Cost-Effectiveness and Cost-Benefit Analysis for Public Policy Decision-Making

Ross D. Shachter
Management Science and Engineering
Stanford University

Risks and Benefits


MS&E 290 Health Policy Lectures

- Jan. 8 Cost-Effectiveness and Cost-Benefit Analysis
- Jan. 22 Introduction to Decision Analysis
- Jan. 29 HIV Vaccines
- Feb. 3 Maintenance Treatment for Opiate Addiction
  Professor Margaret Brandeau
  Management Science and Engineering Department, Stanford
- Feb. 5 Helicobacter pylori Vaccines

Reference Policy and Situation

- Changes are considered relative to a particular reference policy and situation
- Normally this is assumed to be the status quo, the current policy and situation in effect.
- Alternatively, it could be a particular policy projected to be in place, or a particular situation of concern

Cost-Benefit Rationale

- A policy change is a Pareto improvement if some people are better off and no one is worse off after the change.
- Some policy changes benefit some at the cost of others. An exchange could have those who benefit compensate those who suffer, and thus make everyone better off.
- A policy change is a potential Pareto improvement if an exchange could be made among people that would make it a Pareto improvement, even if that exchange never occurs.
- A policy change is considered desirable if it is a real or potential Pareto improvement. This is determined by accumulating its direct and indirect benefits and costs.

Cost-Benefit Examples Which Projects Should Be Done?

<table>
<thead>
<tr>
<th>Project</th>
<th>Net Benefits: Benefits Minus Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>OK</td>
</tr>
<tr>
<td>B</td>
<td>Not OK</td>
</tr>
<tr>
<td>C</td>
<td>OK</td>
</tr>
<tr>
<td>D</td>
<td>OK</td>
</tr>
<tr>
<td>E</td>
<td>Not OK</td>
</tr>
</tbody>
</table>

© Ross D. Shachter
MS&E 290, Public Policy Analysis
Cost-Benefit Examples
Which Projects Should Be Done?

<table>
<thead>
<tr>
<th>Project</th>
<th>Cost</th>
<th>Benefit</th>
<th>Net Benefit</th>
<th>OK?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$200K</td>
<td>$250K</td>
<td>$50K</td>
<td>OK</td>
</tr>
<tr>
<td>B</td>
<td>$280K</td>
<td>$250K</td>
<td>-$30K</td>
<td>Not OK</td>
</tr>
<tr>
<td>C</td>
<td>$75K</td>
<td>$100K</td>
<td>$25K</td>
<td>OK</td>
</tr>
<tr>
<td>D</td>
<td>$280K</td>
<td>$350K</td>
<td>$70K</td>
<td>OK</td>
</tr>
<tr>
<td>E</td>
<td>$90K</td>
<td>$80K</td>
<td>-$10K</td>
<td>Not OK</td>
</tr>
<tr>
<td>F</td>
<td>$90K</td>
<td>$100K</td>
<td>$10K</td>
<td>OK</td>
</tr>
</tbody>
</table>

Cost-Effectiveness Rationale

- Consider a set of $n$ projects that can be implemented independently, in parallel.
- Each project $i$ has a cost $c_i$ and a benefit $b_i$ (not usually in dollars) and there is a total budget of $C$.
- This can be represented as a mathematical program:
  - maximize $\sum_i b_i$
  - subject to $\sum_i c_i \leq C$
    
- $0 \leq x_i \leq 1$ for all $i = 1, \ldots, n$
- (assuming that some of the projects can be completely partially).

Cost-Effectiveness Example
Which Project is Most Attractive?

