Assessing Externalities

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Introduction

Last class, we concluded that information is key

- Assessing externalities requires collecting right info
- This typically comes from several different sources:
  1. Some is scientific, technical, etc.: usually best by expertise
  2. Some information is subjective, held by affected individuals
     - Problematic for policy: given incentive to reveal
- Today we'll see how to combine, trade-offs between
  1. Benefit-cost analysis as encompassing framework
  2. Scientific and technical studies, combined with economics
  3. Key ingredient: the value of human life and health
  4. Example: Stern Review of Economics of Climate Change
  5. Types of useful subjective and private information
  6. Contingent valuation approaches: a naïve first pass
  7. The Vickrey-Clarke-Groves mechanism

The Benefit-Cost Analysis framework

Benefit-cost analysis is common paradigm for policy evaluation

- Supported by economists, lines up well with economics
- Emphasizes importance of trade-offs, pro's and con's
- Applied to a wide range of decisions
- Analyses involve many different dimensions:
  1. Direct harms on economic resources
     - Gauge amount of destruction, market value of this
  2. Limits on utilization of existing resources
     - Requires assessing market value of different uses
  3. Effects on human life and health: more soon
  4. Intangible harms on subjectively-valued resources
     - One approach takes values directly from ethical theory
     - In this case, centralized expert in charge
     - Another derives from values to individuals
     - Requires difficult elicitation

Benefit-cost analysis and externalities

BCA often used to make big public decisions:

1. Institute a new regulation on industry
2. Build a public project in some location

But same basic methodology applies to externalities

1. Determining correct Pigouvian tax:
   - Need to add up all marginal costs/benefits
   - Requires considering same list of factors
2. Assessing damages in a court case
   - Economists employed to do this very often
   - As in last lecture, acts as effective Pigouvian tax
3. Determining optimal level for cap and trade
   - Closest to classic CBA: determine best level
   - Often choice rather discretized, so almost like project

Analyses by academics, courts and bureaucracy

The role of technical and scientific studies

Crucial element in evaluating is technical

- What physical harms, benefits actually follow
- Typically requires detailed knowledge of (among others)
  1. Physics:
     - What are chances of nuclear reactor spilling over?
     - What are chances of CERN blowing up the world?
  2. Chemistry:
     - How much SO_2 causes how much acid rain?
     - What is effect of pollution on lake chemistry?
  3. Epidemiology:
     - How much does vaccination reduce others infections?
  4. Ecology:
     - How are fish stocks affected by pollution, overfishing?
     - Ecosystem servies impacts of deforestation

Tying scientific studies to economics

However, all of this is useless without economic backend:

1. How much should we value land lost to Fukushima?
   - Market value of land, reduction after the disaster
2. How valuable are crops destroyed by acid rain?
   - Market price of crops, plus future prices
3. How should we treat small risk of catastrophic outcome?
   - Expected utility theory, include concave utility for risk
4. How to discount future value of fish v. pollution today?
   - Market interest rates for discounting
5. What are ecosystem services worth for medicine?
   - Chance of discovery from past yields profits plus spillovers
6. How much are lives, health ruined by disease worth?
   - Turn to this in just a minute

$\Longrightarrow$ Every study combines economics, science

Leading example: the value of human life and health

Perhaps most famous economic input is value of human life

- This is quite controversial as some say "life is invaluable"
- But if this were true, no one would drive a car
  - To choose what is worth investing in, need standard
- Clearly, people make trade-offs that risk their lives often
- How much they will pay to reduce risks depends on income
  - Wealthy have more to spend, more to lose
  - Marginal utility of money declines, but of life constant

$\Longrightarrow$ Rich person's life "worth more" than a poor person's

- May seem unjust, but just one more thing money buys
- Redistribute, if you want, but don't distort trade-offs

- Thus three categories must be measured:
  1. Value of life (statistical, per unit probability)
  2. Value of other types of injuries, diseases
  3. Income elasticity (to extrapolate): about $.6 - .8$

Approaches to measuring value of statistical life

Usual approach to measuring is:

1. Assume value is on life, state, not how it happens
   - Crucial assumption, basis of all numbers
   - Problematic if injury process painful, degrading
2. Look for cases where people make trade-offs
   - Deciding whether to take dangerous work (like mining)
   - Deciding how safe of a car to purchase
3. Price difference measures willingness-to-pay of...
   - *Marginal person just indifferent between two choices*
4. Assume everyone cares same amount as marginal

Obviously problematic in many ways but...

