappears
 - Less aggregation, less overview, more complexity
 - Normative premises for monetary valuation: Simple, transparent

Summary: Evaluation of environmental projects

- Project analysis as ranking device:
 - Everything should be valued
 - Normative assumptions must be made by analyst
- Project analysis as input to public debate:
 - Requires distinction description/evaluation
 - Main criterion: Pedagogical effect
- Rational evaluation by policy makers can be made using either monetary or non-monetary indicators
- Monetary evaluation: Direct and indirect methods
- To read on your own (Perman Ch 12): WTP vs WTA for non-marginal changes (equivalent and compensating variation measures)

Next time

- Voluntary contributions to public goods:
 - Voluntary industry agreements
 - Corporate social responsibility
 - Purchase of eco-labeled goods
 - Recycling
- How can this be explained using economic theory?

Welfare and distribution

- Optimal income distribution:
 - $V'_i u'_{ix} = V'_j u'_{jx}$ for all i, j
 - If each individual's interests is given the same weight:
Marginal utility of income equal for everyone.
- Previous lectures:
 - Assumed that full information and costless lump-sum transfers were available
 - Regulator can then redistribute income costlessly to achieve $V'_i u'_{ix} = V'_j u'_{jx}$
 - This is why we could separate Pareto efficiency and welfare maximization: First, maximize the size of the pie (PO), then share it as you wish (WM)
- Now: Allow that costless redistribution may not be possible