INTRODUCTION TO ENVIRONMENTAL ECONOMICS (IKT3620)

VALUING THE ENVIRONMENT: METHODS

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METHODS FOR VALUING THE ENVIRONMENT

- In this class, we are going to consider different approaches to estimate the economic values of environmental change,
  - using the concepts of value explained in the previous class.
- An overview:
  - How do we empirically estimate economic values for non-market environmental goods.
  - Directly or indirectly, all environmental values in economics are traced back to effects on utility.
  - One can categorize environmental valuation methods into one of three groups:
    1. Stated preference methods
    2. Revealed preference methods
    3. Production-function approaches

1 & 2 focus on direct impacts of the environment on utility.

3 focuses on the environment as an input

METHODS FOR VALUING THE ENVIRONMENT

- 1 & 2 focus on direct impacts of the environment on utility.
- 3 focuses on the environment as an input
- Valuing changes in ecosystem service flows can involve the use of all of these approaches

- Stated preference approaches include the
  - Contingent valuation
  - Choice experiments

These two have the common feature that they are surveys in which economists ask the general public or some set of the public, e. g., users of a national park, about their WTP or WTA for hypothetical changes in environmental quality.

Contingent valuation method

- Given the absence of prices for many environmental goods, because the market is absent, CVM asks respondents how they would behave if such a market existed.
- For example, A CVM survey could ask:
  - Suppose the only way of improving water quality in your local river was for all residents to pay a surcharge on their taxes. If you were asked to pay an additional 100TL, would you agree to have these improvements?
- The important point about CVM is that respondents are asked to reveal what they would be willing to pay (or accept) for a clearly-specified hypothetical increase or decrease in environmental quality:
  - Their responses are contingent on the description of this hypothetical 'market,' in terms of the change being valued, and how they would pay for it.

The choice experiment method

- Sometimes referred to as Choice modelling or Discrete choice analysis.
- *Characteristics theory of value:* the value of, say, a forest, is best explained in terms of the characteristics or attributes of that forest.
- Different forests are actually different bundles of attributes and what people value is these bundles
- The value of any particular forest can then be broken down into the values of each attribute of that forest.

The choice experiment method

- The method is also based on *random utility* theory.
- States that people's choices between different goods can be thought of as being based on a utility function comprising two components:
  - Deterministic component – a function of the observable attributes of the things that people are choosing between, given the observable characteristics of the person choosing (e.g., their age)
  - Stochastic/random component – represents uncertainty of the part of people choosing (e.g., I do not really know what I like best) or an inability of the researcher to observe/measure all the factors that explain people's choices.

The choice experiment method

- Using observations of people's choices between different bundles of attributes, the researcher can infer:
  i. Which attributes significantly influence their choices
  ii. Assuming price or cost is included as one attribute, what they are willing to pay for an increase in any other attribute
  iii. What they would be willing to pay for a policy which changed several attributes simultaneously

The choice experiment method is becoming increasingly popular as a tool to estimate attributes that are relevant for describing the environmental good in question

The choice experiment method

- In the choice experiment method, the researcher first identifies the main attributes that are relevant for describing the environmental good in question.
- Different bundles of the attributes are combined using experimental design principles.

The choice experiment method

- A study by Morrison et al. (2002) looked at the benefits of protecting wetlands in Australia
- Each respondent was asked to choose most preferred alternatives amongst pairs of different wetland management options, such as the choice card below (*1 hectare (ha) = 10000m2*):

	Management option A	Management option B	Management option C
Wetland area conserved	1000 ha	800 ha	700 ha
Bird species conserved (#)	40	30	25
Farm jobs protected	15	16	20
Cost to HHs in terms of increase in local taxes over next 5 years	$30/HH	$15/HH	$0/HH

Which option would you prefer the government went ahead with? A, B, or C?

The choice experiment method

Once the questionnaires have been completed, the researcher has data on which options individuals chose (A, B, or C), and she can relate these choices to the levels that the attributes took in these options.

This way, choices can be statistically related to attribute levels, including price/cost.

One way to model such choices uses the Conditional Logit model:

- The probability that an individual I choses a particular option A is
  - $P_i(A) = \frac{\exp(\mu V_{iA})}{\sum_J \exp(\mu V_{iJ})}$
  - V is the observable part of the utility
  - μ is a scale parameter which shows the variance of the errors in the choice model
  - J are all the options the individual could chose

The choice experiment method

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  - μ is a scale parameter which shows the variance of the errors in the choice model
  - J are all the other options the individual could have chosen instead of A

A typical assumption is that V is a linear function of the attributes of the good (and of the choice alternatives):

$$V = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \beta_c C$$

Where Xs are the attributes.

