Impact Analysis/Evaluation and Cost-Benefit Analysis

- Formative vs. summative evaluations
  - Process-based vs. outcome-based
- Quantitative, qualitative, mixed methods
- Purpose
  - Ex-ante analysis of plan, program, or policy
  - Ex-post assessment or evaluation
Why Evaluate Plans, Programs or Policies?

- Understand the impact of a program
  - Fiscal impacts
  - Societal impacts
- Help improve plan or policy to increase or create impact
- Improve implementation to increase or create impact
- Assist in reconceptualizing purpose and objectives
- Assist in building consensus on goals and objectives
- Help inform decisions about investment or subsidy levels
- Verify or quantify impacts – possibly for political and public relations purposes
Early Questions...

- Why is the analysis being done?
- Who is the audience?
- What sorts of resources and time are available for the analysis?
- Who will do it?
- What are the end-outcomes? What are the intermediate outcomes or outputs?
- Which indicators and data will be used?
- Where will these come from?
Key Criteria Types:

- Technical feasibility
  - Effectiveness
  - Adequacy

- Economic and financial possibility
  - Fiscal benefits and costs to government
  - Total societal benefits and costs

- Equity

- Risk and Uncertainty

- Reversibility

- Political viability

- Administrative operability

- Other types of criteria: security, liberty, rights
Distributional and Equity Issues

- C’s and B’s for *whom*?
- Vertical vs. horizontal equity
- “Standing” in the analysis
- Transitional equity
- Intergenerational equity
- Interactions with risk, uncertainty, and reversibility
CBA Issues...

- Costs and benefit valuation types:
  - monetary
  - monetarizable
  - tangible but nonmonetarizable
  - intangible

- Including opportunity costs

- Direct vs. indirect –
  - first- vs. second- or third-level effects

- Long-term vs. short-term

- Intended vs. unintended effects
Fixed Costs, Variable Costs, Marginal Costs

- Sunk cost – cost already expended and not recoverable

- Fixed cost – the costs incurred regardless of the amount of services provided or goods produced – i.e., does not vary with scale of the program
  - Basic infrastructure and administrative costs
  - Assumed to be incurred before the first unit of services or goods are provided/produced

- Variable costs = the portion of total costs that varies with scale

- Average costs = total costs / number of units of output

- Marginal cost = cost of producing one more unit of output
Relationships between FC, VC, TC and MC

\[ TC = FC + VC \]

Where \( n \) is the number of units of service provided

\[ MC = \frac{VC_{n+1} - VC_n}{Q_{n+1} - Q_n} \]

Since \( VC = TC - FC \), and \( FC \) is constant,

\[ MC = \frac{TC_{n+1} - TC_n}{Q_{n+1} - Q_n} \]
Cost-Benefit Analysis – what can it do?

- Do the benefits exceed the costs? Is $B > C$?
  Or… What is the ratio of benefits to costs? Is $B/C > 1$?

- What is the *net* benefit of the project ($B - C$)
  - Is it higher than other alternatives?

- Cost-effectiveness
  - Of the programs meeting minimum effectiveness criteria, which costs least?
  - Hold benefits constant, then identify differences in costs
Present Value

- What is $100 next year worth to you in today’s dollars?
- How much can you earn on a liquid, risk-free investment?
- Assume 3% \( \gg \) 103% * $Today = $100 next year

\[ \gg \quad \frac{100}{1.03} = \text{Today} = \$92.59 \]

General formula for present value:

\[ PV \left[ \begin{array}{c} n \times m \\ S_{n \times m} \end{array} \right] = \frac{S_{n \times m}}{(1 + r/m)^{n \times m}} \]

where \( r \) is annual discount rate, \( n \) is number of years, \( m \) is compounding periods per year (e.g., quarterly, \( m=4 \)).

If \( m = 1 \) \( \Rightarrow \) \[ PV \left[ \begin{array}{c} n \\ S_n \end{array} \right] = \frac{S_n}{(1 + r)^n} \]
Decomposing Discount Rates

\[ r = r_{\text{real}} + r_{\text{inf}} + r_{\text{risk}} \]

\[ r_{\text{risk}} = r_{\text{project}} + r_{\text{liquidity}} + r_{\text{other risks}} \]
Calculating the Net Present Value of a Project

\[ PV(B) = B_0 + PV(B_1) + PV(B_2) + \ldots \]
\[ PV(C) = C_0 + PV(C_1) + PV(C_2) + \ldots \]

\[ NPV = PV(B) - PV(C) \]

Alternatively, the same result can be calculated as:

\[ NPV = B_0 - C_0 + PV(B_1 - C_1) + PV(B_2 - C_2) + \ldots \]
PV (B) (or DB) = 0 + $4,000/(1+ 0.04) + $4,000/(1+0.04)^2 + $4,000/(1+0.04)^3 + $4,000/(1+0.04)^4 + $5,000/(1+0.04)^5

