Cost-Benefit Analysis

1. Discounting and NPV. Implications for environment.
2. Measuring benefits:
   a. Area under the demand curve. Consumer surplus.
   b. Practical issues:
      i. Value of life
      ii. Value of good health. QALY.
      iv. Adjusting prices for “distortions” like taxes.
   v. Valuing environmental benefits: example – Cape Wind project
   1. Contingent valuation
   2. Hedonic pricing
   3. Travel cost method
   4. Defensive expenditures
3. What discount (interest) rate
4. How deal with risk
5. How deal with distributional effects of projects and policies.

Discounting and NPV. Implications for environment.

Recap:

I would prefer $100 now to $100 in a year’s time.

Why? Because the $100 now could be put in a bank, or invested, and yield a return.

Assume a 20% return.

Then $100 now gives back $120 next year. And if you wait another year, it will give back $144.

I added 20% of $120, which is $24.

$100 now is the present value
$120 is the future value in one year’s time
$144 is the future value in two year’s time.

FV(1) = PV × (1+interest rate)
FV(2) = PV × (1+interest rate) × (1+interest rate)
FV(3) = PV × (1+interest rate) × (1+interest rate) × (1+interest rate)
Therefore

$$PV = \frac{FV_1}{(1+i)}$$

Or

$$PV = \frac{FV_2}{(1+i)^2}$$

And so on.

$$PV = \frac{FV_t}{(1+i)^t}$$ This applies to any year $$t = 0, 1, \ldots n.$$ 

Internal rate of return. This is the interest rate that just makes the project worth doing (i.e. $$NPV=0$$).

Note: Lower interest rates make projects more attractive.

Environmental projects often need very low interest (discount) rates to be worthwhile.

If you use market interest rates, may environmental projects would not be worth doing. Some people argue that a lower interest rate should be used for environmental projects, because they concern future generations. Good discussion in the Stern Report on Climate Change.

**Example: Value of an education.**

More years of education are associated with higher earnings. We typically collect information from many people about their education and earnings.

Regression: $Earnings\ per\ year = a + b\ years\ of\ education + c\ age$

Suppose the estimate of the $$b$$ coefficient is 120. This says that every extra year of education adds $120 to your annual earnings. But your education cost $1,000.

<table>
<thead>
<tr>
<th>Cash flow</th>
<th>Year 0</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV cash flow</td>
<td>-1000</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>NPV</td>
<td>-1000</td>
<td>$120/(1+i)$</td>
<td>$120/(1+i)^2$</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

This might help guide a country that needs to decide how much to spend on more higher education.

**Measuring benefits:**

a. **Area under the demand curve. Consumer surplus.**
Market for shoes.

Each point shows what people are willing to pay. Also shows their demand for shoes. Demand curve may be thought of as a willingness-to-pay curve.

Consumer surplus is what I am willing to pay minus what I have to pay.

Example. I might be willing to pay $50 for a pair of shoes, but they only cost me $10, so I have $40 in consumer surplus. Great.

In cost benefit analysis, the benefits, especially of environmental projects, typically require us to measure consumer surplus. That means we need to measure demand curves.

What is the market price? Hard to measure. But necessary when constructing price indices.

How to measure willingness to pay.

Contingent Valuation Method. Survey!

Survey people who might be affected by a project or policy.

1. Choose a random sample of respondents
2. Describe the goods/service/policy so respondents understand what is being valued.
3. Ask respondents to value.
4. Typically also collect some socioeconomic data. Age, gender, income, location, etc.

How pose the question?

a. Open-ended willingness-to-pay question.
   “What is the maximum you would pay per year for air that is much cleaner than now?”
   Worry is that respondents might overstate strategically.

b. Closed-ended iterative bidding.
   Would you pay at least $5? If yes, $6? $7? $6.50?
   Once common, now rarely used. Anchoring problem.
c. Contingent ranking; ranked choice.
Would you prefer: dirty water and a $1 tax; or clean water and a $5 tax.

d. Dichotomous choice /referendum question.
“If clean air cost $10 per year in taxes, would you vote for it?” Common, needs a large sample.

