Lecture # 18 – Estimating Benefits and Costs of Environmental Policy

I. Estimating Benefits: General Principles

- Having discussed techniques for valuing environmental benefits, we now discuss how to determine what those benefits are.
    - We begin with general principles for determining benefits, then look at two examples: ecosystem services and climate change
- In principle, comprehensive analyses of all environmental effects of a policy are desirable.
    - However, this is difficult.
    - Thus, with some exceptions (such as the social cost of carbon calculations), benefit calculations are done using an "effect-by-effect" approach.
    - Need to avoid double-counting in these cases.
        - For example, stated value techniques get at non-use values, but may double count use values already included in revealed preference measures.
        - Thus, caution is needed when combining results from different methods.
- Steps to "effect-by-effect" approach to benefits analysis
    1. Identify benefit categories potentially affected
        - Need to understand how policy will affect the environment, so as to know what the benefits will be.
        - Research physical effects of pollutants
            - Often relies on interdisciplinary literature
        - Consider potential changes in these effects from policy
        - Determine which benefits to include
            - E.g. health benefits, recreation, non-use benefits
            - Are there benefits likely to affect particular groups that should be considered.?
        - Should co-benefits be included?
            - In the MATS case, 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 or requires installation of abatement equipment. Both also reduce fine particulate matter.
                - The Trump Administration said that these co-benefits should not be included.

2. Quantify changes in significant endpoints
    - Focus on changes to the environment resulting from the policy.
        - Consultation with natural scientists important (e.g. to understand transport of pollution through the environment)
    - These are done relative to a baseline (further discussed below)
    - Role of economics in this step:
        - Ensure information provided useful for subsequent valuation
            - Are endpoints appropriate?
        - Consider behavioral changes that may affect results of risk assessment.
            - Will people change behavior to reduce risk (e.g. stay indoors to avoid air pollution)
3. Estimate the value of these effects

- Because benefits analysis should capture *marginal* values, we need to properly define the baseline.
    - The baseline is "the best assessment of the world absent the proposed regulation or policy action." (EPA 2010, Chapter 5)
    - Note that the appropriate analysis of a policy is not *before* vs. *after*, but rather what happened compared to what would have happened without a policy intervention.
        - Because other factors in the economy will change whether or not the policy is enacted (e.g. changing demographics, economic activity, technology)
    - Usually use a single baseline, but multiple baselines used if policy is particularly complex (e.g. IEA energy projections)
- Examples of important variables for baseline consideration
    - Demographics
        - Population exposed to pollution matters.
        - Is the population changing?
            - Behavioral models needed if the policy may change demographic trends
    - Future economic activity
        - Is the regulated industry growing or in decline?
        - Is there increasing competition from abroad?
    - Changes in consumer behavior
        - Regulation may change prices
        - But would some behavior have changed anyway?
    - Technological change
        - Even without regulation, technology is changing
            - E.g. how will driverless vehicles affect energy demand?

- Consideration of baselines in statistical analyses
    - Observational studies may miss important factors influencing outcomes
    - These relate to defining a proper baseline
        - Example: Polluted areas may have higher population, different economic conditions, different crime rates
    - Quasi-experimental use regression analysis to compare similar treatment and control groups
        - Goal is to approximate random experiments in natural sciences
    - Differences-in-differences is one example
- Example: estimating the benefits of reducing mercury from coal-fired power plants.
    - Background
        - The Supreme Court invalidated the rule in 2015 for not appropriately considering costs.
        - It is also the rule discussed in the *Economist* reading, where co-benefits dominate the direct benefits discussed here.
            - Thus, in identifying potential benefit categories, the EPA considered a wide range of benefits
    - Here, I focus on the EPA's estimate of the direct benefits of reduced mercury pollution focus on the effects of mercury on the IQ of children exposed.
        - First, project the number of pregnant mothers exposed to mercury from recreationally caught freshwater fish.
            - Used 2000 Census data to find the number of females aged between 15 and 44 in each state
            - # of pregnant women = # of females aged 15-44 * state's fertility rate
        - Second, estimate number of prenatally exposed children
            - Estimate number of households with angler fisherman using results of a survey on recreational activities
            - # potentially exposed children = # of pregnant women * (# of anglers/adult population in state)
                - Assumes fertility rate the same for angler and non-angler households
        - Third, estimate daily exposure for 32 different sub-populations (urban/rural, high or low income, distance to water, etc.)
            - average daily mercury ingestion rate = average mercury concentration in fish in each region * average daily self-caught freshwater fish consumption
            - Based on scientific literature, divide by 0.08 to get maternal mercury concentration
        - Fourth, convert maternal mercury concentration to IQ reduction
            - Multiply maternal mercury concentration by 0.18
                - Again, this is based on a scientific study
                - Assumes a linear relationship between mercury & IQ
        - Fifth, estimate monetary loss for each IQ point lost

        - Two measures, both based on outside studies:
            - Lost earnings: 1.76-2.379%
            - Decreased schooling costs:
                - Lower IQ => less time in school => cost savings of $13,453
        - Combining these two effects, each IQ point results in a lifetime income loss of:
            - $8,013-$11,859 with 3% discount rate
            - $893-$1,958 with 7% discount rate
    - Sixth, multiply change in IQ times monetary loss per IQ point to get benefits from reducing mercury
        - Estimate ranges from $0.5 million to $6.1 million
        - Depends no discount rate and net monetary loss per IQ point
- Potential concerns:
    - Is IQ the best measure of effects of prenatal mercury exposure?
    - Is there a linear relationship between IQ loss and earnings
    - Uncertainties in calculation of exposure (e.g. # of fish consumed, demographics of angler population)
    - Note that the analysis uses scientific studies on different populations and applies them to this regulation
        - For example, the studies on mercury concentration come from New Zealand and the Seychelles Islands.
        - This is an example of *benefits transfer* described in the EPA reading

