Chapter 10

The Basics of Capital Budgeting: Evaluating Cash Flows

Topics
- Overview and “vocabulary”
- Methods
  - Payback, discounted payback
  - NPV
  - IRR, MIRR
  - Profitability Index
- Unequal lives
- Economic life

What is capital budgeting?
- Analysis of potential projects.
- Long-term decisions; involve large expenditures.
- Very important to firm’s future.

Steps in Capital Budgeting
- Estimate cash flows (inflows & outflows).
- Assess risk of cash flows.
- Determine $r = \text{WACC}$ for project.
- Evaluate cash flows.

Independent versus Mutually Exclusive Projects
- Projects are:
  - independent, if the cash flows of one are unaffected by the acceptance of the other.
  - mutually exclusive, if the cash flows of one can be adversely impacted by the acceptance of the other.

What is the payback period?
- The number of years required to recover a project’s cost,
- or how long does it take to get the business’s money back?
Payback for Franchise L
(Long: Most CFs in out years)

<table>
<thead>
<tr>
<th></th>
<th>CFt</th>
<th>Cumulative</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-100</td>
<td>-100</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>-90</td>
</tr>
<tr>
<td>2</td>
<td>60</td>
<td>-30</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>80</td>
<td>50</td>
</tr>
</tbody>
</table>

Payback_L = 2 + 30/80 = 2.375 years

Franchise S (Short: CFs come quickly)

<table>
<thead>
<tr>
<th></th>
<th>CFt</th>
<th>Cumulative</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-100</td>
<td>-100</td>
</tr>
<tr>
<td>1</td>
<td>70</td>
<td>-30</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>40</td>
</tr>
</tbody>
</table>

Payback_S = 1 + 30/50 = 1.6 years

Strengths and Weaknesses of Payback

- **Strengths:**
  - Provides an indication of a project's risk and liquidity.
  - Easy to calculate and understand.

- **Weaknesses:**
  - Ignores the TVM.
  - Ignores CFs occurring after the payback period.

Discounted Payback: Uses discounted rather than raw CFs.

<table>
<thead>
<tr>
<th></th>
<th>CFt</th>
<th>PVCFt</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-100</td>
<td>-100</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>9.09</td>
</tr>
<tr>
<td>2</td>
<td>60</td>
<td>49.59</td>
</tr>
<tr>
<td>3</td>
<td>80</td>
<td>60.11</td>
</tr>
</tbody>
</table>

Cumulative -100 -90.91 -41.32 18.79

Discounted payback = 2 + 41.32/60.11 = 2.7 yrs

Recover invest. + cap. costs in 2.7 yrs.

NPV: Sum of the PVs of all cash flows.

\[
NPV = \sum_{t=0}^{n} \frac{CF_t}{(1 + r)^t} - CF_0.
\]

Cost often is CF_0 and is negative.

NPV = \sum_{t=1}^{n} \frac{CF_t}{(1 + r)^t} - CF_0.

What's Franchise L's NPV?

<table>
<thead>
<tr>
<th></th>
<th>L's CFs:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-100.00</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>60</td>
</tr>
<tr>
<td>3</td>
<td>80</td>
</tr>
</tbody>
</table>

\[
\begin{align*}
9.09 & \quad 49.59 \\
60.11 & \quad 18.79 = NPV_L \\
\end{align*}
\]

NPV_L = $19.98.
Calculator Solution: Enter values in CF0 register for L.

-100 CF0
10 CF1
60 CF2
80 CF3
10 I \( NPV = 18.78 = NPV_L \)

Rationale for the NPV Method

- \( NPV = PV \text{ inflows} - \text{Cost} \)
- This is net gain in wealth, so accept project if \( NPV > 0 \).
- Choose between mutually exclusive projects on basis of higher NPV. Adds most value.

Using NPV method, which franchise(s) should be accepted?