**Hedonic price method**

Method for measuring the benefits of an environmental project, especially cleaner air or water.

North of Boston, there is an incinerator in the town of Andover. Burns household waste. The incinerator produces smoke.

Some proposed closing down the incinerator. [Build an incinerator in an area with fewer people.] Would it make sense to close it?

Idea: If incinerator were closed down, the value of houses in the area would rise. The increase in property values would measure the value of closing down the incinerator.

Price of a house depends on:
- Environment
- Noise
- House: number of bathrooms, sq meters, sq meters of plot of land, age
- Distance from the Andover incinerator (or a dump site)

Price of house = \( a + b \times \text{sq meters of house} + c \times \text{sq meters of plot} + d \times \text{age} \)  
\[ + e \times \text{number of bathrooms} + f \times \text{distance from incinerator up to 500 m} \]

Regression, reflecting the value of the features of the house and the locality. Hedonic price regression.

Collect data from lots of houses.

Suppose, based on estimating a regression, we have:

\[ P_{\text{house}} (\$) = 0 + 600 \times \text{sq m} + 60 \times \text{sq m plot} - 1000 \times \text{age} + 9000 \times \text{no. bathrooms} + 60 \times (\text{meters from incinerator}) \]

e.g. House 2 baths, 180 sq m, plot is 500 sq m, 25 years old, 100 m from incinerator. What is the estimated price of the house? \( \$_{\text{estimated}} = 137,000 \)

e.g. Similar house, but 500 m from incinerator: Estimated price: \( \$_{\text{estimated}} = 161,000 \)

House gains $24,000 in value if it is 400 m further from the incinerator.
Add up the gains from every house, and get the total value of removing the incinerator.

**Defensive spending**

Example. Study by Abdalla et al. Town of Perkasia in Pennsylvania, USA. From December 1987 through September 1989, the town well – source of all drinking water – was polluted with trichloroethylene (TCE). What is the value of finding a new source of clean water?

Look at what people spent in order to get clean water during this period. “Defensive spending” because they were defending themselves from the pollution in the town water.

<table>
<thead>
<tr>
<th>Cost in total per year</th>
<th></th>
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<tbody>
<tr>
<td>Buy more bottled water than before</td>
<td>11,100</td>
</tr>
<tr>
<td>Buy bottled water when not used before</td>
<td>17,300</td>
</tr>
<tr>
<td>Home water treatment systems</td>
<td>4,700</td>
</tr>
<tr>
<td>Hauled water</td>
<td>12,500</td>
</tr>
<tr>
<td>Boiled water</td>
<td>15,600</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>61,200</strong></td>
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</tbody>
</table>

**Life**

Many projects save lives. For instance, widening a road. Or requiring seat belts. Or building code.

What is the value of a life?

We all take risks, so we are all willing to accept a higher chance of dying in order to have more convenience. So we do not value our own lives infinitely highly!

Economists ask: how much do we need to pay people in order for them to accept higher risks?

   Dangerous job. Fishing: more dangerous than being a fish seller. Suppose a fish seller earns $2,000 per year. A fisherman has a 1% chance of drowning in a year. Fisherman earns $2,200 per year. The fisherman has to earn an extra $200 a year to compensate for the greater risk of the job. “Compensating differential.” Then the value of a **statistical life** is $200/1% = $20,000.
Final exam.

Only questions on material covered in class.

Open book, but you may not help each other.

Saturday, March 12, 2-5 p.m.

Take the exam anywhere.

I will: post the exam on the website, and also e-mail to each person.

E-mail me if any questions or problems.

E-mail me your answers when you have finished.

Examples.

Is GDP/capita a good measure of wellbeing? Explain. [10 minutes]

A project invests $500 this year and gets income of $700 next year. The interest rate is 12%. Calculate NPV. Show workings.

What is the contingent valuation method used for?

How deal with regressions where the Y variable is binary: i.e. 1 or 0.

Do you buy a good or not? Yes (1), No (0).