Engineering Economy
Chapter 9
Other Analysis Techniques

1. Benefit-Cost Ratio Analysis
   • In the previous chapters, we determined that an alternative is acceptable if its NPW (i.e., $PW_{Ben} - PW_{Cost}$ at the MARR) is $\geq 0$ (which also means that its $EUAB - EUAC \geq 0$).

   • Likewise, an alternative is acceptable if its ___________ (which also means that its ___________).

   • Civil Engineers most often see benefit-Cost Ratio Analysis because of its high utilization for public projects.

   • If the B/C ratio equals 1.0, the alternative earns an interest rate _______ to the_______.

   • A B/C ratio greater than 1.0 indicates that the alternative earns an interest rate that is _______ than the MARR.

   • A B/C ratio less than 1.0 indicates that the alternative earns an interest rate that is _______ than the MARR.

2. Making a Decision: One Alternative
   • If the B/C ratio $> 1.0$, the alternative is acceptable.

   • If the B/C ratio $< 1.0$ and do-nothing is an option, do-nothing should be chosen.

   • If the B/C ratio $< 1.0$ and do-nothing is NOT an option, then the alternative is to be chosen because it is the only available alternative.

3. Incremental B/C ($\Delta B/\Delta C$) Analysis
   • Incremental B/C ratio analysis must be used when choosing ________________________.

   • The Incremental B/C ratio is the ratio that is found on the ___________________________ ___________________________.
• While you may calculate the alternatives’ benefits and costs using either Present Worth Equations or Annual Cash Flow Equations, it may be more convenient to utilize Annual Cash Flow Equations. This is especially true when the alternatives’ ________________________.

• The difference is calculated by subtracting the ____________________________________ (i.e., high cost alternative – low cost alternative)

• The high/low cost alternative is based on the higher/lower EUAC. If you were to use PW\textsubscript{Ben} and PW\textsubscript{Cost} calculations, then use PW\textsubscript{Cost} to determine the higher/lower cost alternative.

• For example:

\[ \Delta B/\Delta C = (EUAB\text{highcost} – EUAB\text{lowcost})/(EUAC\text{highcost} – EUAC\text{lowcost}) \]

4. Whether to use PW Equations or Annual Cash Flow Equations

• If you decide to use PW Equations, then you MUST utilize a __________________________ in your calculations. This is based on the reasons provided in chapter 5.

• If you decide to use Annual Cash Flow Equations, then you DO NOT need to utilize a Least Common Multiple. This is based on the reasons provided in chapter 6.

5. ****Recommendation****

• Based on the previous note, it is definitely to your advantage to use Annual Cash Flow Equations.

• Therefore, it is highly recommended that you use Annual Cash Flow Equations.

6. Accounting for Salvage Values

• As discussed in chapter 6, salvage values are considered a __________________________ (i.e., a negative cost).

• Therefore, salvage values belong in the _________________ of the B/C (and \( \Delta B/\Delta C \)) ratio.
7. Making a Decision: Two Alternatives

• If $\frac{\Delta B}{\Delta C} \geq 1$, choose the ___________________________.

• If $\frac{\Delta B}{\Delta C} < 1$, choose the ____________________________.

• As in $\Delta ROR$ analysis, the above decision rules assume that at least one of the alternatives is acceptable based on a given MARR.

8. An Example

• Utilize Benefit-Cost Ratio Analysis to decide which, if any, of the following alternatives should be accepted.

• MARR = 10%.

<table>
<thead>
<tr>
<th></th>
<th>TOPS Corp.</th>
<th>Quality, LLC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Cost</td>
<td>10,000</td>
<td>$8,000</td>
</tr>
<tr>
<td>Benefits</td>
<td>$4,000/yr</td>
<td>$3,500 in year 1, growing by $500 each year after</td>
</tr>
<tr>
<td>Costs</td>
<td>$1,000/yr</td>
<td>$1,500/yr</td>
</tr>
<tr>
<td>Salvage</td>
<td>$1,000</td>
<td>0</td>
</tr>
<tr>
<td>Life (yrs)</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

• The first thing we need to do is calculate the benefits and costs for both alternatives (using either annual cash flow equations or present worth equations).