PV(C) (or DC) = $15,000 + $1,223 / (1+0.04)^3

NPV = PV(B) – PV(C) = $17,807.20 - $16,087.25 = $1,719.95
A Cost-Benefit Example

- Tunnel vs. ferry
- Discount rate = 8%
- Tunnel costs:
  - $64 million in year 0 for construction
  - $20,000 each year
  - $500,000 every 10 years in deferred maintenance
  - Life of tunnel 50 years

- Benefits
  - $500,000 in ferry expenses annually
  - Commute time: 5,000 commuters * ½ hr *$8/hr*250 days
  - $1.50 per day-car * 3,000 cars * 250 days in other auto-related savings

The Cost-Benefit Calculation

Costs = $64MM + $20,000 * \left[ \frac{1}{1+(1+r)^{50}} \right] +
$500,000 * \left[ \frac{1}{1+r}^{10} + \frac{1}{1+r}^{20} + \frac{1}{1+r}^{30} + \frac{1}{1+r}^{40} \right]

Benefits = [$500,000 + (5,000 \times 250 \text{ days} \times 0.5 \times 8) +
(3,000 \times 250 \text{ days} \times 1.50) ]
\times \left[ \frac{1}{1+(1+r)^{50}} \right]

With \ r = 0.08, \ \text{Benefits} - \text{Costs} = $16.4MM
Sensitivity Analysis – Changing $r$, and Changing the Value of Commuting Time

Discounted Cash Flows and the Long-Term

DCF/IRR/CBA methodology generally favors near-term returns over longer-term returns

Planning outputs and outcomes can last for decades, but DCF often largely neglects benefits in “outlying” years (e.g., 10+)

→ Does DCF undervalue durability?
  → Physical durability
  → Market durability
  → Social durability
  → Environmental durability and sustainability
## What’s in a Discount Rate?

### Annual Net Benefits (B-C), ($MM)

<table>
<thead>
<tr>
<th>Year 0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposal A</td>
<td>(100)</td>
<td>0</td>
<td>8</td>
<td>11</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>176</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proposal B</td>
<td>(100)</td>
<td>(5)</td>
<td>(5)</td>
<td>0</td>
<td>5</td>
<td>11</td>
<td>12</td>
<td>14</td>
<td>17</td>
<td>20</td>
<td>23</td>
<td>25</td>
<td>27</td>
<td>28</td>
<td>29</td>
</tr>
</tbody>
</table>

### NPV@ Discount Rates

<table>
<thead>
<tr>
<th></th>
<th>8%</th>
<th>12%</th>
<th>16%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposal A</td>
<td>$43.35</td>
<td>$15.74</td>
<td>($4.08)</td>
</tr>
<tr>
<td>Proposal B</td>
<td>$86.54</td>
<td>$19.31</td>
<td>($18.74)</td>
</tr>
</tbody>
</table>
CBA Under Uncertainty

Do Nothing

- Development Occurs
  - Probability = P1
- Development Does Not Occur
  - Probability = 1 - P1

Abate

- Development Occurs
  - Probability = P2
- Development Does Not Occur
  - Probability = 1 - P2

### Table 7-6  The Costs and Benefits of Different Possible Outcomes of a Policy to Abate Taxes for Downtown Development (in millions of dollars)

<table>
<thead>
<tr>
<th>Costs and Benefits of the Outcome</th>
<th>Outcome 1 Do Nothing/Get Development</th>
<th>Outcome 2 Do Nothing/Get No Development</th>
<th>Outcome 3 Abate Taxes/Get Development</th>
<th>Outcome 4 Abate Taxes/Get No Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased property tax receipts</td>
<td>+$100</td>
<td>$0</td>
<td>+$900</td>
<td>$0</td>
</tr>
<tr>
<td>Decreased property tax receipts (taxes abated)</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Increased public service costs</td>
<td>−$25</td>
<td>$0</td>
<td>−$100</td>
<td>$0</td>
</tr>
<tr>
<td>Net benefit (+) or loss (−) to city</td>
<td>+$75</td>
<td>$0</td>
<td>+$200</td>
<td>−$200</td>
</tr>
</tbody>
</table>

Development Occurs  

Probability = \( P_1 \)  

\[ \text{Expected NPV of “ABATE”=} \quad 0.6 \times 200 \text{MM} + 0.4 \times (-200 \text{MM}) = 40 \text{ MM} \]

Development Does Not Occur  

Probability = 1 - \( P_1 \)

Do Nothing  

Probability = 30%  

Expected NPV of “DO NOTHING”=

\[ 0.3 \times 75 \text{MM} + 0.7 \times (0) = 22.5 \text{ MM} \]

Probability = 70%

Abate  

Development Occurs  

Probability = 60%  

Development Does Not Occur  

Probability = 40%

\[ \text{Expected NPV of “DO NOT} \]