<table>
<thead>
<tr>
<th>Project</th>
<th>Cost</th>
<th>Benefit</th>
<th>Ratio</th>
<th>Cumulative Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>-$40K</td>
<td>3</td>
<td>-$13K</td>
<td>-$40K 3</td>
</tr>
<tr>
<td>C</td>
<td>$20K</td>
<td>6</td>
<td>$3.3K</td>
<td>-$20K 9</td>
</tr>
<tr>
<td>A</td>
<td>$120K</td>
<td>7</td>
<td>$17K</td>
<td>$100K 16</td>
</tr>
<tr>
<td>E</td>
<td>$100K</td>
<td>3</td>
<td>$33K</td>
<td>$200K 19</td>
</tr>
<tr>
<td>F</td>
<td>$80K</td>
<td>1</td>
<td>$80K</td>
<td>$280K 20</td>
</tr>
<tr>
<td>B</td>
<td>$80K</td>
<td>-5</td>
<td>-$16K</td>
<td>$360K 15</td>
</tr>
</tbody>
</table>

Cost-Effectiveness Example
Which Project is Most Attractive?

Net Change in Costs

<table>
<thead>
<tr>
<th>Net Change in Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0</td>
</tr>
</tbody>
</table>

Cost-Effectiveness Example
Threshold Based on Budget

<table>
<thead>
<tr>
<th>Net Change in Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0</td>
</tr>
</tbody>
</table>

Cost-Effectiveness as Portfolio Optimization

Simultaneous Project ordered by cost-effectiveness

Cost Effect
Positive Benefit
Positive Cost

Cost-Saving
Positive Benefit
Negative Cost

Least Efficient Projects, Beyond Budget

Net Change in Costs

<table>
<thead>
<tr>
<th>Net Change in Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0</td>
</tr>
</tbody>
</table>

Cost-Effectiveness as Portfolio Optimization

Simultaneous Project ordered by cost-effectiveness

Cost Effect
Positive Benefit
Positive Cost

Cost-Saving
Positive Benefit
Negative Cost

Least Efficient Projects, Beyond Budget

Net Change in Costs

<table>
<thead>
<tr>
<th>Net Change in Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0</td>
</tr>
</tbody>
</table>
QALY
Quality-Adjusted Life Year

The Quality-adjusted life year is the period of time in perfect health that a patient considers indifferent to one year in a particular health state.

For example:

QALY Health State
1.00 Perfect health
0.95 Chronic atrophic gastritis
0.50 Gastric cancer
0.00 Surgical death

Assessment might be different before, during, or afterwards, e.g. pain, incontinence, impotence, ostomy.

Cost-Effectiveness Threshold in Medicine

When there is no explicit budget

Projects must all pass cost-benefit threshold

For benefits in terms of QALY’s

- Current Standard Practice in Medical Technology Assessment in USA
- Benefit of 1 QALY is $50,000
- Project is cost-effective if Cost/QALY < $50,000

Operating Expense and Capital Expenditure

Capital project is evaluated once for cost-benefit, relative priority--flood control, airport expansion, bridge/highway

Operating expense expected to be ongoing decision--reimbursable medical procedures

- Want consistency from year to year
- Value of $50K/QALY standard
- Threshold necessary but not sufficient for policy!

Time Value of Costs and Benefits

How do we compare costs and benefits in one year to costs and benefits in another?

- Spending now to protect air quality
- Spending now to prevent future cancers
- Spending now to immunize against future epidemics
- (We are trading current benefits for future benefits.)

How far out should an analysis be performed when there is great model uncertainty?

Utilities for Losses and Gains

Which is preferred?

- Spend $1M to save 100 QALY’s for sure
- Spend $1M to save 200 (or 0) QALY’s with prob 0.5
- New therapy with cost-effectiveness $100K/QALY

Which is preferred?

- Save $10M by giving up 100 QALY’s for sure
- Save $10M by giving up 200 (or 0) QALY’s with prob 0.5
- Old therapy with cost-effectiveness $100K/QALY

Choice depends on problem frame!

We tend to be risk-averse toward gains, risk-seeking toward losses.
Perceived versus Actual Risk

Summary

Costs and benefits are discounted for time value, and adjusted for uncertainty and risk-attitude.

A capital project is evaluated on its net benefits—total benefits minus costs and whether it is a potential Pareto improvement.

An ongoing decision, especially one where the benefit is not monetary, is evaluated for its marginal cost-effectiveness.