Net Present Worth Measure

- Principle: Compute the equivalent net surplus at \( n = 0 \) for a given interest rate of \( i \).
- Decision Rule: Accept the project if the net surplus is positive.
Example 5.3 - Tiger Machine Tool Company

\[ PW(15\%)_{\text{inflow}} = 24,400 \left( \frac{1}{1+0.15} \right)^1 + 27,340 \left( \frac{1}{1+0.15} \right)^2 + 55,760 \left( \frac{1}{1+0.15} \right)^3 \]
\[ = 78,553 \]

\[ PW(15\%)_{\text{outflow}} = 75,000 \]

\[ PW(15\%) = 78,553 - 75,000 \]
\[ = 3,553 > 0, \text{ Accept} \]

Excel Solution

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Period</td>
<td>Cash Flow</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>($75,000)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>$24,400</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>$27,340</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>$55,760</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>PW(15%)</td>
<td>$3,553.46</td>
<td>=NPV(15%,B3:B5)+B2</td>
</tr>
</tbody>
</table>
**Present Worth Amounts at Varying Interest Rates**

<table>
<thead>
<tr>
<th>$i$ (%)</th>
<th>PW($i$)</th>
<th>$i'(%)$</th>
<th>PW($i'$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$32,500</td>
<td>20</td>
<td>-3,412</td>
</tr>
<tr>
<td>2</td>
<td>27,743</td>
<td>22</td>
<td>-5,924</td>
</tr>
<tr>
<td>4</td>
<td>23,309</td>
<td>24</td>
<td>-8,296</td>
</tr>
<tr>
<td>6</td>
<td>19,169</td>
<td>26</td>
<td>-10,539</td>
</tr>
<tr>
<td>8</td>
<td>15,296</td>
<td>28</td>
<td>-12,662</td>
</tr>
<tr>
<td>10</td>
<td>11,670</td>
<td>30</td>
<td>-14,673</td>
</tr>
<tr>
<td>12</td>
<td>8,270</td>
<td>32</td>
<td>-16,580</td>
</tr>
<tr>
<td>14</td>
<td>5,077</td>
<td>34</td>
<td>-18,360</td>
</tr>
<tr>
<td>16</td>
<td>2,076</td>
<td>36</td>
<td>-20,110</td>
</tr>
<tr>
<td>17.45*</td>
<td>0</td>
<td>38</td>
<td>-21,745</td>
</tr>
<tr>
<td>18</td>
<td>-751</td>
<td>40</td>
<td>-23,302</td>
</tr>
</tbody>
</table>

*Break even interest rate

**Present Worth Profile**

![Present Worth Profile](image-url)
Future Worth Criterion

- **Given**: Cash flows and MARR ($i$)
- **Find**: The net equivalent worth at the end of project life

$$
\begin{align*}
FW(15\%)_{\text{inflow}} &= $24,400(F/P,15\%,2) + $27,340(F/P,15\%,1) + $55,760(F/P,15\%,0) \\
&= $119,470 \\
FW(15\%)_{\text{outflow}} &= $75,000(F/P,15\%,3) \\
&= $114,066 \\
FW(15\%) &= $119,470 - $114,066 \\
&= $5,404 > 0, \text{ Accept}
\end{align*}
$$
Excel Solution

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Period</td>
<td>Cash Flow</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>($75,000)</td>
<td>$5,404.38</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>$24,400</td>
<td>$3553.46</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>$27,340</td>
<td>$5,404.38</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>$55,760</td>
<td>$5,404.38</td>
</tr>
<tr>
<td>6</td>
<td>PW(15%)</td>
<td>$3553.46</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>FW(15%)</td>
<td>$5,404.38</td>
<td></td>
</tr>
</tbody>
</table>

= FV(15%, 3, 0, -B6)

How To Use Cash Flow Analyzer

Cash Flow Input Fields

Output or Analysis results

Graphical Plots
Solving Example 5.3 with Cash Flow Analyzer

Project Cash Flows

Net Present Worth

Net Future Worth

Payback period

Obtaining a NPW Plot

NPW plot Between 0% and 100%

Specify the Range of Interest Rate to plot
Can you explain what $3,553 really means?

1. Project Balance Concept
2. Investment Pool Concept

**Project Balance Concept**

<table>
<thead>
<tr>
<th>$N$</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Beginning Balance</strong></td>
<td>-$75,000</td>
<td>-$61,850</td>
<td>-$43,788</td>
<td></td>
</tr>
<tr>
<td><strong>Interest</strong></td>
<td>-$11,250</td>
<td>-$9,278</td>
<td>-$6,568</td>
<td></td>
</tr>
<tr>
<td><strong>Payment</strong></td>
<td>-$75,000</td>
<td>+$24,400</td>
<td>+$27,340</td>
<td>+$55,760</td>
</tr>
<tr>
<td><strong>Project Balance</strong></td>
<td>-$75,000</td>
<td>-$61,850</td>
<td>-$43,788</td>
<td>+$5,404</td>
</tr>
</tbody>
</table>

Net future worth, FW(15%) = PW(15%) = $5,404 (P/F, 15%, 3) = $3,553
Investment Pool Concept

- Suppose the company has $75,000. It has two options. (1) Take the money out and invest it in the project or (2) leave the money in the company. Let’s see what the consequences are for each option.
Meaning of Net Present Worth

$75,000

How much would you have if the investment is made?