For each attribute, the model estimates a value β which shows the effect on utility of a change in the level of each attribute.

The model also estimates a parameter, β_c. This is the effect of a change in the price or cost of the option on the likelihood of choosing that option.

The choice experiment method

- Whether the attributes are statistically significant, that is, the coefficients are statistically significant, the coefficient values will tell us whether people will prefer an increase or a decrease in each attribute.

- The next step is to calculate the WTP estimates, based on the estimated coefficients.
- The βs show the effect on utility of changes in the attributes. But for cost-benefit analysis (we will see), we need measures of willingness to pay.
- For a marginal change in an attribute, the WTP value is given by:
  - $IP_{X_i} = \frac{\beta_{X_i}}{\beta_c}$

The choice experiment method

- $IP_{X_i} = \frac{\beta_{X_i}}{\beta_c}$
- This value for an attribute (other than the price) is called the *implicit price*.
- Consider the number of birds attribute
  - Dividing the corresponding (and significant) coefficient with β_c would show the average willingness to pay of people in the sample to an unit increase in the number of bird species conserved.
- We often wish to value multiple changes in attributes
  - A new policy on wetlands conservation could alter the area conserved (A), the #s of bird species conserved (B), and the provision of recreational trails (R).
  - The price of this would be an increase in local taxes, which are attribute c.
- The average WTP for this suite of changes can be calculated using the equations below:
  - $CS = -\frac{1}{\beta_c}(V_1 - V_0)$ where

$$V_0 = \alpha + \beta_A A_0 + \beta_B B_0 + \beta_R R_0$$

$$V_1 = \alpha + \beta_A A_1 + \beta_B B_1 + \beta_R R_1$$

  - CS stands for compensating surplus.
  - Once you have the coefficient estimates, straightforward to calculate

The choice experiment method

- $CS = -\frac{1}{\beta_c}(V_1 - V_0)$ where

$$V_0 = \alpha + \beta_A A_0 + \beta_B B_0 + \beta_R R_0$$

$$V_1 = \alpha + \beta_A A_1 + \beta_B B_1 + \beta_R R_1$$

  - The CS from an improvement in wetlands conservation is given by the difference between their difference between the utilities (V_1 and V_0)

- By varying the levels of the attributes, compensating surplus can be produced for a wide range of policy outcomes.

Revealed-preference approach

- Inferring the value that people place on environmental goods from their behavior in markets for related goods.
- In RP methods, we make use of people's actual behavior, rather than their intentions
- Hedonic pricing method:
  - The hedonic pricing method (HPM) is based on the characteristics theory of value, similar to choice experiments.
  - People value goods as bundles of attributes. For a house, there attributes include the number of bedrooms, the age of the house, the size of the garden, and whether it has a garage. These represent a property's site characteristics, S_i
  - Buyers and sellers also care where the house is located; i.e., how far from major employment areas, quality of local school, and its public transport options. Call these neighborhood characteristics, N_i
  - Finally, environmental characteristics, E_i also effect house prices: for example, noise levels, air quality, scenic views and proximity to green space etc.

Revealed-preference approach

Hedonic pricing method (ctd.)

- The basic assumption of this method is that people's valuation of environmental attributes can be inferred from the amount they are willing to pay for these attributes through the housing market
  - *Ceteris paribus*, a house in a quiter part of town may sell for more than a similar house in a noisier part
  - If I value peace and quite, I will pay this premium
  - Sellers will know that peace and quite is a beneficial feature when they are advertising the house
  - For the buyer, the highest premium they would be willing to pay for any environmental attribute would indicate the maximum value they place on it.
  - If these premia could be identified from market transactions, this would tell us something about the value of these environmental attributes, like noise, which can be linked to house prices.
  - Ideally, the researcher would be able to identify a marginal WTP function for peace and quite, or air quality, from observing the interaction of house buyers and sellers.

Revealed-preference approach

Hedonic pricing method (ctd.)

