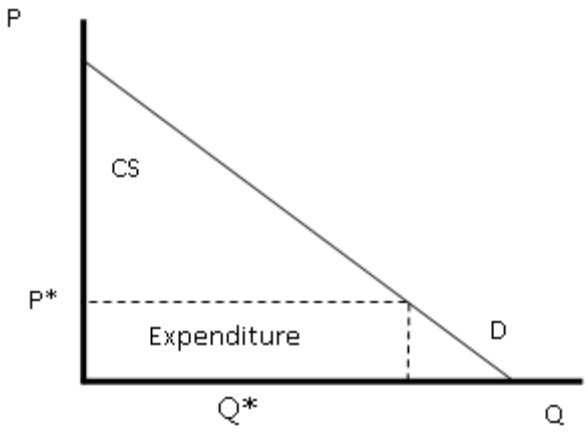
Lecture # 16 – Valuing Environmental Benefits: Revealed Preference Approaches

Note: we likely won't cover all the material on this topic on Monday. But I am putting all the notes on the topic here so they are in one place.

I. What is Value?

- Up to now, we have found the optimal level of pollution by considering the marginal damage function, which we have taken as given. Now, we discuss how to place a value on environmental amenities.
    - We can use data from firms to measure MAC.
    - Measuring benefits is more difficult, because they are not typically part of market transactions.
        - We can measure damages directly, by looking at damages and the value of what is lost, or we can infer damages indirectly from the behavior of individuals.
- To begin, consider what makes up the value of environmental amenities:
    - Use value -- the benefits people get from direct use of a good.
        - For most consumer goods, this is what we care about.
        - For environmental goods, this can include:
            - The value of recreation at a site
            - The value of open land near a home
            - The value from better health
            - The value of ecological services provided (e.g. by a wetland)
    - Non-use value
        - For environmental goods, not all value is use value.
        - Examples of non-use value:
            - Option value – the amount a person would be willing to pay to preserve the option of being able to experience a particular environmental amenity in the future.
                - Even if you won't go to the Grand Canyon this year, preserving it may have value to you so that you can visit in the future.
            - Existence value – a willingness to pay simply to help preserve the existence of some environmental amenity.
                - Protection of endangered species is an example.
            - Bequest value – a willingness to pay to leave behind environmental quality for future generations.
            - Stewardship value – a value placed on preserving the environment not for human use, but rather to maintain the health of the environment for all living organisms.

- To measure value, economists focus on willingness to pay.
    - Willingness to pay is the area under the demand curve.
        - Recall that the difference between what consumers actually pay and the actual price is the consumer surplus.
        - Willingness to pay includes actual expenditures and consumer surplus.
            - Note that it includes CS plus a bit more because we are only measuring benefits, not costs. It is the total benefit, not just the benefit above and beyond the cost of producing the good, that we want here.



            - Simply using a direct measure of expenditures ignores the consumer surplus, and underestimates the value.
    - We need to consider the same issues for costs and supply curves.
        - For example, changes in policy may lead to changes in costs (see figure 7.1 in the text).
        - Thus, we look at changes in producer surplus.
    - Putting these together, the net value is the sum of consumer surplus and producer surplus.
    - Since policy analysis should focus on marginal analysis, we want to ask how these change as we have an incremental change in pollution.

II. Revealed Preference Approaches

- Economists typically use one of two approaches to measure the benefits of environmental quality:
    1. Revealed preference approach – infer the value of environmental goods from other market transactions
        - Note that revealed preference approaches get at use values, but not non-use values.
    2. Stated preference techniques – ask individuals hypothetical questions about their willingness to pay.
- Today we consider revealed preference approaches.

