WHY NET PRESENT VALUE LEADS TO BETTER INVESTMENT DECISIONS THAN OTHER CRITERIA

Chapter 5

THE NET PRESENT VALUE RULE

\[ NPV = C_0 + \frac{C_1}{1 + r} + \frac{C_2}{(1 + r)^2} + \ldots \]

WHERE
\[ C_i = \text{Change in cash flow in period } i \text{ due to project}, \]
\[ r = \text{discount rate that reflects time value and risk of project} \]

**RULE:**
ACCEPT PROJECT if \( NPV \geq 0 \) otherwise, REJECT.
3 COMPETITORS OF NPV

➤ Payback

➤ Average Return on Book

➤ Internal Rate of Return

PAYBACK

➤ The PAYBACK PERIOD is the number of years before cumulated forecasted cash flow equals initial investment.

EXAMPLE:

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Payback period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proj. A</td>
<td>-2</td>
<td>+2</td>
<td></td>
<td>1 year</td>
</tr>
<tr>
<td>Proj. B</td>
<td>-2</td>
<td>+1</td>
<td>+1</td>
<td>+5</td>
</tr>
</tbody>
</table>

initial outlay
Let’s calculate the net present value of these two projects assuming a discount rate of 10%

**EXAMPLE:**

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Payback</th>
<th>NPV At 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-2</td>
<td>+2</td>
<td></td>
<td></td>
<td>1</td>
<td>-0.20</td>
</tr>
<tr>
<td>B</td>
<td>-2</td>
<td>+1</td>
<td>+1</td>
<td>+5</td>
<td>2</td>
<td>3.50</td>
</tr>
</tbody>
</table>

The problem: Better project has a longer payback.

**Problems with PAYBACK**

1. **NO DISCOUNTING**

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
</table>
   Project A | -100 | 0 | 0 | 100 |
   Project B | -100 | 99 | 0 | 1 |

   Payback rule implies projects A & B are equal. Which would you rather have?

2. **IGNORES CASH FLOWS AFTER PAYBACK PERIOD**

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
</table>
   Project A | -100 | 0 | 0 | 100 | 10,000 |
   Project B | -100 | 50 | 50 | 10 | 10 |

   Payback rule implies project B is better.
Problems (continued)

3. PAYBACK IGNORES SCALE

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project A</td>
<td>-10</td>
<td>5</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Project B</td>
<td>-1000</td>
<td>500</td>
<td>500</td>
<td>10,000</td>
</tr>
</tbody>
</table>

Payback implies that A and B are the same
...but, if mutually exclusive Project B is better.

4. THERE IS NO NATURAL CUTOFF POINT!

AVERAGE RETURN ON BOOK

\[
\text{Average Return on Book} = \frac{\text{Average Annual Income}}{\text{Average Annual Investment}}
\]

**EXAMPLE:** Investment in $9,000 3-yr. project

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Book</td>
<td>9</td>
<td>6</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Gross Profit (= cash flow)</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Depreciation (non-cash expense)</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Net Profit</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Average Return on Book = \(\frac{2}{4.5} = 44\%\)
PROBLEMS WITH AVERAGE RETURN ON BOOK

1. IGNORES TIMING:

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Book</td>
<td>9</td>
<td>6</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Gross Profit</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>(= cash flow)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depreciation</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>(non-cash expense)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Profit</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Average Return on Book = \( \frac{2}{4.5} \) = 44%

Same average return on book, but cash flows come later and NPV IS LESS

Problems (continued)

2. BASED ON ACCOUNTING INCOME, NOT CASH FLOWS

➤ Affected by depreciation method

3. NO LOGICAL BENCHMARK

➤ RATE OF RETURN ON EXISTING PROJECTS NOT NECESSARILY A GOOD YARDSTICK.
INTERNAL RATE OF RETURN RULE (IRR)

The IRR is the discount rate that sets NPV = 0.

\[
NPV = C_0 + \frac{C_1}{1 + IR\ R} + \frac{C_2}{(1 + IR\ R)^2} + \ldots = 0
\]

EXAMPLE: \( C_0 = -1000 \); \( C_1 = 1100 \)

\[
NPV = -1000 + \frac{1100}{1 + IR\ R} = 0 \quad \rightarrow \quad IRR = .10 \text{ or } 10\%
\]

RULE:

ACCEPT PROJECT IF

\( IRR \geq \text{opportunity cost of capital} \)

Otherwise, REJECT.

INTERNAL RATE OF RETURN (IRR)

To obtain return on a long-lived project

find the discount rate at which NPV = 0, e.g.

\[
NPV = 4 + \frac{2}{1 + IR\ R} + \frac{4}{(1 + IR\ R)^2} = 0
\]

\[
NPV = 4 + \frac{2}{1.28} + \frac{4}{(1.28)^2} = 0
\]

Find by Trial and Error . . .

OR

by computer or calculator.
IRR (continued)

NOTE: IRR and NPV give the same result . . .

\[ \text{IRR} = 28\% \]

Discount rate

. . . BUT BEWARE

PROBLEMS WITH IRR

1. LENDING OR BORROWING?

<table>
<thead>
<tr>
<th>Project</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>IRR</th>
<th>NPV @ 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project A</td>
<td>-100</td>
<td>60</td>
<td>72</td>
<td>20%</td>
<td>$14.05</td>
</tr>
<tr>
<td>Project B</td>
<td>100</td>
<td>-60</td>
<td>-72</td>
<td>20%</td>
<td>-$14.05</td>
</tr>
</tbody>
</table>
PROBLEMS WITH IRR (continued)

2. MULTIPLE ROOTS

<table>
<thead>
<tr>
<th>Discount Rate</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-72,727</td>
<td>170,909</td>
<td>-100,000</td>
</tr>
</tbody>
</table>

NOTE: NPV at 10% is negative.

PROBLEMS WITH IRR (continued)

3. NO ROOTS

<table>
<thead>
<tr>
<th>Discount Rate</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>-2</td>
<td>2</td>
</tr>
</tbody>
</table>

NPV

Discount Rate

.10

.25

NOTE: NPV at 10% is negative.
MORE PROBLEMS WITH IRR

4. IRR IS SCALE FREE

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>IRR</th>
<th>NPV @ 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project A</td>
<td>-100</td>
<td>150</td>
<td>50%</td>
<td>$0.36</td>
</tr>
<tr>
<td>Project B</td>
<td>-1000</td>
<td>1200</td>
<td>20%</td>
<td>$91.00</td>
</tr>
</tbody>
</table>

For independent projects this is not a problem

TAKE BOTH.

But obviously a problem if projects are mutually exclusive.

MORE PROBLEMS WITH IRR (continued)

5. IRR ASSUMES A FLAT TERM STRUCTURE

i.e., \( r_1 = r_2 = \ldots = r \)

Not a problem for NPV since

\[
NPV = C_0 + \frac{C_1}{(1 + r_1)} + \frac{C_2}{(1 + r_2)^2} + \frac{C_3}{(1 + r_3)^3} + \ldots = 0
\]

The problem is that it is not clear which \( r \) we should compare IRR with.
VERDICT ON IRR

Gives the same result as NPV if:

1. Flat Term Structure

2. Conventional Cash Flows
   [ i.e., outflow followed by inflows.]

3. Independent Projects

Otherwise may lead to incorrect decision.