# PSC 556: Policy Analysis

Assessing Policy Alternatives:
Part II

April 14, 2004

## Topic Outline

- IV. Tools:
  - Cost-benefit analysis
  - Cost-effectiveness analysis

## A. Cost-Benefit Analysis

- Identify projects to be analyzed
- Identify impacts of projects:
  - Favorable and unfavorable
  - Present and future
- Assign quantitative values to impacts (e.g., $)
- Calculate net benefit
- Choose project with highest net benefit
  - Assuming it is above zero

## Categories of Costs and Benefits

- Real vs. pecuniary
- Direct vs. impact
- Tangible vs. intangible

## Categories of Costs and Benefits

- OMB identifies three category of costs and benefits to be identified when assessing Federal regulations:
  - Monetized
  - Quantified, but not monetized
  - Qualitative, but not quantified

**OMB #:** **Agency/Program Office:**
**Role Title:**
**RIN#:** **Date:**

| *Category* | *Primary Estimate* | *Minimum Estimate* | *Maximum Estimate* | *Source Citation (RIA, preamble, etc.)* |
|---|---|---|---|---|
| *BENEFITS* | | | | |
| Annualized monetized benefits | | | | |
| Annualized quantified, but unmonetized, benefits | | | | |
| Qualitative (unquantified) benefits | | | | |
| *COSTS* | | | | |
| Annualized monetized costs | | | | |
| Annualized quantified, but unmonetized, costs | | | | |
| Qualitative (unquantified) costs | | | | |
| *TRANSFERS* | | | | |
| Annualized monetized transfers: "on budget" | | | | |
| From whom to whom? | | | | |
| Annualized monetized transfers: "off-budget" | | | | |
| From whom to whom? | | | | |
| *Category* | *Effects* | | | *Source Citation (RIA, preamble, etc.)* |
| Effects on State, local, and/or tribal governments | | | | |
| Effects on small businesses | | | | |
| Effects on wages | | | | |
| Effects on growth | | | | |

## Valuation of Costs and Benefits

- Two fundamental postulates:
  - The social value of a project is the sum of the values of the project to the individual members of society
  - The value of a project to an individual is equal to his (fully informed) willingness to pay for the project

## Valuation of Costs and Benefits

- Difficulties apply these approaches:
  - Externalities
  - Public goods
  - Incommensurables

## Valuation of Costs and Benefits

- Approaches:
  - Market prices
  - Shadow prices (especially for intangibles)
    - Comparable prices (of comparable goods)
    - Survey analysis
    - Consumer choice (examine observed choices in the past and trade-offs consumers accepted)
    - Derived demand (estimated indirect costs associated with a good (e.g., how much spent on travel to enjoy a park)
    - Cost of compensation (identify costs of actions to correct for problems; related to negative externalities of a good)

## Valuation of Costs and Benefits

- A difficult example—Valuing a human life:
  - What is a human life worth?
  - Do all have the same value?

## Valuation of Costs and Benefits

- First approach: Human capital
  - Discounted future earnings
  - Measures what an individual is expected to have contributed to society
  - Application to nations:
    - Nett National Product per capita (NPP) (Vrijling and van Gelder)

$$\text{NNP} = \frac{\text{GNP - Depreciation}}{\text{Population}}$$

## Valuation of Costs and Benefits

  - Multiply NNP (which is an annual figure) by average life expectancy and convert future values into present value
  - Example:
    - Netherlands—NNP = $19,400
    - Assume average life expectancy is 70 years
    - Discounted into present value = $800,000

## Valuation of Costs and Benefits

- Second approach: Willingness-to-pay (WTP)
  - Discounted future earnings
  - Hedonic approach
    - Hedonism: ancient Greek philosophical approach that placed importance on pursuing a pleasurable life
  - Based on the amount one is willing-to-pay to reduce risk of death

## Valuation of Costs and Benefits

- Related concept: willingness-to-accept (WTA) increased risk of death
  - Extra amount of compensation you require to take on increased risk
- Determined through:
  - Labor market studies: research on the extra compensation to induce workers to take risky job
    - Compare the extra wages required for riskier occupations (e.g., police officers, miners) to the extra risk of death