A. Aversion Costs

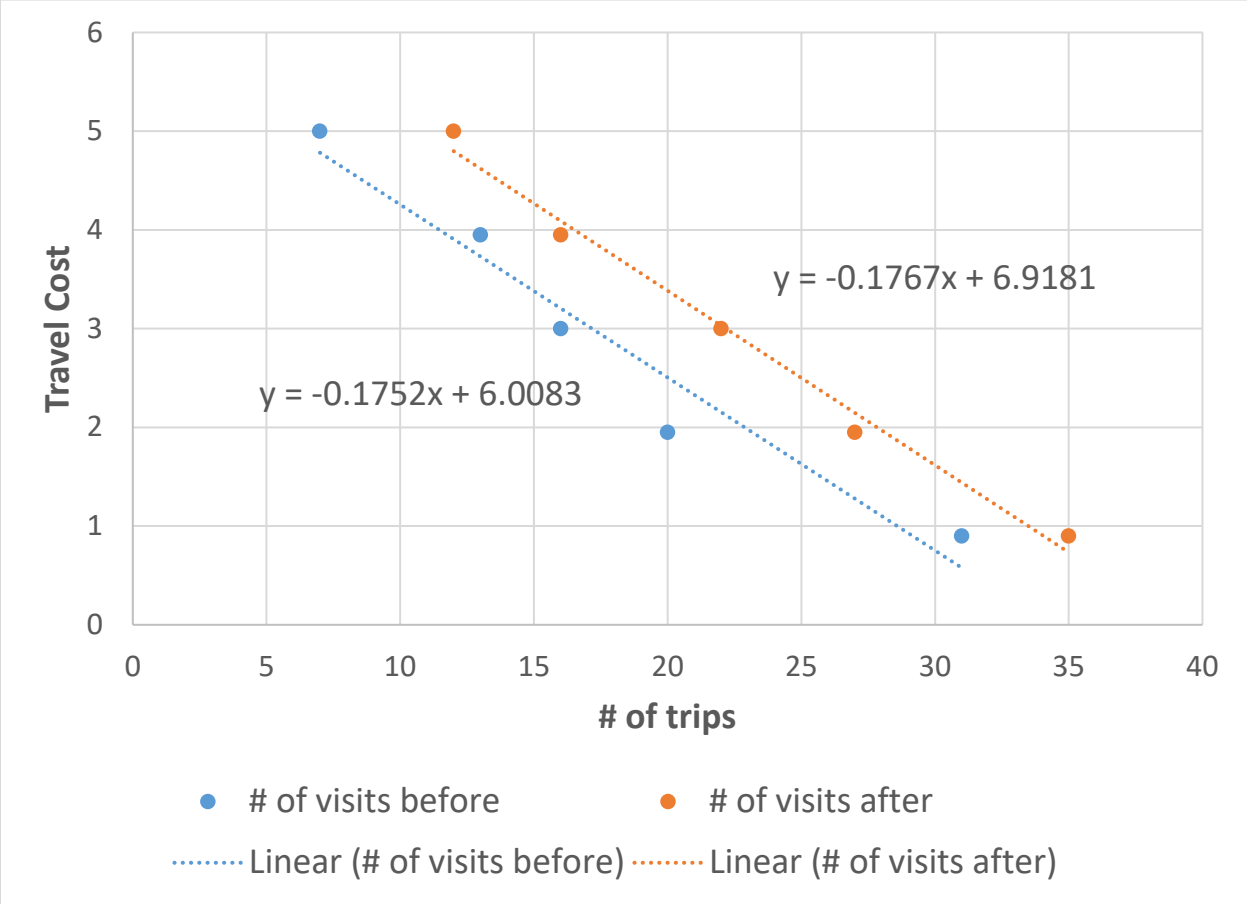
- Note that, in reaction to environmental harms, people may undergo expenses to remedy the problem.
    - Examples:
        - Filters for drinking water
        - Air conditioners so that windows can remain closed
        - Medication to mask symptoms of health effects
        - Shrubbery to hide a polluted neighboring site
- By studying how much people spend on averting expenditures, we can estimate the benefits they would receive if the harm were removed.
- Potential issues:
    - Perceived risk vs. actual risk: Consumers decisions are based on what they perceive risk to be, which may differ from actual risk
    - Actions that avoid risk also have other benefits (e.g. air conditioners provide cooling, bottled water tastes better)
    - Is the study related to a specific contamination episode (e.g. groundwater contamination) or a general risk (e.g. shortness of breath)
        - For general risks, it is harder to connect the concern to a specific contaminant.