- If Franchise S and L are mutually exclusive, accept S because \( NPV_S > NPV_L \).
- If S & L are independent, accept both; \( NPV > 0 \).

Internal Rate of Return: IRR

IRR is the discount rate that forces \( PV \text{ inflows} = \text{cost} \). This is the same as forcing \( NPV = 0 \).

NPV: Enter \( r \), solve for NPV.

\[
\sum_{t=0}^{n} \frac{CF_t}{(1 + r)^t} = NPV.
\]

IRR: Enter NPV = 0, solve for IRR.

\[
\sum_{t=0}^{n} \frac{CF_t}{(1 + IRR)^t} = 0.
\]

What’s Franchise L’s IRR?

Enter CFs in CFLO, then press IRR: \( IRR_L = 18.13\% \). \( IRR_S = 23.56\% \).
Find IRR if CFs are constant:

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>-100</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
</tbody>
</table>

**INPUTS**

- N
- IRR
- PV
- PMT
- FV

**OUTPUT**

IRR = 9.70%

Or, with CFLO, enter CFs and press IRR = 9.70%.

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### Rationale for the IRR Method

- If IRR > WACC, then the project’s rate of return is greater than its cost—some return is left over to boost stockholders’ returns.

- Example:
  
  WACC = 10%, IRR = 15%.

  So this project adds extra return to shareholders.

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### Decisions on Projects S and L per IRR

- If S and L are independent, accept both: IRR_S > r and IRR_L > r.

- If S and L are mutually exclusive, accept S because IRR_S > IRR_L.

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### Construct NPV Profiles

- Enter CFs in CFLO and find NPV_S and NPV_L at different discount rates:

<table>
<thead>
<tr>
<th>r (%)</th>
<th>NPV_S</th>
<th>NPV_L</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>5</td>
<td>33</td>
<td>29</td>
</tr>
<tr>
<td>10</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>15</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>20</td>
<td>(4)</td>
<td>5</td>
</tr>
</tbody>
</table>

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### NPV Profile

- NPV Profile

  - Crossover Point = 8.7%
  - IRR_S = 23.6%
  - IRR_L = 18.1%

---

### NPV and IRR: No conflict for independent projects.

- IRR > r and NPV > 0 Accept.
- r > IRR and NPV < 0. Reject.
Mutually Exclusive Projects

Mutually Exclusive Projects

To Find the Crossover Rate

r < 8.7: NPV_L > NPV_S, IRR_S > IRR_L
CONFLICT

r > 8.7: NPV_S > NPV_L, IRR_S > IRR_L
NO CONFLICT

Two Reasons NPV Profiles Cross

- Size (scale) differences. Smaller project frees up funds at t = 0 for investment. The higher the opportunity cost, the more valuable these funds, so high r favors small projects.
- Timing differences. Project with faster payback provides more CF in early years for reinvestment. If r is high, early CF especially good, NPV_S > NPV_L.

Reinvestment Rate Assumptions

- NPV assumes reinvest at r (opportunity cost of capital).
- IRR assumes reinvest at IRR.
- Reinvest at opportunity cost, r, is more realistic, so NPV method is best. NPV should be used to choose between mutually exclusive projects.

Modified Internal Rate of Return (MIRR)

- MIRR is the discount rate which causes the PV of a project's terminal value (TV) to equal the PV of costs.
- TV is found by compounding inflows at WACC.
- Thus, MIRR assumes cash inflows are reinvested at WACC.

MIRR for Franchise L: First, find PV and TV (r = 10%)

PV outflows

TV inflows

\[
\begin{array}{c|c|c|c|c}
0 & 10\% & 1 & 10\% & 2 & 10\% & 3 & 10\% \\
\hline
-100.0 & 10.0 & 60.0 & 10\% & 66.0 & 10\% & 12.1 & 10\% \\
\hline
\end{array}
\]
To find TV with 10B: Step 1, find PV of Inflows

- First, enter cash inflows in CFLO register:
  - CF₀ = 0, CF₁ = 10, CF₂ = 60, CF₃ = 80
- Second, enter I = 10.
- Third, find PV of inflows:
  - Press NPV = 118.78

Step 2, find TV of inflows.