- The HPM proceeds by collecting data on most usually house prices from sales records, along with data on E_i, N_i, and S_i. A regression analysis can then be carried out to estimate the equation:

$$P_i = f\left(E_{i1} \dots E_{im}, N_{i1} \dots N_{in}, S_{i1} \dots S_{iq}\right),$$

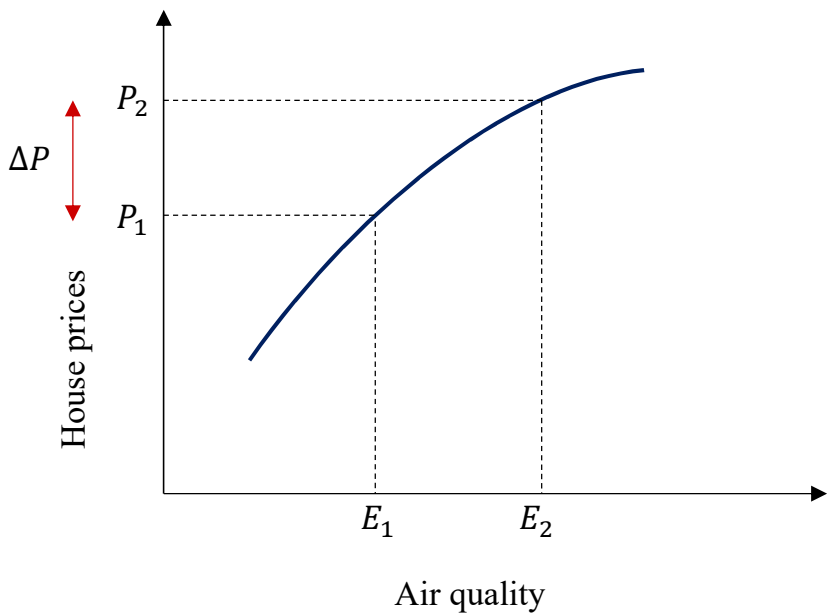
where there are m environmental attributes, n neighborhood attributes, and q site attributes, and where P_i is the price of the ith house.

- For those attributes that have a statistically significant effect on house prices, the 'implicit price ' (the price premium) can be calculated.
  - Statistically significant results can tell us, for example, that a 1% improvement in air-quality levels increases house prices by 0.2% on average.
  - This could then be used to calculate the WTP of house-buyers for such an air-quality improvement.
  - Money values are placed on environmental attributes linked to house prices

Revealed-preference approach

Hedonic pricing method (ctd.)

- The following figure demonstrates the kind of relationship (here, the change in the value in the housing market coming from an improvement in air quality,) one might find in the data:



Revealed-preference approach

Hedonic pricing method (ctd.)

- Bayer et al. (2009) study the relationship between HH location choices and one measure of air pollution–suspended particulates–for 10000 HHs in US cities in 1990 and 2000.
  - They find that, on average, a 1% increase in air pollution translates into a 0.63% decrease in house prices.
  - Moreover, on average, HHs are willing to pay around $150 per annum in 1984 dollars (about 340 in 2016 dollars) for a 1% improvement in air quality, when evaluated at the median income and air pollution levels.

- The HPM has been widely used to study the implicit prices of changes in air quality, noise, proximity to waste sites.

Revealed-preference approach

Travel cost models

- Oldest environmental valuation technique
- Based on the observation that expenditure is necessary to participate in recreational activities
  - Time (opportunity cost) and money spent in travelling to recreational sites

Consider the Picos de Europa national park in northwest Spain: a mountainous national park close to the Atlantic coast, popular among hikers and nature-lovers

Revealed-preference approach

Travel cost models (ctd.)

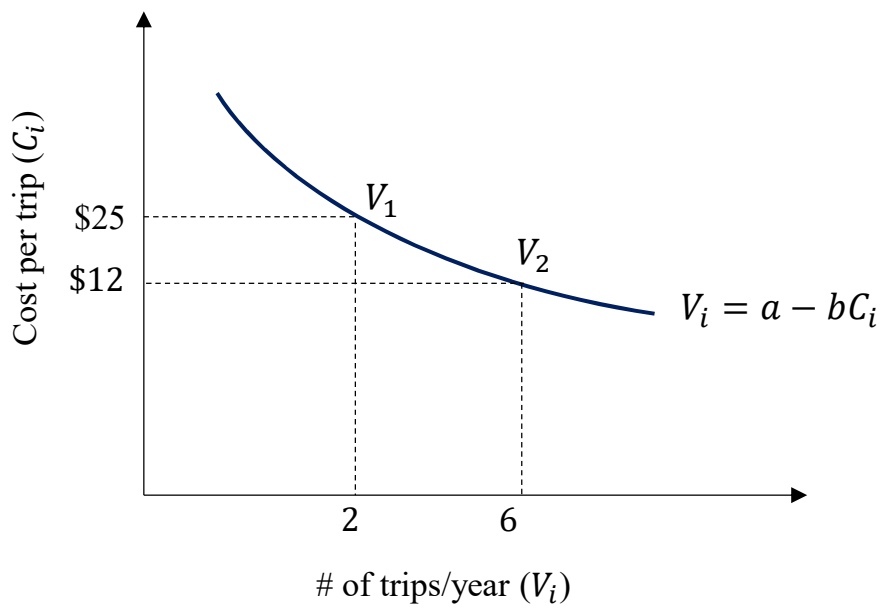
- Suppose we want to estimate the value of informal recreation in this area.
- Visitors would be irrational if they spent more in visiting the park than the utility they derive from their visit.
- Therefore, they enjoy consumers' surpluses from visiting, equal to the difference between the most they would pay per trip and what they actually do.
- By observing the relationship between visits and travel costs, it might be possible to infer the value (consumers' surplus) which recreationalists enjoy.