B. Travel Cost Method

- The travel cost method looks at how far visitors travel to come to a site.
- By placing a value on the cost of travel, we can infer the value of the site.
    - The travel cost includes both direct costs (e.g. airfare) and indirect costs (e.g. the opportunity cost of travel time).
    - We can infer the value of a change in *quality* by looking at demand during different days (e.g. in different types of weather).
- Travel cost example. Consider a survey that collects data on the number of visits a person makes to a beach.
    - Based on how far they travel, the survey includes an estimate of the travel cost for each person.
    - Suppose we also have data on how many more trips they would make if the water quality were higher.
    - These data are given in the chart below:

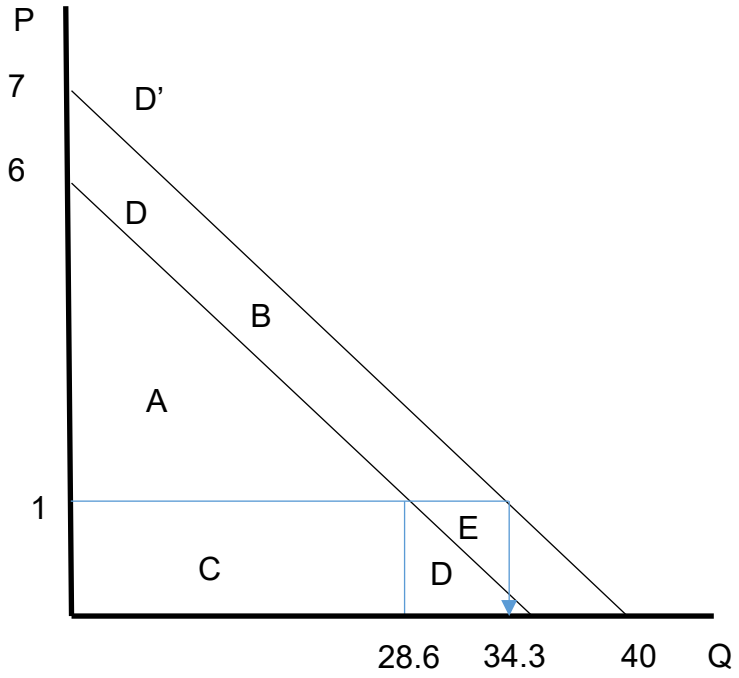
	Travel Cost	**# of visits before**	**# of visits after**
A	0.9	31	35
B	1.95	20	27
C	3	16	22
D	3.95	13	16
E	5	7	12

- This graph shows the scatter plot of these data, along with the regression line that best fits the data:



- Using the estimated demand functions, we can calculate the consumer surplus before and after. The change in consumer surplus is the value of improved water quality.
- For simplicity, we'll assume there is no admission fee for the beach, so that the price is 0 – anyone willing to travel to the beach can use it.
  - The only costs are the travel costs for visitors
- Rounding to simplify the math, we have two demand curves:
  - Before: P = 6-0.175Q
  - After: P = 7-0.175Q

- To calculate the change in WTP as water quality changes, assume that the current average travel cost of visitors is $1.
  - Thus, we begin by finding how many visitors come with the old and new demand curves.
  - Before:
    1 = 6 – 0.175Q
    0.175Q = 5
    Q = 5/0.175 = **28.6**
  - After:
    1 = 7 – 0.175Q
    0.175Q = 6
    Q = 6/0.175 = **34.3**
- Our graph is thus:



  - Willingness to pay after = A + B + C + D + E
  - Willingness to pay before = A + C
    - Change in WTP = B + D + E
  - To calculate, note that B is the change in consumer surplus and D + E is the change in expenditure
    - Change in consumer surplus
      - CS After = 0.5(6)(34.3) = $102.9
      - CS Before = 0.5(5)(28.6) = $71.50
        - Change in CS = $31.40
    - Additional expenditure = ($1)(34.3-28.6) = $5.7
    - Total change in WTP = $31.40 + $5.70 = $37.10

- Potential problems with the travel cost method
    - Compare single-site vs. multiple site models
        - Single site looks at how value changes as access to a site changes (e.g. closing a lake due to poor water quality)
            - Doesn't address possible substitutes
                - If one lake closes, can go to a nearby lake
        - Multiple-site models consider the choice of which site to visit
            - Include distance (or travel cost) to neighboring sites as additional controls
            - Key question: what are the relevant sites in the choice set?
                - e.g. 1000's of lakes in Minnesota – do we include them all
    - What is the opportunity cost of time?
    - Only measures value of those that use the amenity. We need to account for substitutes.
        - For example, do all beach users in Florida come for the beaches, or are they there for other reasons (e.g. Disney)?
    - Sampling bias in surveys.