## Valuation of Costs and Benefits

- Example:
  - » Assume it costs an extra $500 to pay workers to increase their odds of death from 0.0002 to 0.0003

$$\text{Hedonic value of a human life} = \frac{\$500}{0.0001} = \$5{,}000{,}000$$

- EPA (1983) placed the value of a human life between $400,000 and $7,000,000 (1982$)

## Valuation of Costs and Benefits

- Survey research: offer people various gambles and see what compensation they will accept for additional risk

## Example

In the U.S., about 1 in 5000 people die annually in traffic. A possible measure to reduce the traffic risk is to equip cars with safety equipment. Imagine a new type of safety equipment. If this equipment is installed in your car, the risk of dying in a traffic accident will be cut in half for you and everyone traveling in the car. This safety equipment must be tested and serviced each year to make sure it is working correctly. Would you choose to install this safety equipment in your car if it will cost you $X Per year? ($30, $150, $300, $750, $1500, or $3,000)

Or…

In the U.S., about 1 in 5000 people die annually in traffic. The number of death can be reduced if we devote more resources to preventing traffic accidents. We can, for example, straighten out turns, build safer crossing, and increase the supervision of traffic. Imagine a program that cuts in half the risk of your and everyone else's risk of dying in a traffic accident. Are you will to pay $X per year more in taxes on your car for this program? ($30, $150, $300, $750, $1500, or $3,000)

$$\text{Reduced risk of death} = \frac{\text{no. of lives saved}}{\text{affected population}}$$

# Valuation of Costs and Benefits

– Calculating reduced risk of death:

$$\text{Reduced risk of death} = \frac{\text{no. of lives saved}}{\text{affected population}}$$

$$\text{Reduced risk of death} = \frac{1}{10000} = 0.0001$$

– Multiply reduced risk of death by the average WTP (assume $500):

$$\text{Value of a statistical life} = \frac{\$5001}{0.0001} = \$5{,}000{,}000$$

# Valuation of Costs and Benefits

- Examples of the Value of a Statistical Life (VSL):
  - The value of private and public safety measures to reduce by half the number of fatal traffic accidents is about $712 and $590 (1996 $). The implied VSL is between $8.9 mil. And $7.4 mil.
  - Based on market studies the EPA estimated VSL to be between $400,000 and $7 mil. (1982 $)

# Valuation of Costs and Benefits

- Examples of the Value of a Statistical Life (VSL) (cont.):
  - Research that compared the price of smoke detectors and the very small expected reduction in the risk of death estimated VSL to be between $101,000 and $676,000

# Valuation of Costs and Benefits

- Benefits and costs of Federal regulations

TABLE 2.—ESTIMATES OF THE ANNUAL BENEFITS AND COSTS OF MAJOR FEDERAL RULES, OCTOBER 1, 1992 TO SEPTEMBER 30, 2002
[Millions of 2001 dollars]

| Agency | Benefits | Costs |
|---|---|---|
| Agriculture | 3,109 to 6,283 | 1,649 to 1,679. |
| Education | 658 to 816 | 363 to 612. |
| Energy | 4,764 to 4,772 | 2,473. |
| Health & Human Services | 8,733 to 11,724 | 3,168 to 3,337. |
| Housing & Urban Development | 527 to 601 | 796. |
| Labor | 1,868 to 4,290 | 1,057. |
| Transportation | 6,150 to 9,465 | 4,313 to 6,812. |
| Environmental Protection Agency | 106,858 to 179,757 | 23,967 to 27,028. |
| Total | 134,547 to 217,539 | 37,686 to 43,794. |