- This is about all we have; even rough rules out crazy things
  - Some programs cost orders of magnitude more or less
- Also surveys, but equally problematic (see below)

Sample calculation of statistical value of life

Let's take a simple example to see how this works

- Imagine every year 3 in every 2,000 coal miners die
- Suppose factory workers have comparable skills
- Assume 1 in every 2,000 factory workers die each year
- Suppose coal mining pays \$4,000 more per year
- Assume this is the only relevant difference between jobs
- Difference in chance of death is $\frac{3}{2{,}000} - \frac{1}{2{,}000} = \frac{1}{1{,}000}$
- In exchange, get \$4,000, so per chance is $\frac{4{,}000}{\frac{1}{1{,}000}} = \$4,000,000$

$\Longrightarrow$ Statistical value of life is \$4,000,000

  - Real calculations nothing more than detailed version
  - Shows all the ups and downs
  - To calculate income elasticity, look for rich man's coal mine

Estimates of statistical value of life

Author (Year)	Sample	Risk Variable	Mean Risk	Nonfatal Risk Incl?	Workers' Comp Incl?	Avg Income Level (1990 U.S. $)	Implicit Value of Life ($ million)	Implicit Value of Life for Air Travelers ($ million)
R. S. Smith (1974)	Industry data: Census of Manufacturers, U.S. Census, Employment and Earnings	Bureau of Labor Statistics (BLS)	NA	Yes	No	22,640	7.2	11.0
Thaler & Rosen (1976)	Survey of Economic Opportunity	Society of Actuaries	0.001	No	No	27,034	0.8	1.0
R. S. Smith (1976)	Current Population Survey (CPS), 1967, 1973	BLS	0.0001	Yes, not signif.	No	NA	4.6	NA
Viscusi (1978a, 1979)	Survey of Working Conditions, 1969–1970 (SWC)	BLS, subjective risk of job (SWC)	0.0001	Yes, signif.	No	24,834	4.1	5.7
Charles Brown (1980)	National Longitudinal Survey of Young Men 1966–71, 1973	Society of Actuaries	0.002	No	No	NA	1.5	NA
Viscusi (1981)	Panel Study of Income Dynamics, 1976	BLS	0.0001	Yes, signif.	No	17,640	6.5	12.8
Craig Olson (1981)	CPS 1978	BLS	0.0001	Yes, signif.	No	NA	5.2	NA
Alan Marin & George Psacharopoulos (1982)	U.K. Office of Population Censuses and Surveys, 1977	Occupational Mortality U.K.	0.0001	No	No	11,287	2.8	8.1
Richard Arnould & Len Nichols (1983)	U.S. Census	Society of Actuaries	0.001	No	Yes	NA	0.9	NA
Richard Butler (1983)	S.C. Workers' Compensation Data 1940–69	S.C. Workers' Compensation Claims Data	0.00005	No	Yes	NA	1.1	NA
J. Paul Leigh & Roger Folsom (1984)	Panel Study of Income Dynamics, 1974; Quality of Employment Survey (QES) 1977	BLS	0.0001	Yes	No	27,693, 28,734	9.7 10.3	11.0 11.7
V. Kerry Smith and Carol Gilbert (1984)	CPS 1978	BLS	NA	No	No	NA	0.7	NA
Alan Dillingham (1985)	QES 1977	BLS; Constructed by author	0.000008, 0.00014	No	No	20,848	2.5–5.3; 0.9	4.2–8.8; 1.5

Stern Review goals

Perhaps most ambitious BCA of all time was *Stern Review*

- Commissioned by British government, with others
- Goal: evaluate economic B's and C's of climate change
- Many stages?
  1. Determine largest sources of greenhouse gases?
     - Methane from animals, carbon from energy, deforestation
  2. Determine effects of gases on global climate?
     - Use large-scale climate models, filled with uncertainty

     $\Longrightarrow$ *Distribution* of conditional outcomes
  3. Determine economic effects of changes?
     - Disasters, productivity of farm land, direct harms
  4. Determine extent to which adaptation mitigates?
     - Helpful, but institutions lack; Dust Bowl study
  5. Similar for other impacts?
     - Salinification of oceans, ecosystems, etc.

Externality and optimal level calculations

Corresponding to Cap and Trade v. Tax, two approaches?

1. Marginal harm from carbon, given business as usual
   - Benefits: no estimates of technology costs needed
   - Thus simpler, less assumptions needed
   - Drawbacks: effects highly non-linear
     - Large effects catastrophic, mild not too bad
     - Most harm comes from catastrophic effects
   - Estimate: $85 per tonne
2. Socially optimal level of carbon
   - Advantages: deals with non-linearity
   - Drawbacks: requires understanding technology better
   - Estimate: optimal to stabilize at 450-550 ppm

Most helpful because illustrates how hard this is!

- Example: geo-engineering eliminates catastrophes?

Things left out of the Stern Review

Stern Review focuses on "hard" economic costs; leaves out

1. Do people like being warmer, cooler, rain, etc.?
   - Sounds frivolous, but CA v. Chicago real estate
   - How might you quantify in objective fashion?
     - Use real estate prices like with value of life!
2. How much do people care about animals?
   - Potential to cause massive extinctions
   - How might you quantify in objective fashion?
     - Use government decisions in other domains
3. Value on civilizations, cities destroyed
   - We put a lot of value on culture preservation, etc.
   - Objective quantification?
4. Private knowledge about agriculture, mitigation innovations

All of these share that science, expertise not enough

Types of subjective and private information

True for broad class of cases:

1. Subjective existence values (environment or culture)
   - Can be assigned by expert, but some prefer via individuals
   - Comparing government decisions gives you consistency
   - But to get overall value, if you value through individuals...
2. Personally/privately valued property, consumption
   - Inframarginal valuation of weather, health, life
   - Standard approaches only give you marginal valuation
   - Similarly subjective value of your home, things you own
3. Local information about technology, impacts
   - Entrepreneurs know of existing new mitigation technology
   - Farmer may know his farm is particularly dry
   - New Yorker may know he is subject to flood risk
   - But, as practical matter, how much of this is there?

