Chapter 10: THE BASICS OF CAPITAL BUDGETING

Should we build this plant?

Topic Overview

- Project Types
- Capital Budgeting Decision Criteria
  - Payback Period
  - Discounted Payback Period
  - Net Present Value (NPV)
  - Internal Rate of Return (IRR)
  - Modified Internal Rate of Return (MIRR)

Learning Objectives

- Understand how to calculate and use the 5 capital budgeting decision techniques: Payback, Discounted Payback, NPV, IRR, & MIRR.
- Understand the advantages and disadvantages of each technique.
- Understand which project to select when there is a ranking conflict between NPV and IRR.
WHAT IS CAPITAL BUDGETING?

- Analysis of potential additions to fixed assets.
- Long-term decisions; involve large expenditures.
- Very important to firm’s future.

Capital Budgeting Steps:

1. Estimate CFs (inflows & outflows).
2. Assess riskiness of CFs.
3. Determine $k = WACC$ (adj.).
4. Find NPV and/or IRR.
5. Accept if $NPV > 0$ and/or $IRR > WACC$.

Think about this as we cover Chapter 10
Capital Budgeting Decision Methods.

- Which of the following investment opportunities would you prefer?
- #1) Give me $1 now and I’ll give you $2 at the end of class.
- #2) Give me $100 now and I’ll give you $150 at the end of class.
Types of Projects

- Brand new line of business
- Expansion of existing line of business
- Replacement of existing asset
- Independent vs. Mutually Exclusive
- Normal vs. Non-normal

An Example of Mutually Exclusive Projects:

BRIDGE VS. BOAT TO GET PRODUCTS ACROSS A RIVER.

Normal vs. Nonnormal Projects

- Normal Project:
  - Cost (negative CF) followed by a series of positive cash inflows. One change of signs.
- Non-normal Project:
  - Two or more changes of signs.
  - Most common: Cost (negative CF), then string of positive CFs, then cost to close project.
  - Nuclear power plant, strip mine.
Inflow (+) or Outflow (-) in Year

<table>
<thead>
<tr>
<th>Year</th>
<th>Inflow</th>
<th>Outflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>2</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>3</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>4</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>5</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

Our Case Study

- We want to help Marge Simpson analyze the following business opportunities by using the following free cash flow information. Assume Marge’s cost of capital is 12%.

<table>
<thead>
<tr>
<th>Time</th>
<th>Falafel-Full</th>
<th>How ‘Bout A Pretzel?</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>(20,000)</td>
<td>(20,000)</td>
</tr>
<tr>
<td>1</td>
<td>15,000</td>
<td>2,000</td>
</tr>
<tr>
<td>2</td>
<td>15,000</td>
<td>2,500</td>
</tr>
<tr>
<td>3</td>
<td>13,000</td>
<td>3,000</td>
</tr>
<tr>
<td>4</td>
<td>3,000</td>
<td>50,000</td>
</tr>
</tbody>
</table>

Payback Period (PB)

- Measures how long it takes to recover a project’s cost (CF₀ = initial outlay).
- Easy to calculate and a good measure of a project’s risk and liquidity.
- Decision Rule: Accept if PB < some maximum period of time.
- If cash inflows are equal each year (in the form of an annuity), PB = CF₀/Annual CF
- Otherwise: see our continuing example.
Marge's Payback (Assume Marge's max is 2 years)

\[ PB = \text{Years Before Full Recovery of Initial Cost} + \frac{(\text{Unrecovered CF}_0)}{(\text{Cash inflow during year})} \]

\[ \text{Falafel PB} = 1 + \frac{5,000}{15,000} = 1.33 \]

\[ \text{Pretzel PB} = 3 + \frac{12,500}{50,000} = 3.25 \]

Marge should choose Falafel using Payback Period.

<table>
<thead>
<tr>
<th>Time (Years)</th>
<th>Falafel Full</th>
<th>Cumulative CF</th>
<th>How 'Bout A Pretzel?</th>
<th>Cumulative CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>20,000</td>
<td>(20,000)</td>
<td></td>
<td>(20,000)</td>
</tr>
<tr>
<td>1</td>
<td>15,000</td>
<td>(5,000)</td>
<td>2,000</td>
<td>(18,000)</td>
</tr>
<tr>
<td>2</td>
<td>15,000</td>
<td>10,000</td>
<td>2,500</td>
<td>(15,500)</td>
</tr>
<tr>
<td>3</td>
<td>13,000</td>
<td>23,000</td>
<td>3,000</td>
<td>(12,500)</td>
</tr>
<tr>
<td>4</td>
<td>3,000</td>
<td>26,000</td>
<td>50,000</td>
<td>37,500</td>
</tr>
</tbody>
</table>

Problems with Payback

- Ignores time value of money!
- Ignores cash flows beyond payback period.
- The Discounted Payback Period addresses the first problem.
- Disc. PB tells how long it takes to recover capital and financing costs for a project.
- Discount rate = cost of capital.