TABLE 8.—ESTIMATE OF BENEFITS AND COSTS OF 3 MAJOR RULES, OCTOBER 1, 2001 TO SEPTEMBER 30, 2002
[Millions of 2001 dollars]

| Regulation | Agency | Benefits | Costs | Explanation |
|---|---|---|---|---|
| Energy Conservation Standards for Central Air Conditioners and Heat Pumps. | DOE | 710 | 636 | Present value estimates amortized over 24 years. We valued $NO_x$ emission reductions at $350–$2500 per ton. |
| Tire Pressure Monitoring Systems (TPMS) | DOT | 409–944 | 749–1,206 | We valued each equivalent fatality (see p. iv of the Executive Summary of the Final Economic Assessment) at $3 million. |
| Control of Emissions From Nonroad Large Spark-Ignition Engines, and Recreational Engines. | EPA | 913–4,818 | 192 | We amortized the benefit estimates in proportion to the estimated $NO_x$ emission reductions. The lower end of the range reflects the alternative approach to valuing benefits of EPA rules discussed elsewhere. |
| Total | | 2,032–6,472 | 1,577–2,034 | |

Assumptions: 7 percent discount rate unless another rate explicitly identified by the agency. For DOL: $5 million VSL assumed for deaths averted when not already quantified. Injuries averted valued at $50,000 from Viscusi.* All values converted to 2001 dollars. All costs and benefits stated on a yearly basis.

*W. Kip Viscusi, Fatal Tradeoffs: Public & Private Responsibilities for Risk. New York, NY, Oxford University Press, 1992, p. 65.

## Decision Rules

- Net benefit:

NET BENEFIT = Total Benefits - Total Costs

  - Select the project that produces greatest net benefit (NB)
    - Assuming it is greater than zero
  - Net benefit of doing nothing is zero
  - The superior criterion

## Decision Rules

- Benefit-cost ratio:

$$\text{Benefit/Cost ratio} = \frac{\text{Total Benefits}}{\text{Total Costs}}$$

  - Indicates the amount of benefit per unit of cost
  - An acceptable decision criteria when several independent projects are to be chosen
  - In other situations: may recommend a project that does not maximize net benefit

## Decision Rules

  - Example 1:

| Project I | Benefits | Costs | Net Benefits | B/C Ratio |
|---|---|---|---|---|
| A | $10,000 | $1,000 | $9,000 | 10.0 |
| B | $100,000 | $25,000 | $75,000 | 4.0 |

    - Suggests the project with lower net benefit is preferred
    - Not sensitive to the size of the total benefits and costs involved

## Decision Rules

  - Example 2—Municipal Marina Project:
    - First presentation:
      - Costs: $1 mil. (construction)
      - Benefits: $4 mil. (recreational benefits), -$2 mil. (environmental damage)
      - Benefit-cost ratio: 2/1 = 2.0
      - Net benefit: 2 – 1 = 1
    - Second presentation:
      - Costs: $1 mil. (construction), $2 mil. (environmental damage)
      - Benefits: $4 mil. (recreational benefits)
      - Benefit-cost ratio: 4/3 = 1.33
      - Net benefit: 4 – 3 = 1

## Decision Rules

    - Indicates that benefit-cost ratio is sensitive to the definition of a benefit or a cost

## Decision Rules

- Internal rate of return (IRR)
  - The discount rate at which a project has zero net benefit
  - Typically there is only one for a project (but not always)
  - If deciding about a single project:
    - Undertake a project if the IRR is greater than the appropriate discount rate
  - If choosing from several projects:
    - Choose that project with the highest IRR
  - Generally valid rule, but not always

## Application of Decision Rule

- One projected to be accepted or rejected:
  - Situation:
    - Project under consideration is a new headquarters to be built on a designated tract of land
    - The Wildlife Management Authority which operated the area has on particular building in mind

## Application of Decision Rule

- Costs:
  - $175,000
- Benefits:
  - $150,000 (savings on energy costs)
  - $75,000 (savings on maintenance costs)
- Net Benefit:
  - $50,000
- Decision:
  - Undertake the project because net benefit is greater than zero

## Principle Behind Decision Rule

- Kaldor-Hicks Compensation Principle
  - An elaboration of the Pareto criterion
    - Pareto optimum: an allocation of resources such that any change makes at least one party worse off
  - "Select the policy that maximizes the difference between the gains to the gainers and the losses to the losers" (Munger 2000:103)
  - Losses and gains