C. Hedonic Pricing Techniques: Housing

- Hedonic pricing techniques look at the value that people place on the *attributes* of a good.
    - That is, it assumes that people don't value a house itself, but rather the *features* of a house (e.g. number of rooms, location, is there a fireplace)
    - One such feature is environmental quality.
- Using regression analysis, we can find the correlation between housing prices and environmental quality in an area.
- Most studies find an elasticity of housing prices with respect to pollution that is around 0.1.
    - That is, a 1% decrease in pollution leads to a 0.1% increase in housing prices.
- Example
    - Data are median house prices and community characteristics
    - Includes data on NOx concentrations in each neighborhood
    - Consider first a regression of just prices and NOX.
        - Both are in logs so can interpret as elasticities.

```
. reg lprice lnox

      Source |       SS           df       MS      Number of obs   =       506
-------------+----------------------------------   F(1, 504)       =    180.36
       Model |  22.2916457         1  22.2916457   Prob > F        =    0.0000
    Residual |  62.2906252       504   .12359251   R-squared       =    0.2635
-------------+----------------------------------   Adj R-squared   =    0.2621
       Total |  84.5822709       505  .167489645   Root MSE        =    .35156

------------------------------------------------------------------------------
      lprice |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnox |  -1.043143   .0776728   -13.43   0.000    -1.195746    -.890541
       _cons |   11.70719   .1324326    88.40   0.000     11.44701    11.96738
------------------------------------------------------------------------------
```

        - The elasticity is -1.04. A 10% increase in NOx concentrations reduces prices by 10.4%.

- But, this model ignores controls. Add the following variables:
  - rooms: average # of rooms per house
  - ldist: log of weighted distance to 5 employment centers
  - lproptax: log of property tax rate per $1000
  - stration: average student-teacher ratio
  - crime: crimes committed per capita

```
. reg lprice lnox ldist rooms stratio lproptax crime

      Source |       SS           df       MS      Number of obs   =       506
-------------+----------------------------------   F(6, 499)       =    161.15
       Model |  55.7902689         6  9.29837815   Prob > F        =    0.0000
    Residual |   28.792002       499  .057699403   R-squared       =    0.6596
-------------+----------------------------------   Adj R-squared   =    0.6555
       Total |  84.5822709       505  .167489645   Root MSE        =    .24021

------------------------------------------------------------------------------
      lprice |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnox |  -.8075904   .1143758    -7.06   0.000    -1.032308   -.5828729
       ldist |  -.2123361   .0398586    -5.33   0.000    -.2906474   -.1340248
       rooms |    .246118   .0168155    14.64   0.000     .2130801    .2791558
     stratio |  -.0384403   .0057099    -6.73   0.000    -.0496586   -.0272219
    lproptax |  -.0898723   .0415893    -2.16   0.031    -.1715839   -.0081607
       crime |  -.0137003   .0015339    -8.93   0.000    -.0167141   -.0106866
       _cons |   11.3062   .3203163    35.30   0.000     10.67686    11.93553
------------------------------------------------------------------------------
```

  - The elasticity falls to -0.8.
    - A 10% increase in NOx concentrations reduces prices by 8%.
- To get a value for reducing pollution, we need to know current home values and the number of homes affected.
  - The median home value in this data set is about $22,500.
  - Suppose there are 1 million homes in this region.
  - A 10% reduction in NOX concentrations would increase the median home value by $2,250.
  - Multiplying by 1,000,000 gives us a total value of $2,250,000,000 ($2.25 billion)

- Example: do wind turbines affect housing values (Guo *et al. PNAS* 2024)
  - Studies whether being able to see a wind turbine affects housing values
  - Compares homes in same neighborhoods with different views (e.g. because of a hill)
    - *Question:* Are these reasonable comparison groups? Why or why not?
    - Implemented using a difference-in-differences (DiD) regression
    - Their regression controls for other house characteristics (X), such as age, number of bedrooms and bathrooms, and lot size
  - Results
    - On average, homes with a wind turbine in its viewshed sell for 1.2% less
    - Effect is larger if the wind turbine is closer
    - Effect fades over time. Suggests people get used to seeing turbines.

D. Hedonic Pricing Techniques: Wages

- Another application of hedonics is with wages.
- Examples:
    1. People will choose to live in cities with positive characteristics.
        - Differences in wages can be seen as the value of these characteristics.
        - E.g.: Kahn (2017) studied public sector compensation
            - California workers are paid just 9% more than workers in Alabama
            - Adjusting for the cost of living, these workers are paid less
            - Implies they value the other amenities of living in California
    2. People need to be compensated to be willing to take riskier jobs.
        - Differences in wages represent the value of a human life.

