Lecture # 19 – Benefit-Cost Analysis

I. Introduction to Benefit-Cost Analysis

- *Goal*: Maximize total net benefits (= total benefits - total costs).
- Benefit-cost analysis calculates the costs and benefits of a project and finds the total net benefits.
- Note that some costs and benefits can be observed directly from market data. Others will need to be inferred from data.
- Steps to benefit-cost analysis
    1. Specify clearly the project or program.
        - For environmental economics, this is usually a physical project such as a dam or wastewater treatment plant, or a regulatory program, such as pollution control standards.
    2. Determine quantitatively the inputs and outputs of the program.
        - Can be difficult – for example, general equilibrium effects.
        - Also, it is important to distinguish between *transfers* of resources due to substitution and the creation of new resources.
        - For example, jobs created by a project should normally not be included as a benefit.
            - Jobs created are a transfer of resources. If the project wasn't done, the workers could have been used elsewhere.
    3. Estimate the social costs and benefits of these inputs and outputs.
        - Identify potentially affected benefit categories
            - What are all the potential effects?
            - Research physical effects of the pollutants. How do they change as a result of policy?
            - Which benefits are the most important to include?
        - Quantify significant endpoints
            - What changes relative to baseline will occur because of the policy?
        - Estimate the values of the effects
            - Uses the tools we discussed over the past weeks
    4. Compare these costs and benefits.
        - Here, one can also include other considerations, such as equity.

- The *Economist* article "The rule of more" shows how assumptions matter
    - Including co-benefits made the net benefits of environmental regulations higher.
        - For example, an Obama Administration analysis found that most of the estimated benefits from reducing mercury pollution come from other related benefits.
            - Reducing mercury pollution reduces the use of coal, which also reduces fine particulate matter.
        - The Trump Administration said that these co-benefits should not be included.
    - We discussed in class whether such benefits should be included.
        - Being transparent about assumptions is important.
- In this class we'll focus on two issues particularly important for environmental policy:
    - Uncertainty
    - Discounting
- Students who would like a review of the details of benefit-cost analysis, you can view my lecture notes from the topic in my fall economics class. The last set of lectures cover benefit-cost analysis.

II. Dealing with Uncertainty

- The first step in dealing with uncertainty is risk assessment.
- Risk has two components:
    1. stochastic – depends on chance
    2. systematic – depends on circumstances (e.g. a smoker is more likely to get cancer)
- In addition, assessing risk involves two concerns:
    - the probability of an event occurring
    - how serious the event will be
- Risk assessment
    - First, we focus on finding the probability of an event occurring.
        - Historical data
            - Risk can be determined by looking at past records.
            - However, it is important to be aware of changes that occur over time. For example, increased safety features reduce the risk of death from auto accidents. This is a change in systemic risk.
        - Engineering studies of new technologies
            - Component analysis is often used to assess the risks of new technologies.
            - Problem: components may be related.
        - Risk by analogy
            - Often, time lags make perceiving risk difficult.
                - For example, cancer may be caused after exposure to a toxin, but only after many years.
                - As a result, studies on animals are often used to extrapolate human risks.
                    - Problems:
                        - Animals are exposed to unrealistically high doses of toxins in the laboratory.
                        - Need to extrapolate risk of humans from low exposure from calculated risk based on high exposure.
                        - Physiology of animals and humans may be different.
                        - The risk may be different for different people.

- Once risk has been assessed, policy makers face several alternatives for using the information:
  - Benefit cost analysis
    - For BCA, pieces of information needed to deal with risk include:
      - The risk probability
        - The government often uses conservative estimates (e.g. 95% percentile).
      - The population exposed
        - For example, Superfund regulations consider possible future populations on a site.
      - The value of a life
  - Avoid upper bound of risks
    - Government agencies, such as EPA, often use conservative risk estimates (e.g. 95% percentiles)
    - However, this adds up
      - If use 95% percentiles for several estimates, actual percentile is above 99% (.95 x .95 x .95)
      - Consider two chemical hazards:
        - Chemical A poses a known risk of 2 in 100,000
        - Chemical B is uncertain
          - 9 out of 10 scientists believe no risk
          - 1 out of 10 believe risk is 6 in 100,000
        - Government policy says risk of B is greater, since focuses on upper bound – that is, greatest potential risk.
          - However, chemical A has a higher expected value of risk.
  - Cost-Effectiveness analysis
    - Rather than compare costs and benefits, simply show that the agency has adopted the cheapest way possible to achieve its goal.
      - Takes the policy objective as worthwhile.
    - We can than ask if the costs justify the benefits received, without needing to place a dollar value on the benefits.
  - Risk-risk analysis
    - Compare risk after regulation to risk before.
    - Notes that regulation will affect behaviors, and could even increase risk.
    - Substitution of risks is important
      - If substances that replace banned substances are also risky, net gain from banning the substance is not as great as it seems.

- As we discussed in class, climate change provides an example where uncertainties are high and using cost-benefit analysis is challenging. Reasons for high uncertainty include:
    - Difficulty understanding the severity of climate change itself (e.g. cascading effects leading to high damages).
    - Impacts that are hard to value in dollars (e.g. ecosystem services)
    - Difficult to extrapolate from current experience what impacts will be, since some effects of climate change will be unprecedented.
        - This also means that people may adapt to climate change in unexpected ways.
    - Some low probability events have nearly infinite damages, making the expected value of damage's very high. How much can we reasonably spend?
        - E.g. Weitzman's "Dismal Theorem"

III. Discounting

- The costs and benefits we've discussed often occur at different times. To compare them fairly, it is important to discount costs and benefits that occur in the future.
    - The idea is to compare a flow of benefits and costs into a single value.
- The present value of a future amount of money is the maximum amount you would be willing to pay today for the right to receive that money in the future.
    - Present value accounts for the opportunity cost of not investing the money elsewhere.
    - Example:
        - You have $100 now
        - If you put it in the bank, you will get 5% interest
        - Next year, that money is worth (1 + 0.05)x100 = $105
        - After two years, it is worth $(1.05)(1.05)(100) = (1.05)^2(100) = \$110.25$
    - General rule:
        - FV = future value, PV = present value, r = interest rate
        - $FV = PV(1 + r)^t$
    - As a result, you wouldn't give up $100 now for $100 next year, because you could invest the money and get $105 next year.
        - The present value of $100 next year is the most you would give up today to get $100 next year
        - $FV => PV(1.05) = \$100(1.05)$
        - $PV = FV/r = 100/1.05 = \$95.24$
    - General rule
        - $PV = FV/(1 + r)$
    - For a stream of payments:
        - $PV = x + X/(1+r) + X/(1+r)^2 + \ldots + X/(1+r)^t$
- Please see the spreadsheet from class for additional examples.
- To proceed, we need to know what value to use for r. This is the discount rate.

- The discount rate reflects the relative value a person places on future consumption compared to current consumption.
    - Lower values show a greater preference for future consumption.
        - If your discount rate is greater than the interest rate, you will be willing to borrow money.
            - A high discount rate says that current consumption is important to you.
        - If your discount rate is lower than the interest rate, you will be willing to loan money.
            - A low discount rate says that future consumption is important to you.
    - Since the market interest rate reflects an equilibrium of lenders and borrowers, we can use the market interest rate as a measure of the discount rate.