Marge's Discounted Payback

\[ PB = \text{Years Before Full Discounted Recovery of Initial Cost} + \frac{(\text{Unrecovered Initial Cost})}{(\text{Disc. CF during year})} \]

\[ \text{Falafel DPB} = 1 + \frac{6,607}{11,958} = 1.55 \]

\[ \text{Pretzel DPB} = 3 + \frac{14,086}{31,776} = 3.44 \]

Discounted Payback stills ignores cash flows beyond the discounted payback period.
**Net Present Value (NPV)**

- NPV = PV of inflows minus Cost = Net gain in wealth.
- Acceptance of a project with a NPV > 0 will add value to the firm.
- Decision Rule:
  - Accept if NPV > 0,
  - Reject if NPV < 0

**Marge's NPVs: k = 12%**

<table>
<thead>
<tr>
<th>Time</th>
<th>Falafel-Full</th>
<th>PV(CF)</th>
<th>How 'Bout A Pretzel?</th>
<th>PV(CF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>(20,000)</td>
<td>(20,000)</td>
<td></td>
<td>(20,000)</td>
</tr>
<tr>
<td>1</td>
<td>15,000</td>
<td>13,393</td>
<td>2,000</td>
<td>1,788</td>
</tr>
<tr>
<td>2</td>
<td>15,000</td>
<td>11,958</td>
<td>2,500</td>
<td>1,993</td>
</tr>
<tr>
<td>3</td>
<td>13,000</td>
<td>9,253</td>
<td>3,000</td>
<td>2,135</td>
</tr>
<tr>
<td>4</td>
<td>3,000</td>
<td>1,907</td>
<td>50,000</td>
<td>31,776</td>
</tr>
<tr>
<td>NPV</td>
<td>16,510</td>
<td></td>
<td></td>
<td>17,690</td>
</tr>
</tbody>
</table>

- Calculator Steps: Falafel-Full: CF0 = -20,000, C01 = 15,000, F01 = 2, C02 = 13,000, F02 = 1, C03 = 3,000. NPV: I = 12, CPT NPV = 16,510
- Pretzel: CF0 = -20,000, C01 = 2,000, C02 = 2,500, C03 = 3,000, C04 = 50,000. NPV: I = 12, CPT NPV = 17,690

NPV: Sum of the PVs of inflows and outflows.

$$\text{NPV} = \sum_{t=0}^{n} \frac{CF_t}{(1+k)^t}.$$
Excel and NPV: Why Microsoft deserves its legal troubles.

- Excel’s NPV function is goofed up. =NPV(k, range of cash flows)
- Assumes first cash flow in range occurs at t = 1.
- See spreadsheet.
- Solution to this spreadsheet problem: exclude CF0 (t = 0 cash flow) from NPV cell range and add CF0 (if CF0 is already negative) or subtract CF0 (if CF0 is positive) from NPV function.

Marge’s NPV Decision

- If projects are independent, Marge should select both.
  - Both have positive NPV.
- If the projects are mutually exclusive, select How ‘Bout A Pretzel?
  - Pretzel NPV > Falafel NPV.

Internal Rate of Return: IRR

IRR is the discount rate that forces PV inflows = cost. This is the same as forcing NPV = 0.
**NPV:** Enter $k$, solve for NPV.

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

**IRR:** Enter NPV = 0, solve for IRR.

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

**Internal Rate of Return (IRR)**

- Internal Rate of Return is a project’s expected rate of return on its investment.
- IRR is the interest rate where the PV of the inflows equals the PV of the outflows.
- In other words, the IRR is the rate where a project’s NPV = 0.
- **Decision Rule:** Accept if IRR > $k$ (cost of capital).
- Non-normal projects have multiple IRRs. Don’t use IRR to decide on non-normal projects.

