Economic Evaluation

- Objective of Analysis
- Criteria
  - Nature
  - Peculiarities
- Comparison of Criteria
- Recommended Approach

Objectives of Economic Evaluation Analysis

- Is individual project worthwhile? Above minimum standards?
  - This is a “choice”, is it better or not?
  - This is easier
- Is it best? Is it at top of ranking list?
  - This is a “judgment” about details
  - This is more difficult
Principal Evaluation Criteria

- Net Present Value
- Benefit - Cost Ratio
- Internal Rate of Return
- Cost-Effectiveness Ratio
- Pay-Back Period

Net Present Value

- \( NPV = B - C \) (stated in present values)
- Objective: To Maximize
- Advantage: Focus on Result
- Disadvantage
  - Interpretation of NPV
  - No account for scale, thus difficult to use for ranking
Evaluation of Projects S and T

<table>
<thead>
<tr>
<th>Project</th>
<th>Benefit $</th>
<th>Cost $</th>
<th>Net Value $</th>
<th>NPV as % of Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>2,002,000</td>
<td>2,000,000</td>
<td>2,000</td>
<td>0.1</td>
</tr>
<tr>
<td>T</td>
<td>2,000</td>
<td>1,000</td>
<td>1,000</td>
<td>100</td>
</tr>
</tbody>
</table>

Benefit - Cost

- Ratio = \( \Sigma B / \Sigma C \) (Present Values)
- Objective:
  - To Maximize
- Advantage:
  - Common Scale, Useful in Ranking
- Disadvantages:
  - Treatment of Recurring Costs
    \( \Sigma B / \Sigma C \) or Net Benefits/Investment
    = > Bias against operating projects
  - Ranking sensitive to \( r \)
    low \( r \) = > higher rank for long-term projects
### A Comparison of a Capital Intensive and Operations Project (Benefits in Present Values)

<table>
<thead>
<tr>
<th>Project</th>
<th>K</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment, Q&lt;sub&gt;k&lt;/sub&gt;</td>
<td>$1,000,000</td>
<td>$1,000,000</td>
</tr>
<tr>
<td>Annual Cost, G</td>
<td>$50,000</td>
<td>$500,000</td>
</tr>
<tr>
<td>Annual Benefits</td>
<td>$200,000</td>
<td>$700,000</td>
</tr>
<tr>
<td>Annual Return</td>
<td>$150,000</td>
<td>$200,000</td>
</tr>
<tr>
<td>Useful Life</td>
<td>10 Years</td>
<td>10 Years</td>
</tr>
<tr>
<td>Total Benefits</td>
<td>$2,000,000</td>
<td>$7,000,000</td>
</tr>
<tr>
<td>Total Cost, Q&lt;sub&gt;k&lt;/sub&gt; + C&lt;sub&gt;r&lt;/sub&gt;</td>
<td>$1,500,000</td>
<td>$6,000,000</td>
</tr>
<tr>
<td>Benefit/Cost Ratio</td>
<td>1.34 better than</td>
<td>1.17</td>
</tr>
<tr>
<td>Annual Return</td>
<td>15% worse than</td>
<td>20%</td>
</tr>
<tr>
<td>Net Value Present</td>
<td>$500,000 worse than</td>
<td>$1,000,000</td>
</tr>
</tbody>
</table>

### The Ranking of Projects by Benefit-Cost Criterion Can Depend on DR

<table>
<thead>
<tr>
<th>Project</th>
<th>Investment C&lt;sub&gt;k&lt;/sub&gt;, $</th>
<th>Annual Benefits R, $</th>
<th>Project Life N Years</th>
<th>Benefit - cost at discount rate of 3%</th>
<th>Benefit - cost at discount rate of 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1000</td>
<td>200</td>
<td>10</td>
<td>1.73</td>
<td>1.23</td>
</tr>
<tr>
<td>B</td>
<td>1000</td>
<td>125</td>
<td>20</td>
<td>1.86 (best)</td>
<td>1.05 (best)</td>
</tr>
</tbody>
</table>

Dynamic Strategic Planning Richard de Neufville, Joel Clark, and Frank R. Field
Massachusetts Institute of Technology Economic Evaluation Slide 7 of 17
Internal Rate of Return

- IRR = r such that NPB = 0
- Objective:
  - Maximize IRR
- Advantages:
  - No need to choose r
  - Manipulation by r impossible
- Disadvantages:
  - Calculations complex -- but easy in spreadsheet
  - Ambiguous
- Note: ranking by IRR and B/C ratio may differ