- Enter PV = -118.78, N = 3, I = 10, PMT = 0.
- Press FV = 158.10 = FV of inflows.

Step 3, find PV of outflows.

- For this problem, there is only one outflow, CF₀ = -100, so the PV of outflows is -100.
- For other problems there may be negative cash flows for several years, and you must find the present value for all negative cash flows.

Step 4, find “IRR” of TV of inflows and PV of outflows.

- Enter FV = 158.10, PV = -100, PMT = 0, N = 3.
- Press I = 16.50% = MIRR.

Second, find discount rate that equates PV and TV

\[
\text{PV outflows} = \text{TV inflows}
\]

\[
100 = \frac{158.1}{(1+\text{MIRR})^3}
\]

\[
\text{MIRR} = 16.5\%
\]

Why use MIRR versus IRR?

- MIRR correctly assumes reinvestment at opportunity cost = WACC. MIRR also avoids the problem of multiple IRRs.
- Managers like rate of return comparisons, and MIRR is better for this than IRR.
Normal vs. Nonnormal Cash Flows

- Normal Cash Flow Project:
  - Cost (negative CF) followed by a series of positive cash inflows.
  - One change of signs.
- Nonnormal Cash Flow Project:
  - Two or more changes of signs.
  - Most common: Cost (negative CF), then string of positive CFs, then cost to close project.
  - For example, nuclear power plant or strip mine.

Inflow (+) or Outflow (-) in Year

<table>
<thead>
<tr>
<th>Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>N</th>
<th>NN</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>N</td>
<td>NN</td>
</tr>
<tr>
<td>CF</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>CF</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>CF</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>NN</td>
<td>NN</td>
</tr>
</tbody>
</table>

Pavilion Project: NPV and IRR?

Enter CFs in CFLO, enter I = 10.
NPV = -386.78
IRR = ERROR. Why?

Nonnormal CFs--two sign changes, two IRRs.

Logic of Multiple IRRs

- At very low discount rates, the PV of CF₂ is large & negative, so NPV < 0.
- At very high discount rates, the PV of both CF₁ and CF₂ are low, so CF₀ dominates and again NPV < 0.
- In between, the discount rate hits CF₂ harder than CF₁, so NPV > 0.
- Result: 2 IRRs.

Finding Multiple IRRs with Calculator

1. Enter CFs as before.
2. Enter a “guess” as to IRR by storing the guess. Try 10%:
   10 STO
   IRR = 25% = lower IRR
   (See next slide for upper IRR)
Finding Upper IRR with Calculator

Now guess large IRR, say, 200:
200 STO
IRR = 400% = upper IRR

When there are nonnormal CFs and more than one IRR, use MIRR:

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-800,000</td>
<td>5,000,000</td>
<td>-5,000,000</td>
</tr>
</tbody>
</table>

PV outflows @ 10% = -4,932,231.40.
TV inflows @ 10% = 5,500,000.00.
MIRR = 5.6%

Accept Project P?

- NO. Reject because MIRR = 5.6% < r = 10%.
- Also, if MIRR < r, NPV will be negative: NPV = -$386,777.

Profitability Index

- The profitability index (PI) is the present value of future cash flows divided by the initial cost.
- It measures the “bang for the buck.”

Franchise L’s PV of Future Cash Flows

<table>
<thead>
<tr>
<th>Project L:</th>
<th>0</th>
<th>10%</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>60</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>9.09</td>
<td>49.59</td>
<td>60.11</td>
<td>118.79</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Franchise L’s Profitability Index

\[ PL = \frac{PV \text{ future CF}}{Initial \text{ Cost}} = \frac{118.79}{100} \]

\[ PL = 1.1879 \]

\[ PL_g = 1.1998 \]
S and L are mutually exclusive and will be repeated. \( r = 10\% \).