- Here is how one can proceed:
  - Visitors to the national park would be surveyed and asked
    - how far they had travelled
    - How frequently they had visited the site in the last twelve months

Revealed-preference approach

Travel cost models (ctd.)

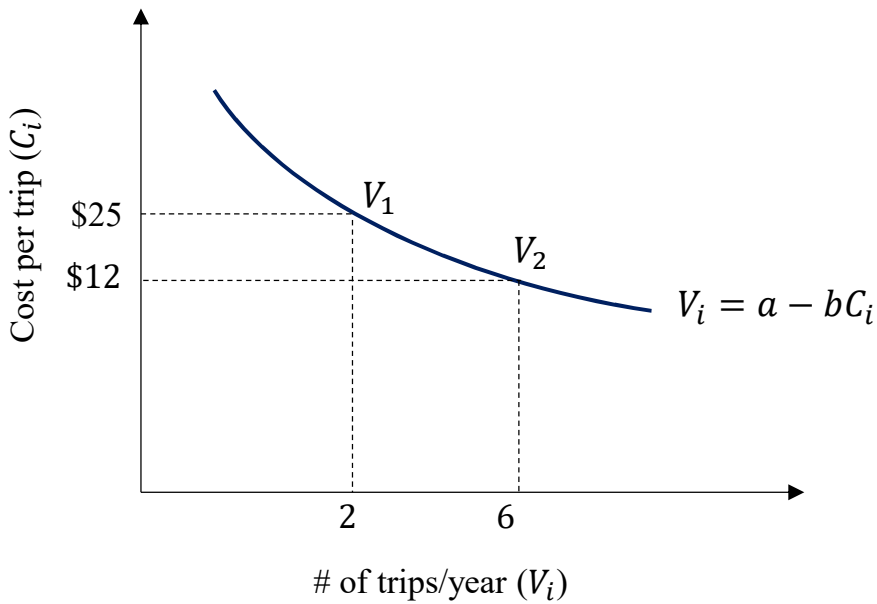
- The figure shows a possible relationship between the number of visits individuals make to the park (V_i) and the costs to them per visit (C_i).



Revealed-preference approach

Travel cost models (ctd.)

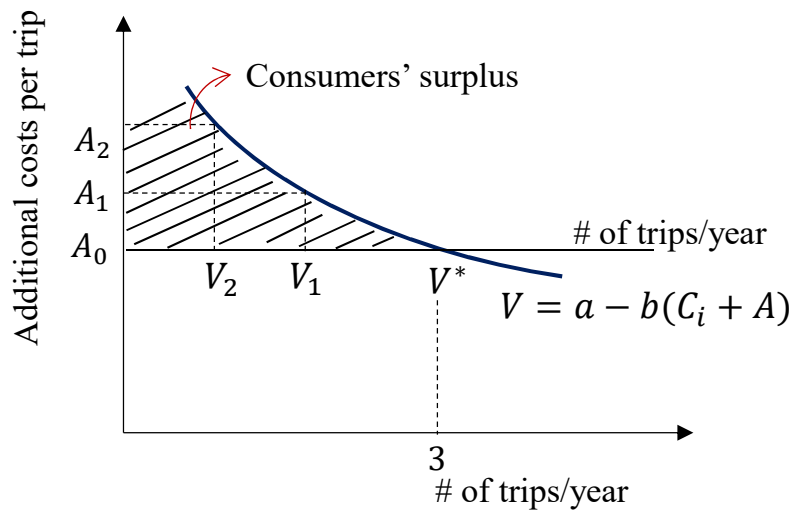
- If responses from 1000 visitors were collected, this woud probably allow us to estimate such a curve with reasonable precision.
- The figure below is a demand curve for the site



Revealed-preference approach

Travel cost models (ctd.)

- One can measure the area under the travel-cost curve to calculate the consumer surplus per visit.
- How to do this?