## Principle Behind Decision Rule

- Kaldor-Hicks Compensation Principle
  - Assumes losses and gains can be measured and balanced
    - Even if different individuals receive the gains compared to those who are burdened with the costs
  - Is the basis for all cost-benefit analysis
  - Consistent with utilitarian ethical system

## Discounting

- A procedure for estimating the present value of costs and benefits that will be realized in the future
- Permits the comparison of costs and benefits which occur at different time points to be compared
- Discounting reduces a stream of benefits or costs to a single amount—the present value
- Modified decision rule:
  - Maximize net present value (NPV)

## Discounting

- Calculating present value:

$$\text{Present Value} = \frac{\text{Benefit or Cost}}{(1.0 + r)^{n}}$$

  - Where:
    - *r* is the discount rate
    - *n* is the year the benefit or cost occurs

| Project Year | Benefits | Costs | Annual Net Benefit | Discount Factor | Present Value |
|---|---|---|---|---|---|
| 0 | $0 | $15,000 | ($15,000) | 1 | ($15,000) |
| 1 | $4,000 | $0 | $4,000 | 0.909091 | $3,636 |
| 2 | $4,000 | $0 | $4,000 | 0.826446 | $3,306 |
| 3 | $4,000 | $1,223 | $2,777 | 0.751315 | $2,086 |
| 4 | $4,000 | $0 | $4,000 | 0.683013 | $2,732 |
| 5 | $4,000 | $0 | $4,000 | 0.620921 | $2,484 |
| | | | | | |
| Discount | | | | NPV = | ($756) |
| Rate = | 10.00% | | | | |

| Project Year | Benefits | Costs | Annual Net Benefit | Discount Factor | Present Value |
|---|---|---|---|---|---|
| 0 | $0 | $15,000 | ($15,000) | 1 | ($15,000) |
| 1 | $4,000 | $0 | $4,000 | 0.934579 | $3,738 |
| 2 | $4,000 | $0 | $4,000 | 0.873439 | $3,494 |
| 3 | $4,000 | $1,223 | $2,777 | 0.816298 | $2,267 |
| 4 | $4,000 | $0 | $4,000 | 0.762895 | $3,052 |
| 5 | $4,000 | $0 | $4,000 | 0.712986 | $2,852 |
| | | | | | |
| Discount | | | | NPV = | $402 |
| Rate = | 7.00% | | | | |

# Discounting

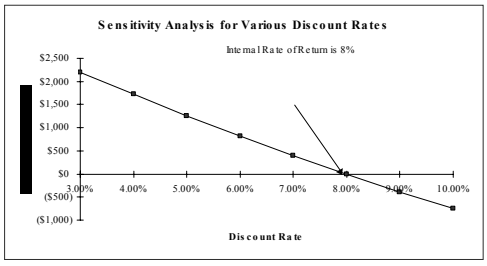
- Importance:
  - Can influence whether or not a project is deemed worthwhile
  - Low discount rates are favorable for projects with early costs and late benefits
  - High discount rates are favorable for projects with delayed costs and a quick rate of return

# Selecting a Discounting Rate

- Three approaches:
  - Based on the return to private investment
  - Based on the cost of government borrowing (risk free)
  - Social time preference

# Selecting a Discounting Rate

- Selection in practice:
  - Client indicates the discount rate to use
  - Recent cost of borrowing for similar project
  - Dictated by policy or law
    - Federal level: OMB Circular A-94
  - Identify IRR
    - Is the cost of borrowing likely to be above or below?



## Selecting a Discounting Rate

- Selection in practice:
  - Client indicates the discount rate to use
  - Recent cost of borrowing for similar project
  - Dictated by policy or law
    - Federal level: OMB Circular A-94
  - Identify IRR
    - Is the cost of borrowing likely to be above or below?

## Examples

- UTK stadium expansion

## B. Cost-Effectiveness Analysis

- Example