**Marge’s IRRs**

- Best to use calculator. Calculator Steps.
- Falafel-Full: $CF_0 = -20,000$, $C01 = 15,000$, $F01 = 2$, $C02 = 13,000$, $F02 = 1$, $C03 = 3,000$. Press IRR, then CPT: IRR = 54.7%
- Pretzel: $CF0 = -20,000$, $C01 = 2,000$, $C02 = 2,500$, $C03 = 3,000$, $C04 = 50,000$. Press IRR, then CPT: IRR = 33.3%
- $k = 12\%$. If independent projects: select both, IRRs > 12\%. Mutually exclusive: select Falafel; higher IRR.
Comparison of NPV & IRR

- For normal independent projects, both methods give same accept/reject decision.
  - NPV > 0 yields IRR > k in order to lower NPV to 0.
- However, the methods can rank mutually exclusive projects differently.
- What to do, then?

NPV Profiles

- A graph which shows a project’s NPV at different interest rates (cost of capital).
- Can illustrate ranking conflicts between NPV and IRR.
- Below is a table of NPVs for Marge’s projects.

<table>
<thead>
<tr>
<th>k</th>
<th>Falafel-Full</th>
<th>How 'Bout A Pretzel?</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td>21,589</td>
<td>27,899</td>
</tr>
<tr>
<td>10%</td>
<td>17,849</td>
<td>20,289</td>
</tr>
<tr>
<td>12%</td>
<td>16,510</td>
<td>17,690</td>
</tr>
<tr>
<td>15%</td>
<td>14,649</td>
<td>14,190</td>
</tr>
<tr>
<td>25%</td>
<td>9,485</td>
<td>5,216</td>
</tr>
<tr>
<td>35%</td>
<td>5,529</td>
<td>(874)</td>
</tr>
<tr>
<td>55%</td>
<td>(68)</td>
<td>(8,201)</td>
</tr>
</tbody>
</table>

Marge’s Projects

- Marge’s NPV Profiles
Determining NPV/IRR Conflict Range

- For each year, subtract one project's cash flows from the other.
- If there is a change of signs of these cash flow differences, a ranking conflict exists.
- Find IRR of these cash flow differences to find rate where the two projects have the same NPV = crossover rate.
- At a cost of capital less than this crossover rate, a ranking conflict between NPV and IRR exists.

Marge's crossover rate

<table>
<thead>
<tr>
<th>Time</th>
<th>Falafel</th>
<th>How 'Bout A Pretzel?</th>
<th>Cash Flow Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-20,000</td>
<td>-20,000</td>
<td>CF0</td>
</tr>
<tr>
<td>1</td>
<td>15,000</td>
<td>2,000</td>
<td>13,000</td>
</tr>
<tr>
<td>2</td>
<td>15,000</td>
<td>2,500</td>
<td>12,500</td>
</tr>
<tr>
<td>3</td>
<td>13,000</td>
<td>3,000</td>
<td>10,000</td>
</tr>
<tr>
<td>4</td>
<td>3,000</td>
<td>50,000</td>
<td>(47,000)</td>
</tr>
</tbody>
</table>

IRR = Crossover Rate 14.1%

- At a cost of capital less than 14.1%, Pretzel has higher NPV but lower IRR = Ranking Conflict.
- At cost of capital greater than 14.1%, Falafel has the higher NPV and IRR.

Two reasons NPV profiles cross:

1) **Size (scale) differences.** Smaller project frees up funds at t = 0 for investment. The higher the opp. cost, the more valuable these funds, so high k favors small projects.

2) **Timing differences.** Project with faster payback provides more CF in early years for reinvestment. If k is high, early CF especially good, NPV$_S$ > NPV$_L$. 
Which project is best for Marge?

- Think back to my indecent proposal.
- Which of the following investment opportunities would you prefer?
  - #1) Give me $1 now and I’ll give you $2 at the end of class.
  - #2) Give me $100 now and I’ll give you $150 at the end of class.

Reconciling Ranking Conflicts absent capital rationing.

- Reinvestment Rate Assumption:
  - NPV assumes cash flows are reinvested at company’s cost of capital (i.e.: the investors’ required rate of return).
  - IRR assumes cash flows are reinvested at IRR.
  - The NPV reinvestment rate assumption is more realistic.
- Shareholder Wealth Maximization:
  - Want to add more value to the firm than less.
- Result: Choose project with highest NPV when NPV/IRR ranking conflict exists for mutually exclusive projects.

Acme, Inc. Rocket-Powered Roller Blade Project

- Acme is considering the following project which would market these roller blades to coyotes trying to catch road runners. Acme expects a cash inflow in the year 1, but an outflow in the 2nd (last) year of the project due to liability claims from injured cartoon coyotes. Acme’s opportunity cost of capital is 13%.