III. Value of a Statistical Life

- The most controversial aspect of cost-benefit analysis is placing a value on human life.
    - What is the value?
        - Is it merely the opportunity cost (e.g. foregone wages)?
        - Are there other values (perhaps non-market values) that need to be considered?
    - Concepts of the value of a life
        - The most commonly used value is the value of a statistical life.
            - We don't know who will die, but we expect someone will.
            - The value of environmental protection is lessening the risk of someone dying.
                - Note that specific deaths capture the attention of individuals. However, that is not what a statistical life focuses on.
            - We are valuing changes in the probability that a random individual will die, by asking what is the willingness to pay for changes in risk.
                - It is the ratio of marginal utility of a small risk reduction over marginal utility of income: VSL = $MU_{\text{Risk reduction}}/MU_{\text{Income}}$.
                - That is, the as the marginal rate of substitution between mortality risk and money
            - Because of diminishing marginal returns, when dealing with large changes in risk, willingness to pay and willingness to accept will differ
            - For policy, this is the most appropriate measure, because policy does not prevent death, but rather changes the probability that death will occur.

        - Can also be put into annual figures: value of a statistical life year (VSLY)
            - Found by dividing VSL by the discounted expected years of life remaining for the average individual studied.
    - Contrast this with the optimal insurance and compensation of accident victims.
        - Colmer notes that other principles apply when lives are identifiable
        - Here, things such as the opportunity cost of foregone wages and medical expenses are often used, since now we are focusing on a specific loss.
- How to measure the value of a life:
    - Revealed preference approaches
        - Expenditures to reduce risk
            - For example, how much more will people spend for a car with airbags, or for bottled drinking water?
            - Challenge: separating value assigned to changing risk to other characteristics (e.g. other features of the car, or better taste for bottled water)
        - Hedonic wage approach
            - People need to be compensated to be willing to take riskier jobs.
                - Differences in wages represent the value of a human life.
            - To calculate, we regress wages on job characteristics, worker characteristics, and risk
            - Key is to compare risk of jobs and compensation required for each.
                - Occupation 1: 1 in 10,000 risk of death per year
                    - As a result, 1 worker dies every 10,000 years.
                    - If 10,000 workers in this occupation, expect 1 to die each year.
                - Occupation 2: 3 in 10,000 risk of death per year
                    - As a result, 3 worker dies every 10,000 years.
                    - If 10,000 workers in this occupation, expect 3 to die each year.
            - Comparison
                - Difference in risk is 2 in 10,000
                - Suppose wages in occupation 2 are $1,000 higher. What is the value of a statistical life?
                    - The value is the willingness to pay to avoid a risk that results in one more death in the population.
                    - This is the wage differential divided by the additional risk

        - = $1,000/0.00002 (or 1,000/(2/10,000)
        - = $5,000,000
    - Note that this assumes people's preferences are linear.
        - Does $1,000 for 1/1000 => $100 for 1/10,000?
  - Issues:
    - Requires people to have perfect information about risks, and to be able to evaluate this information properly.
    - Do people take risks knowingly and willingly?
    - True locally (that is for marginal changes), but for large changes in risks might not be appropriate.
- Ask people: stated preference methods
  - We will discuss these next

- Estimates of the value of a life in the United States vary by agency. These values were in effect in 2011:
  - E.P.A. $9.1 million
  - F.D.A. $7.9 million
  - DOT: $6 million
- Issues for valuing life
  - WTP depends on:
    - Type of risk
    - Amount reduced for each individual
    - Income
    - Substitutes: other ways to mitigate or avoid the risk
    - Preferences: each individual's subjective disutility from the risk, their risk aversion, and discount rate
  - How do we deal with different groups?
    - Reducing risk extends one's life expectancy.
    - Given this, should we place different weights on the lives of children?
    - Should we place less value on protecting the elderly?
      - EPA explored this idea in 2003
      - In some cases (e.g. air pollution), it is these high risk groups who are most affected by a policy.
      - OMB guidelines advise against adjusting VSL for age.
  - Extrapolating results across groups can be a problem.
    - Many VSL studies look at job risk in middle-aged men. However, the young and old tend to be most vulnerable to pollution.
    - Estimating VSL for children particularly difficult.
      - Cannot ask them directly
      - Parents often willing to pay more to reduce risk to children than to themselves.