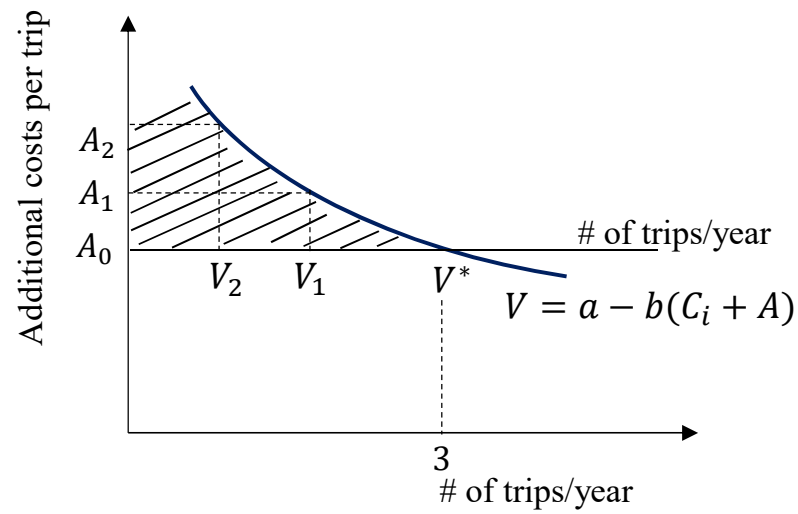


Revealed-preference approach

Travel cost models (ctd.)

- Isabella faces a travel cost of \$18 per visit, and makes three trips per year, V^*.
- Suppose she has as value of each visit of more than \$18 (why?)
- Using the average relationship between visits and travel costs in the earlier figure, it is possible to see that would happen to the # of Isabella's trips if the cost was increased, e.g., a hypothetical admission fee were introduced.
- At an admission fee of A_1, her trips fall to V_1
- At A_2, her trips fall to V_2
- Repeating this exercise, one could trace

out the function shown originating at $V^*$and passing through the points (A_1, V_1) and (A_2, V_2). The area under this curve and above the horizontal line originating at A_0 is the consumer's surplus she enjoys from making $V^* = 3$ trips per year.



Production-function approaches

Production-function approaches

- The environment is values as an input to the production of some market-valued good or services
- Value changes in the quality or quantity of an environmental resource by estimating how this affects outputs and price of market goods and services
- This class of methods includes *dose-response models*.
  - Reflects impacts of pollution on market-valued outputs; e.g., CC → Agricultural crops

Example: Climate change & agriculture

- Wheat production is related to a number of climate variables, such as season temperatures, rainfall…
- For the UK, researchers, using a statistical model, simulate how a 1 degree Celsius increase in mean temperatures affects wheat production and the market value of outputs.
- Results are highly variable; wheat yield rise in some areas and fall in others, as farmers switch to more profitable activities.

- When ecosystem services result in outputs valued by the market, production methods are appropriate for valuing changes in such services.

Production-function approaches

The following table summarizes the range of methods that economists might use to value ecosystem services for the conservation of moorlands (bozkırlar), for example.

Ecosystem service	*Possible change in this service*	*Appropriate valuation methods*
Carbon sequestration	Net change in carbon flux due to change in land management	Market prices for CO_2 from carbon markets
Informal recreation: bird watching	Fall or rise due to loss of moorland to forests	Travel cost models
Landscape quality	Change due to change in frequency of heather burning for grouse shooting; loss of landscape features due to wind farm construction	Stated preference approaches (contingent valuation or choice experiments)
Water quality	Decrease in water quality due to loss of peat	Production function approach: additional costs to water supply companies lower down the catchment
Water storage	Decrease in water supply due to forest planting	Production function approach: costs of measures taken to augment supplies from other sources.

Benefit transfer

- Environmental valuation exercises are costly both in time and money.
- So if environmental valuation is to become a regularly-used for policy making and environmental management, researchers need some method to estimate non-market benefits without the need to undertake an original valuation study.
- Benefit transfers is the practice of extrapolating existing information on the non-market value of goods or services. Where possible, adjustments are made for differences between the environmental characteristics of the site to which the original data was collected, known as the 'study side,' and those of the site at which the original data was collected.
- Differences in socio-economic characteristics of the affected population between the study and policy sites are also usually allowed for.
- The aim of the BT techniques is to provide decision makers with a monetary valuation of environmental good and services in a cost-effective and timely manner.

Benefit transfer

- When multiple study site data sets are available a further approach is toe use a meta-regression analysis.
- Meta analysis is a statistical search for patterns in outcomes (WTP values, for example) from a group of published studies.