• As mentioned earlier, it is to your advantage to use *annual cash flow equations*.

• Therefore, let’s use annual cash flow equations.
EUAB = $4,000

EUAC = 10000(A/P, 10%, 5) + 1000 – 1000(A/F, 10%, 5)

= 10000(.2638) + 1000 – 1000(.1638)

= $3,474.20

EUAB /EUAC = 4000 / 3474.20

= 1.15

The “do-nothing” option is eliminated because we know that at least one of the alternatives has a B/C ratio ≥ 1.0.
9. Another Example

- Given the following two alternatives and Benefit-Cost Ratio Analysis, determine which, if any, should be chosen.
- MARR = 10%

<table>
<thead>
<tr>
<th></th>
<th>Alternative #1</th>
<th>Alternative #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Cost</td>
<td>$35,000</td>
<td>$15,000</td>
</tr>
<tr>
<td>Benefits</td>
<td>$8,000/yr</td>
<td>$7,000 in years 1 and 2; $5,000 in years 3, 4, and 5</td>
</tr>
<tr>
<td>Costs</td>
<td>$1,000/yr</td>
<td>$1,200/yr</td>
</tr>
<tr>
<td>Salvage</td>
<td>$0</td>
<td>$1,000</td>
</tr>
<tr>
<td>Life (yrs)</td>
<td>8</td>
<td>4</td>
</tr>
</tbody>
</table>

CFD for Alternative #1
CFD for Alternative #2

![Bar Chart]

- Alternative 1: 7000
- Alternative 2: 7000
- Alternative 3: 5000
- Alternative 4: 6000

Cumulative: 15000
10. Payback Period Analysis
   • The payback period is the period of time required for__________________________.

11. Example of Payback Period

<table>
<thead>
<tr>
<th>EOY</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Cash Flow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

• Since benefits are uniform, the payback calculation is simple.

• Payback Period = (investment)/(equal annual benefit)

• Payback Period =

12a. Example of Payback Period

<table>
<thead>
<tr>
<th>EOY</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Cash Flow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

• Since benefits are not uniform, the payback calculation is just a little bit more difficult.

• Payback Period =

• Payback Period =
12b. The Previous Calculations are Based On:

<table>
<thead>
<tr>
<th>EOY</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Cash Flow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Cumulative&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Notice that Investments = Benefits between the ________________________.
- Therefore, in order to determine the payback period, ________________________.
- Payback Period =

=  

13. Another Example of Payback Period

<table>
<thead>
<tr>
<th>EOY</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Cash Flow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Cumulative&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Payback Period =

- Payback Period =
14. Problems with Payback Period Analysis

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- 
- 

15. Example of Problems with Simple Payback Period Analysis

<table>
<thead>
<tr>
<th>EOY</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Cash Flow</td>
<td>-1000</td>
<td>1000</td>
<td>500</td>
<td>250</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>&quot;Cumulative&quot;</td>
<td>-1000</td>
<td>0</td>
<td>500</td>
<td>750</td>
<td>850</td>
<td>900</td>
</tr>
</tbody>
</table>

- Payback Period =

<table>
<thead>
<tr>
<th>EOY</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Cash Flow</td>
<td>-1000</td>
<td>500</td>
<td>500</td>
<td>1000</td>
<td>2000</td>
<td>2000</td>
</tr>
<tr>
<td>&quot;Cumulative&quot;</td>
<td>-1000</td>
<td>-500</td>
<td>0</td>
<td>1000</td>
<td>3000</td>
<td>5000</td>
</tr>
</tbody>
</table>

- Payback Period =

- Alternative #1 has the quickest payback period (and a great ROR!).

- However, it is quite obvious that Alternative #2 is the best economic choice for any reasonable MARR.

- Therefore, a decision based solely on payback analysis could lead to wrong and costly decisions.
16. Another Example: Problem 9-50 (parts b, c, and d)