- Estimating co-benefits (Table 10)
  - Why do co-benefits occur?
    - Compliance options include:
      - Switching from coal to natural gas
      - Installing new abatement technologies
        - Expected many firms would install new abatement technology that would capture not only mercury, but also SO_2 and particulate matter.
  - Calculating benefits of reduced mortality
    - Estimate change in $PM_{2.5}$ and ozone due to MATS
    - Estimate change in population exposed
    - Use dose-response functions from epidemiological studies to predict changes in health and welfare due to changes in population exposed
      - Concerns:
        - WTP response might not be linear
        - Most wage studies done on working-age males
        - But elderly are more likely to be affected by air pollution.
    - Converted to dollar values using value of a statistical life
      - Used a value of $8.9 million
      - Sources: 21 studies using wage data & 5 CV studies
  - Other health effects
    - Reduction in chronic bronchitis, nonfatal heart attacks, lost school and work days, and lower medical costs
    - Used social cost of carbon to include benefits from reduced CO_2 emissions

II. Estimating Costs

- Important concerns:
  - Establishing the baseline
    - We want to compare costs *with* regulation versus *without* regulation, not *before* and *after* regulation.
      - Even without regulation, we expect some things to change over time.
  - Distributional issues
    - Note that costs will often be focused on a few individuals (e.g. affected firms or communities).
    - Benefits are more likely to affect a wider range of people.
    - Thus, equity concerns will be an issue.
- Types of costs
  - Direct costs – purchases of tangible units such as equipment, labor, and land
  - Opportunity costs – the value of the best forgone opportunity.
    - It is what we give up by using a resource for this use, rather than the next best alternative use.
      - Example: an opportunity cost of going to school is foregone salary.
    - Important to distinguish between costs and transfers.
  - Environmental costs – because most regulations focus on a single pollutant, regulating one pollutant may increase the use of another pollutant.
    - Example: using scrubbers to clean SO2 emissions leaves behind a sludge that must be disposed of.
  - Enforcement costs
- Shapiro and Walker (2020) use offset permit trades to estimate the marginal costs of abatement
  - Offsets are used in non-attainment counties
    - Generated when existing firms reduce pollution
    - Purchased by new firms or firms wishing to expand operations
    - Represent the marginal costs of abatement, since firms selling offsets need to be compensated for the additional costs of increasing pollution abatement.
  - They compare their estimates of marginal abatement costs to the marginal benefits of reducing pollution in each county
    - Use existing studies of benefits that allow for different marginal benefits in different counties

    - Results
        - Marginal benefits of air pollution reductions exceed the costs in all but one county
        - The exception is Houston, TX
            - There, the cost of additional regulation for volatile organic compounds exceeds the benefits
        - The price of offsets is high in Houston
        - Cheaper natural gas increased demand to open new petrochemical plants in the area
- Example: cost of the Mercury and Air Toxics Standards (MATS)
    - Used an Integrated Planning Model (IPM) to project compliance costs
        - Computer model of generation capacity, electricity demand, and constraints faced by each electricity generator.
        - Used to calculate the lowest cost options for meeting electricity demand under different regulatory constraints.
            - Compliance options include:
                - Switching from coal to natural gas
                - Installing new abatement technologies
                    - Expected many firms would install new abatement technology that would capture not only mercury, but also SO_2 and particulate matter.
    - Table 3 shows projected changes in costs
    - Monitoring and enforcement add another $0.2 billion (Table 4)
    - Table 5 shows projected changes in generation mix.
        - Note baseline is not just before versus after.
        - Renewables increase from 2007-2015 in base case.

IV. How Accurate are Cost Estimates?

- Sources of error
    - One difficulty is that errors can come in many ways.
    - The most obvious is incorrectly estimating the costs of control.
    - However, even if the cost of control is estimated correctly, predictions about emissions levels, number of plants, etc. can also be wrong.
        - See examples on pages 303-304 of Harrington *et al*.
- Evaluation of estimates
    - Harrington *et al*. study 28 estimates of the cost of regulation.
    - They compare pre-regulation estimates to actual costs after the regulation is in place.
        - Label an estimate as “accurate” if it within 25% higher or lower than the actual costs.

- Results:

	Accurate	Overestimate	Underestimate	Unable to Determine
Quantity Reduction	13	9	4	2
Unit Pollution Reduction Cost	8	14	6	0
Total Cost	5	15	3	5

    - Costs more likely to be overestimated
- Discussion of results:
    - The three underestimates were for rather "minor" regulations: EPA aldicarb and CDEC bans and OSHA's powdered platform regulation.
    - EPA and OSHA tend to overestimate reductions, but not per unit costs. As a result, total costs are overestimated.
    - State and foreign agencies were more likely to overestimate per unit costs.
    - For market-based polices, seven of the eight estimates overestimated costs!
        - Note that this is where we would expect technological innovation to be most important.
- Why do errors occur?
    - Many estimates ignore the possibility of technological innovation.
        - Regulators have an obligation to identify a means of complying with the regulation, which usually means considering current technologies.
        - Future technologies are much harder to predict.
    - Quantity errors: misestimating baseline emissions
        - However, keep in mind that this also means that benefits are wrong.
        - For example, overestimating emissions reductions overestimates costs, but also overstates the benefits.
    - Regulations may change during the public comment period.
        - Thus, cost estimates aren't for the final regulation.
    - Estimates may focus on maximum values, rather than means.
        - Especially if rely on industry for data.
    - Asymmetric correction of errors.
        - Firms are likely to bring underestimates to the attention of regulators. There is no similar group with strong incentives to bring overestimates to the attention of regulators.