Retirement/Replacement Problems

March 15, 2004
Why consider replacing a physical asset?

• Physical impairment
• Economic obsolescence
Determining optimum economic lifetime under steady-state conditions

\[ I_0 = \$10,000 \]
\[ M_n = 2000 + (n-1) \times 1000 \]
\[ R = 8260 \]
\[ MARR = 20\% \]

<table>
<thead>
<tr>
<th>N</th>
<th>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>
</tr>
</thead>
<tbody>
<tr>
<td>( I_N )</td>
<td>6400</td>
<td>3200</td>
<td>1600</td>
<td>800</td>
<td>400</td>
<td>200</td>
<td>100</td>
<td>50</td>
<td>25</td>
</tr>
</tbody>
</table>

(Ignore effect of taxes.)
Optimum economic life calculation (contd.)

Two alternative decision criteria for choosing optimal retirement age:

(1) Minimize levelized annual cost, LAC

\[
LAC = I_0 \left( \frac{A}{P, 20\%, N} \right) + I_N \left( \frac{A}{F, 20\%, N} \right) + 2000 + 1000 \left( \frac{A}{G, 20\%, N} \right)
\]

(2) Minimize present worth of net receipts, PW

\[
PW = -I_0 + I_N \left( \frac{P}{F, 20\%, N} \right) + R \left( \frac{P}{A, 20\%, N} \right) + 2000 \left( \frac{P}{A, 20\%, N} \right) + 1000 \left( \frac{P}{G, N} \right)
\]

<table>
<thead>
<tr>
<th>N</th>
<th>LAC</th>
<th>PW (net receipts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10800</td>
<td>-2118</td>
</tr>
<tr>
<td>2</td>
<td>8273</td>
<td>-18</td>
</tr>
<tr>
<td>3</td>
<td>7405</td>
<td>1795</td>
</tr>
<tr>
<td>4</td>
<td>7062</td>
<td>3101</td>
</tr>
<tr>
<td>5</td>
<td><strong>6958</strong></td>
<td>3898</td>
</tr>
<tr>
<td>6</td>
<td>6976</td>
<td>4273</td>
</tr>
<tr>
<td>7</td>
<td>7060</td>
<td><strong>4326</strong></td>
</tr>
<tr>
<td>8</td>
<td>7181</td>
<td>4143</td>
</tr>
</tbody>
</table>

**Question:** Which one of the two criteria gives the correct result?
Retirement of asset in a changing environment

Example:

**Defender**
- Bought 3 yrs ago for $1700
- Expected life at that time = 10 yrs
- NSV=0
- Levelized operating cost for remaining 7 years = $281/yr
- Market value today = $1000

**Challenger**
- Purchase price = $2000
- Economic lifetime = 10 years
- NSV = $600
- Annual operating cost = $100/yr

Assume:
- Weighted average after tax cost of capital = 10%
- Marginal tax rate = 50%

**Question:** Should we replace the defender with the challenger?
Retirement of asset in changing environment (contd.)

- Two common mistakes
  - #1: Comparing projects over different time horizons
  - #2: Allowing ‘sunk costs’ to influence the investment decision
Asset retirement decision: It is helpful to adopt the perspective of an ‘outsider’

The outsider can choose either to buy the challenger at its market price, or the defender at its market price.
The outsider’s choices:
Choice #1 -- Buy the defender for $1000

Suppose the defender today is expected to have the following economic characteristics over the next several years:

<table>
<thead>
<tr>
<th>Years to retirement</th>
<th>Salvage Value ($N)</th>
<th>Operating Cost (levelized)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>600</td>
<td>220</td>
</tr>
<tr>
<td>2</td>
<td>500</td>
<td>230</td>
</tr>
<tr>
<td>3</td>
<td>400</td>
<td>240</td>
</tr>
<tr>
<td>4</td>
<td>300</td>
<td>250</td>
</tr>
<tr>
<td>5</td>
<td>200</td>
<td>260</td>
</tr>
<tr>
<td>6</td>
<td>100</td>
<td>270</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>280</td>
</tr>
</tbody>
</table>

Find the lifetime of the defender for which the **levelized annual cost** is minimized

\[ I_N \]
The outsider’s choices:  
Choice #1 -- Buy the defender for $1000 (contd.)

Find the lifetime of the defender for which the levelized annual cost is minimized

\[
\text{LAC defender} = -1000 \left( \frac{A}{P}, x, N \right) + I_n \left( \frac{A}{F}, x, N \right) + \tau \left( \frac{1000 - I_n}{N} \right) - M_L (1 - \tau)
\]

<table>
<thead>
<tr>
<th>(N)</th>
<th>(\text{LAC}_{\text{defender}})</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>-301</td>
</tr>
<tr>
<td>4</td>
<td>-288</td>
</tr>
<tr>
<td>5</td>
<td><strong>-281</strong></td>
</tr>
<tr>
<td>6</td>
<td>-287</td>
</tr>
</tbody>
</table>

3/15/04  
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The outsider’s choices:  
Choice #2 -- Buy the challenger for $2000

Modified cash flow diagram:

\[
LAC_{challenger} = -2000(A/P,10\%,10) + 600(A/F,10\%,10) - (1 - \tau)100 + \tau \left( \frac{2000 - 600}{10} \right)
\]

= -$268

Thus we might conclude that the challenger is the preferred choice.

**BUT:** This would not be correct because we have different time horizons in the two cases.
The outsider’s choice (contd.)

• Approaches to achieving consistency in time horizons:
  – Sell the challenger at 5 years
  – Modify the defender scenario by replacing the defender after 5 years with another challenger and selling the latter off after another 5 years (i.e. at the end of year 10)
  – Assume that the defender could be replaced by another 5 year replica of itself