$24,400\left(\frac{F}{P},15\%,2\right) = $32,269
$27,340\left(\frac{F}{P},15\%,1\right) = $31,441
$55,760\left(\frac{F}{P},15\%,0\right) = $55,760

$119,470

How much would you have if the investment was not made?

$75,000\left(\frac{F}{P},15\%,3\right) = $114,066

What is the net gain from the investment?

$119,470 - $114,066 = $5,404

PW(15\%) = $5,404\left(\frac{P}{F},15\%,3\right) = $3,553

What Factors Should the Company Consider in Selecting a MARR in Project Evaluation?

- Risk-free return
- Inflation factor
- Risk premiums
**Guideline for Selecting a MARR**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Real Return</strong></td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td><strong>Inflation</strong></td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td><strong>Risk premium</strong></td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td><strong>Total expected return</strong></td>
<td>6%</td>
<td></td>
</tr>
</tbody>
</table>

U.S. Treasury Bills

Risk-free real return

Inflation

Risk premium

Very safe

Very risky

Amazon.com

**Capitalized Equivalent Worth**

- **Principle**: PW for a project with an annual receipt of \( A \) over infinite service life

- **Equation**:
  \[
  CE(i) = A(P/A, i, \infty) = A/i
  \]

- **Diagram**:
  \[
  \begin{align*}
  &\text{0} \quad \text{\ldots} \quad A \\
  &P = CE(i)
  \end{align*}
  \]
Practice Problem

Given: $i = 10\%$, $N = \infty$
Find: $P$ or CE (10%)

Solution

$$CE(10\%) = \frac{\$1,000}{0.10} + \frac{\$1,000}{0.10} (P/F,10\%,10)$$
$$= \$10,000(1 + 0.3855)$$
$$= \$13,855$$
A Bridge Construction Project

- Construction cost = $2,000,000
- Annual Maintenance cost = $50,000
- Renovation cost = $500,000 every 15 years
- Planning horizon = infinite period
- Interest rate = 5%

<table>
<thead>
<tr>
<th>Years</th>
<th>0</th>
<th>15</th>
<th>30</th>
<th>45</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs</td>
<td>$2,000,000</td>
<td>$500,000</td>
<td>$500,000</td>
<td>$500,000</td>
<td>$500,000</td>
</tr>
</tbody>
</table>
Solution:

- **Construction Cost**
  \[ P_1 = $2,000,000 \]

- **Maintenance Costs**
  \[ P_2 = \frac{$50,000}{0.05} = $1,000,000 \]

- **Renovation Costs**
  \[ P_3 = $500,000(P/F, 5\%, 15) + $500,000(P/F, 5\%, 30) + $500,000(P/F, 5\%, 45) + $500,000(P/F, 5\%, 60) \]
  \[ = \frac{$500,000(A/F, 5\%, 15)}{0.05} \]
  \[ = $463,423 \]

- **Total Present Worth**
  \[ P = P_1 + P_2 + P_3 = $3,463,423 \]

Alternate way to calculate \( P_3 \)

- **Concept:** Find the effective interest rate per payment period

  
<table>
<thead>
<tr>
<th>0</th>
<th>15</th>
<th>30</th>
<th>45</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>$500,000</td>
<td>$500,000</td>
<td>$500,000</td>
<td>$500,000</td>
<td></td>
</tr>
</tbody>
</table>

- **Effective interest rate for a 15-year cycle**
  \[ i = (1 + 0.05)^{15} - 1 = 107.893\% \]

- **Capitalized equivalent worth**
  \[ P_3 = \frac{$500,000}{1.07893} \]
  \[ = $463,423 \]
Practice Problem

- Want to purchase an electrical motor rated at 15HP for $1,000.
- The service life of the motor is known to be 10 years with negligible salvage value.
- Its full load efficiency is 85%.
- The cost of energy is $0.08 per kwh.
- The intended use of the motor is 4,000 hours per year.
- Find the total cost of owning and operating the motor at 10% interest.

Solution

- $1 HP = 0.7457 kW$
- $15 HP = 15 \times 0.7457 = 11.1855 kW$
- Required input power at 85% efficiency rating: $\frac{11.1855 kW}{0.85} = 13.1594 kW$
- Required total kWh per year $13.1594 kW \times 4,000\text{ hours/year} = 52,638\text{ kWh/yr}$
- Total annual energy cost to operate the motor $52,638\text{ kWh} \times $0.08/kWh = $4,211/yr$
- The total cost of owning and operating the motor $PW\ (10\%) = $1,000 + $4,211(P/A,10\%,10) = $26,875$
$PW(10\%) = $1,000 + $4,211(P/A, 10\%, 10) = $26,875