Lecture # 15 – Valuing Environmental Benefits: Revealed Preference Approaches

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.
    - We can see willingness to pay from a demand curve.
    - It 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.
            - Thus, 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

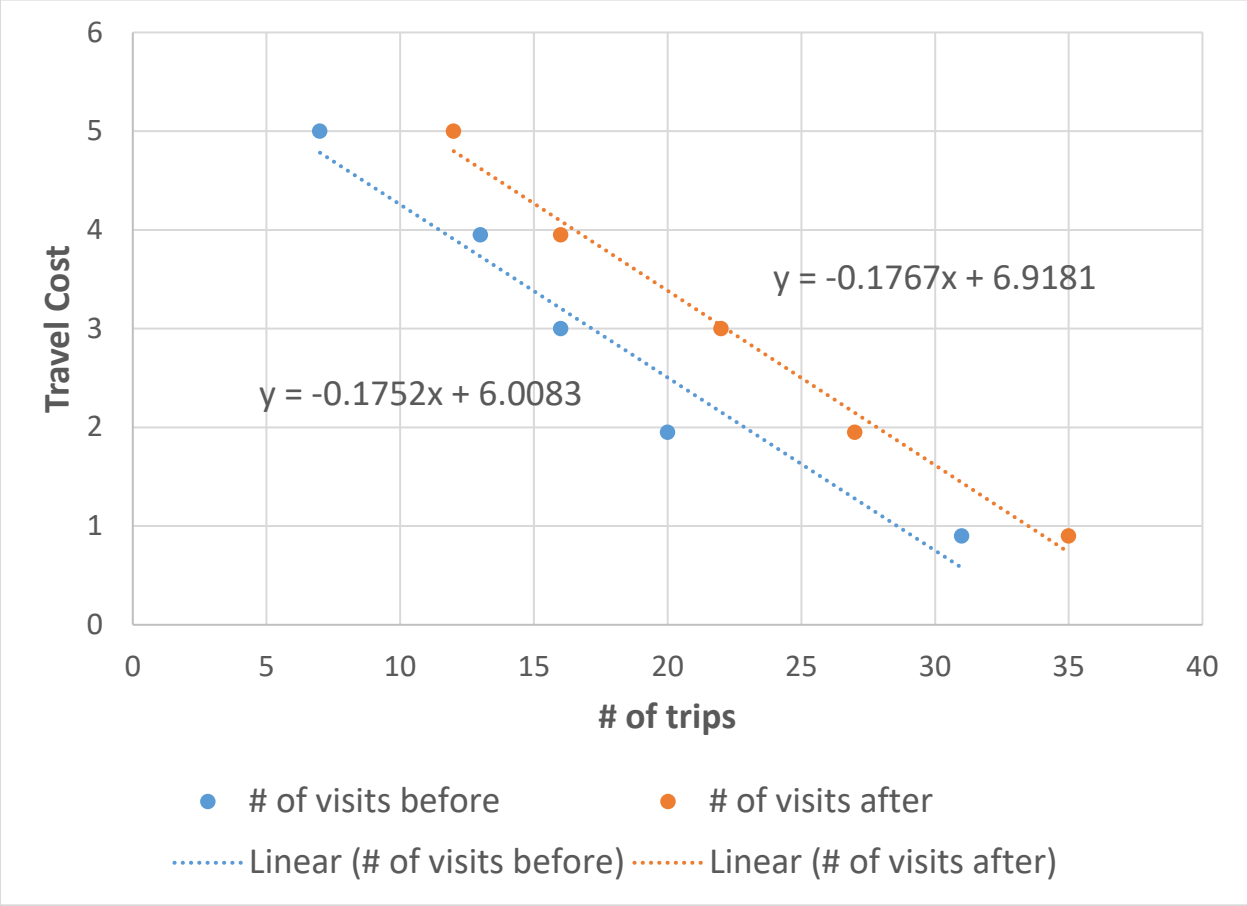
- Note that, in reaction to environmental harms, people may undergo expenses to remedy the problem.
    - Examples:
        - Filters for drinking water
        - Air conditioners so that windows can remain closed
        - Medication to mask symptoms of health effects
        - Shrubbery to hide a polluted 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:

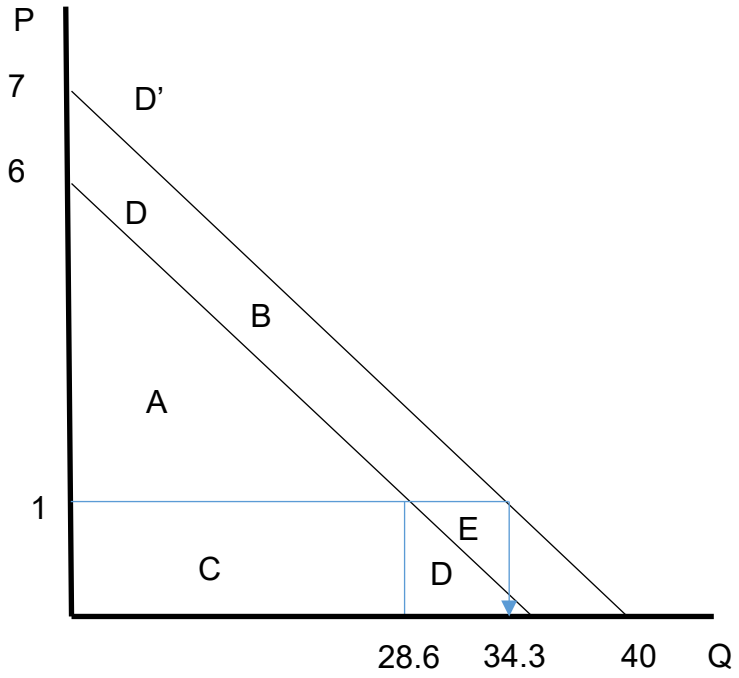
	Travel Cost	**# of visits before**	**# of visits after**
A	0.9	31	35
B	1.95	20	27
C	3	16	22
D	3.95	13	16
E	5	7	12

- 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.
- Rounding to simplify the math, we have two demand curves:
  - Before: P = 6-0.175Q
  - After: P = 7-0.175Q

- To calculate the areas of these, we need Q when P = 0
  - Before: 6 = 0.175Q
    - Q = 6/0.175 = 34.3
  - After: 7 = 0.175Q
    - Q = 7/0.175 = 40
- 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

- 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

- Potential problems with the travel cost method
  - 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)

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 in the next class

- 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.

- Should the value of human life vary by income?
  - Studies such as those focusing on lost income will place more weight on high-income lives.
  - Also, empirical work suggests income elasticity for WTP of risk reduction close to 1.
    - EPA study finds a range between 0.08-1, with a mode of 0.4 for VSL.
  - Given this, should we pay more to reduce risk if high-income people are affected?
    - For example, the average income of air travelers is higher than for the population as a whole.
    - Moreover, the costs of increased air safety will be passed on to these passengers via higher ticket prices.
    - Given this, should the standards for air safety be higher?
  - The EPA does not adjust VSL for incomes within a cross-section (e.g. doesn't say VSL higher for richer neighborhoods than for poorer ones). However, EPA adjusts VSL upward over time to account for higher incomes.
- What about people in other countries?
  - These approaches suggest a lower value for lives in developing countries.
  - Does ability to pay matter?
  - Does it matter if we are considering a plan to be paid for by the Chinese government versus one sponsored by the U.S. to aid China?
    - If China is paying, their ability to pay constrains what they can do.