Contingent valuation surveys

When such information *genuinely important* try to elicit

- Careful that not just opinions, guesses, etc.
- Goal is information, not "individual's value defines"
- For example, inherent value of cultures:
  - Do these come from how individuals or "society" values?
  - Which one determines if individuals or anthropologist better
- When we do need information, why not ask?
  - Simple, traditional approach has long history
  - Called *contingent valuation*; done via surveys
    1. Describe different situations
    2. Ask individuals how much they'd pay for one over other
    3. Impute this as true willingness to pay
  - Most commonly used as for environmental issues
    - Also used for value of creating transport, public goods

Practical examples of surveys and related approaches

Classic examples of contingent valuation?

1. Payment for preserving visibility at Grand Canyon
2. Preserving seals and whales in ocean
3. Avoiding logging in national forests
4. Value of bird killed by Exxon Valdez
5. Value of preserving languages of indigenous cultures
6. Value of new building in a city

Commissioned by regulatory agencies, courts

- Benefit-cost analysis for externalities, regulations, actions
- Also used to assess damages from oil spills, etc.

These are formal, money-based surveys, but informal too:

- Surveys of public opinions often influence politicians
- Not exactly the same as contingent valuation...binary
- But have some significant similarities, impacts

Traditional criticism of contingent valuation

Such surveys are in low repute among economists; why?

1. People don't take these seriously
   - How would you take a question like this?
2. People answer wrong question: overall evaluation
   - What we want is harm/WTP of *that individual personally*
   - Most people make casual, overall social evaluation
3. People don't have any idea, information, experience
   - Takes a lot of reflection to determine value for these things
4. People's answers motivated by "warm glow"
   - Many feel good about thinking they value these things
   - This may be main cause of their answers
5. Responses highly inconsistent, apparently irrational
   - Depend on order, grouping, etc: how to interpret?
6. No incentives to get things right, no experience

Strategic problem: why contingent valuation can't work

Actually, much worse than this; what are incentives?

- Depends on what survey is used for
  1. What if no one takes survey seriously?
     - Then no incentives, but why take survey in first place?
     - Probably true right now, in which case pure waste
  2. Survey has major impact on public policy?
     - In this case, large incentives!
     - If you want preservation, report huge number
     - If you want no preservation, report $0

$\Longrightarrow$ Never a real incentive to report truthfully

- Great example from Haiti in *The Economist*
  - After quake, reporter asked if people got supplies
  - Everyone said no, but later saw people had!
  - Only way to make sure aid keeps flow is to lie

Eliciting information: the incentive problem

$\Longrightarrow$ If we want to take seriously, need to consider *incentives*

- Suppose know private benefits
- We want to determine socially optimal amount
- Each individual knows harm to them of activity
- Total harm is sum of all individuals
- How can we get people to tell truth about harms?
  - One approach pushes question back another layer
  - The harm I report is like taking an action
  - If I pay externalities of action, I will do what is best
  - What are *externalities* of what I say?
  - Without me, choice would maximize welfare concern for me
  - With me, society has to look out for my interests
  - So my externality is how much others' welfare changes
    - Externality = other's welfare with $-$ without me

The Vickrey-Clarke-Groves Mechanism

Let's return to our smoking example

- But now imagine small room
- Value of smoking to one smoker is $100s - s^2$
- There are two other people, each harmed $s^2 + 5s$
- You are harmed $s^2 + 10s$
- Without you, optimum is?
  - $100 - 2s = 4s + 10$ or $s^\star = 15$
- With you, optimum is?
  - $100 - 2s = 6s + 20$ or $s^\star = 10$
- So what's the externality you create?
  - $90 \cdot 15 - 15^2 - 90 \cdot 10 + 10^2 = 75$
  - Pay \$75, but glad, save $15^2 + 10 \cdot 15 - 10^2 + 10 \cdot 10 = 125$
- This is called the *Vickrey-Clarke-Groves Mechanism*
  - Can also be shown visually with marginals

Graphical illustration of VCG

Practical applications of VCG

Most common use of VCG is *second-price auction*?

- Suppose everyone bids for for some object
- If winner pays bid of second-highest, that is his externality
  - Externality created is that the other guy doesn't get it
- Note that you want to bid your value v_i
  1. Conditional on winning/lose, doesn't affect payment
  2. Never want to bid lower and lose: could have won below v_i
  3. Never want to bid higher and win: would have paid above v_i
- Multi-unit (package) auctions sometimes use
- Also course selection: artificial currency for classes
- Many proposals to use, but very uncommon in practice
- Example is land assembly: alternative to eminent domain
  - Offer made, values reported, sale if offer above values
  - Pay for vetoing assembly: $o > \sum_{j \neq i} v_j$ but $o < \sum_{j \neq i} v_j + v_i$