<table>
<thead>
<tr>
<th></th>
<th>S</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>( CF_0 )</td>
<td>-100,000</td>
<td>-100,000</td>
</tr>
<tr>
<td>( CF_1 )</td>
<td>60,000</td>
<td>33,500</td>
</tr>
<tr>
<td>( N_t )</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>( I )</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>( NPV )</td>
<td>4,132</td>
<td>6,190</td>
</tr>
</tbody>
</table>

\( NPV_L > NPV_S \). But is L better?

Put Projects on Common Basis

- Note that Project S could be repeated after 2 years to generate additional profits.
- Use replacement chain to put on common life.
- Note: equivalent annual annuity analysis is alternative method, shown in Tool Kit and Web Extension.

Replace Projects on Common Basis

- Franchise S with Replication:

\[ \text{NPV} = 7,547. \]

Or, use NPVs:

\[ \text{NPV}_S = 3,415 < \text{NPV}_L = 6,190. \]

Suppose cost to repeat S in two years rises to $105,000.

\[ \text{NPV}_S = 3,415 < \text{NPV}_L = 6,190. \]

Now choose L.
Economic Life versus Physical Life

- Consider another project with a 3-year life.
- If terminated prior to Year 3, the machinery will have positive salvage value.
- Should you always operate for the full physical life?
- See next slide for cash flows.

Economic Life versus Physical Life (Continued)

<table>
<thead>
<tr>
<th>Year</th>
<th>CF</th>
<th>Salvage Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>($5000)</td>
<td>$5000</td>
</tr>
<tr>
<td>1</td>
<td>2,100</td>
<td>3,100</td>
</tr>
<tr>
<td>2</td>
<td>2,000</td>
<td>2,000</td>
</tr>
<tr>
<td>3</td>
<td>1,750</td>
<td>0</td>
</tr>
</tbody>
</table>

CFs Under Each Alternative (000s)

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Year 0</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>No termination</td>
<td>(5)</td>
<td>2.1</td>
<td>2</td>
<td>1.75</td>
</tr>
<tr>
<td>Terminate 2 years</td>
<td>(5)</td>
<td>2.1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Terminate 1 year</td>
<td>(5)</td>
<td>5.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NPVs under Alternative Lives (Cost of capital = 10%)

- NPV(3) = -$123.
- NPV(2) = $215.
- NPV(1) = -$273.

Conclusions

- The project is acceptable only if operated for 2 years.
- A project's engineering life does not always equal its economic life.

Choosing the Optimal Capital Budget

- Finance theory says to accept all positive NPV projects.
- Two problems can occur when there is not enough internally generated cash to fund all positive NPV projects:
  - An increasing marginal cost of capital.
  - Capital rationing
Increasing Marginal Cost of Capital

- Externally raised capital can have large flotation costs, which increase the cost of capital.
- Investors often perceive large capital budgets as being risky, which drives up the cost of capital.

(More...)

Capital Rationing

- Capital rationing occurs when a company chooses not to fund all positive NPV projects.
- The company typically sets an upper limit on the total amount of capital expenditures that it will make in the upcoming year.

(More...)

Reason: Companies want to avoid the direct costs (i.e., flotation costs) and the indirect costs of issuing new capital.

Solution: Increase the cost of capital by enough to reflect all of these costs, and then accept all projects that still have a positive NPV with the higher cost of capital.

(More...)

Reason: Companies don’t have enough managerial, marketing, or engineering staff to implement all positive NPV projects.

Solution: Use linear programming to maximize NPV subject to not exceeding the constraints on staffing.

(More...)

Reason: Companies believe that the project’s managers forecast unreasonably high cash flow estimates, so companies “filter” out the worst projects by limiting the total amount of projects that can be accepted.

Solution: Implement a post-audit process and tie the managers’ compensation to the subsequent performance of the project.