Graphical Determination of IRR
(Data from example in Session 4)
Spreadsheet Determination of IRR
(Data from Example in Session 4)

<table>
<thead>
<tr>
<th>Year</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment</td>
<td>15</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Net Income</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Cash Flow</td>
<td>-15</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>5</td>
<td>-2</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>IRR</td>
<td>13.33%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Formula: IRR(b9:k9)

Projects can Lead to Ambiguous Solutions for the Internal Rate of Return

<table>
<thead>
<tr>
<th>Project</th>
<th>Investment, $</th>
<th>Annual Benefits, $</th>
<th>Project Life, Years</th>
<th>Closure cost at Year N-1, $</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>C_k</td>
<td>R</td>
<td>N</td>
<td>C_C &gt; RN - C_k</td>
</tr>
<tr>
<td>Q</td>
<td>200</td>
<td>100</td>
<td>5</td>
<td>310</td>
</tr>
</tbody>
</table>

Cash flow

NPV

Dynamic Strategic Planning
Richard de Neufville, Joel Clark, and Frank R. Field
Massachusetts Institute of Technology
Economic Evaluation
Slide 11 of 17
### Ranking of Projects by Internal Rate of Return and Benefit-Cost Ratio Can Differ

<table>
<thead>
<tr>
<th>Project</th>
<th>Investment, C, $</th>
<th>Annual Benefits, R, $</th>
<th>Project Life, N Years</th>
<th>Benefit - Internal Rate of Return, 0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1000</td>
<td>200</td>
<td>10</td>
<td>1.71</td>
</tr>
<tr>
<td>B</td>
<td>1000</td>
<td>125</td>
<td>20</td>
<td>1.86</td>
</tr>
</tbody>
</table>

**Pay-Back Period**

- **PBP = Cost/Annual Benefits**
  - Note: undiscounted
- **Objective:**
  - To minimize
- **Advantages:**
  - Really simple
  - No choice of \( r \)
- **Disadvantages**
  - Difficult to rank correctly projects with different useful lives or uneven cash flows
### Evaluation of Projects V and W

<table>
<thead>
<tr>
<th>Project</th>
<th>Investment, Cs, $</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Payback Period Years</th>
<th>NPV at 10%</th>
<th>IRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>2000</td>
<td>1000</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td>487</td>
<td>23.4%</td>
</tr>
<tr>
<td>W</td>
<td>2000</td>
<td>800</td>
<td>800</td>
<td>800</td>
<td>800</td>
<td>800</td>
<td>2.5</td>
<td></td>
<td>1484</td>
<td>32.7%</td>
</tr>
</tbody>
</table>

### Cost- Effectiveness Ratio

- **Ratio = (Units of Benefit) / Cost**
  - example: “lives saved/million dollars”
- **Objective: To Maximize**
- **Advantage: Avoids problem of trying to assign $ values to “intangibles” such as a “life”, “ton of pollution”, etc.**
- **Disadvantage: No sense for minimum standard or limits**
Recommended Procedure (if you have discretion to choose)

- Examine Nature of projects
  - Easy to put into $ terms? Steady cash flows? or with closure costs? Or various project lifetimes?
  - An operating or a straight capital investment?

- Choose Method Accordingly

- No method is perfect -- ultimately a judgment

- Current “best practice” uses several criteria; uses judgment to decide on project
## A Note for Exercise 1:
### Average Costs of Production vary

<table>
<thead>
<tr>
<th></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>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cost</td>
<td>5.2</td>
<td>5.4</td>
<td>5.6</td>
<td>5.8</td>
<td>6.0</td>
<td>6.2</td>
<td>6.4</td>
<td>6.6</td>
<td>6.8</td>
<td>7.0</td>
</tr>
<tr>
<td>Average Cost</td>
<td>5.2</td>
<td>2.7</td>
<td>1.867</td>
<td>1.45</td>
<td>1.2</td>
<td>1.03</td>
<td>0.914</td>
<td>0.825</td>
<td>0.756</td>
<td>0.7</td>
</tr>
</tbody>
</table>

- Capital cost = 5
- Labor and Materials = 0.2/part
- Maximum Capacity = 10

---

Dynamic Strategic Planning  
Massachusetts Institute of Technology

Richard de Neufville, Joel Clark, and Frank R. Field  
Economic Evaluation  
Slide 19 of 17