<table>
<thead>
<tr>
<th>Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash Flow</td>
<td>(5)</td>
<td>30</td>
<td>(30)</td>
</tr>
</tbody>
</table>

NPV = -1.95  IRR = 26.8%
At Acme’s 13% opportunity cost of capital, the project has a negative NPV even though the IRRs (~27% & 374%) are greater than 13%. Because of this conflict, don’t use IRR to make decisions for non-normal projects!

Why even mess with IRR?

- Since we like NPV, why mess with something like IRR?
- A rate of return or interest rate is more intuitive for outsiders and easier to understand.
- But IRR assumes an unrealistic reinvestment rate and leads to multiple IRRs for non-normal projects.
- Solution: Modified Internal Rate of Return (MIRR).

Modified Internal Rate of Return, MIRR

- The interest rate where the FV of a project’s inflows (TV) are discounted to equal the PV of a project’s outflows.
- Assumes cash inflows are reinvested at the project’s cost of capital (k).
- \( PV(\text{outflows}) = TV/(1+\text{MIRR})^n \), where
- \( TV = \sum CIF_t(1+k)^{n-t} \), and
- \( PV(\text{outflows}) = \sum COF_t/(1+k)^t \)
  - Where CIF = annual cash inflow, and COF = annual cash outflow.
Steps to finding MIRR.

- Find TV of inflows by finding FV of each annual inflow to the end of the project’s life at the cost of capital.
- Find PV of outflows at the cost of capital today.
- Then find interest rate over the n years of the project that equates the TV (=FV) to the PV of the outflows (=PV).
- Decision rule same as IRR: Compare MIRR to cost of capital.

The MIRR for Marge’s projects.

<table>
<thead>
<tr>
<th>Time</th>
<th>Falafel-Full</th>
<th>PV at yr 4 at 12%</th>
<th>How ‘Bout A Pretzel?</th>
<th>PV at yr 4 at 12%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>(20,000)</td>
<td>21,074</td>
<td>(20,000)</td>
<td>21,074</td>
</tr>
<tr>
<td>1</td>
<td>15,000</td>
<td>18,816</td>
<td>2,000</td>
<td>3,138</td>
</tr>
<tr>
<td>2</td>
<td>13,000</td>
<td>14,560</td>
<td>3,000</td>
<td>3,360</td>
</tr>
<tr>
<td>4</td>
<td>3,000</td>
<td>3,000</td>
<td>50,000</td>
<td>50,000</td>
</tr>
</tbody>
</table>

TV = 57,450  TV = 59,306

- Falafel-Full: -20,000 = PV, 57,450 = FV, 4 = N, 0 = PMT, CPT I/Y = 30.2% = MIRR
- How ‘Bout A Pretzel: -20,000 = PV, 59,306 = FV, 4 = N, 0 = PMT, CPT I/Y = 31.2% = MIRR
- Accept both projects if independent since MIRRs are greater than the 12% cost of capital. Prefer pretzel if mutually exclusive.

CF Worksheet solution to MIRR

- Find NPV of inflows only first, then find FV of this single PV.

<table>
<thead>
<tr>
<th>YR</th>
<th>FALAFEL ACIF</th>
<th>CF WORK</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>CF0 = 0</td>
</tr>
<tr>
<td>1</td>
<td>15,000</td>
<td>C01 = 15,000</td>
</tr>
<tr>
<td>2</td>
<td>15,000</td>
<td>F01 = 2</td>
</tr>
<tr>
<td>3</td>
<td>13,000</td>
<td>C02 = 13,000 F02 = 1</td>
</tr>
<tr>
<td>4</td>
<td>3,000</td>
<td>C03 = 3,000 F03 = 1</td>
</tr>
</tbody>
</table>

NPV: I = 12, CPT NPV = 36,510
-36,510 = PV, 12 = I/Y, 4 = N, 0 = PMT, CPT FV = 57,450.
Now −20,000 = PV, MIRR: CPT I/Y = 30.2%
MIRR if more than one outflow

- **ACME Rocket Roller Blades**
  - **YR**
  - **CF**
  - 0: -5
  - 1: +30
  - 2: -30

Cost of capital = 13%

- FV of inflows at yr 2 = $30(1.13)^2 = 33.9$
- PV of outflows today (yr 0) = $-5 - \frac{30}{(1.13)^2} = -28.49$
- $-28.49 = PV, 33.9 = FV, 0 = PMT, 2 = N, CPT I/Y = 9.1\%$
- MIRR less than 13% consistent with negative NPV

**Summary of Capital Budgeting Methods**

- Want a method that uses the time value of money with all project cash flows: NPV, IRR & MIRR.
- IRR can give erroneous decision for non-normal projects.
- Overall, NPV is the best and preferred method.