NPV & Other Rules
Why Use Net Present Value?

• Accepting positive NPV projects benefits shareholders.
  ✓ NPV uses cash flows
  ✓ NPV uses all the cash flows of the project
  ✓ NPV discounts the cash flows properly

• Reinvestment assumption: the NPV rule assumes that all cash flows can be reinvested at the discount rate.
The Net Present Value (NPV) Rule

• Net Present Value (NPV) =
  Total PV of future CF’s + Initial Investment

• Estimating NPV:
  1. Estimate future cash flows: how much? and when?
  2. Estimate discount rate
  3. Estimate initial costs

• Minimum Acceptance Criteria: Accept if NPV > 0
• Ranking Criteria: Choose the highest NPV
Calculating NPV with Spreadsheets

- Spreadsheets are an excellent way to compute NPVs, especially when you have to compute the cash flows as well.

- Using the NPV function:
  - The first component is the required return entered as a decimal.
  - The second component is the range of cash flows beginning with year 1.
  - Add the initial investment after computing the NPV.
The Payback Period Method

- How long does it take the project to “pay back” its initial investment?
- Payback Period = number of years to recover initial costs
- Minimum Acceptance Criteria:
  - Set by management
- Ranking Criteria:
  - Set by management
The Payback Period Method

• Disadvantages:
  – Ignores the time value of money
  – Ignores cash flows after the payback period
  – Biased against long-term projects
  – Requires an arbitrary acceptance criteria
  – A project accepted based on the payback criteria may not have a positive NPV

• Advantages:
  – Easy to understand
  – Biased toward liquidity
The Discounted Payback Period

• How long does it take the project to “pay back” its initial investment, taking the time value of money into account?

• Decision rule: Accept the project if it pays back on a discounted basis within the specified time.

• By the time you have discounted the cash flows, you might as well calculate the NPV.
Average Accounting Return

\[ AAR = \frac{\text{Average Net Income}}{\text{Average Book Value of Investment}} \]

- Another attractive, but fatally flawed, approach
- Ranking Criteria and Minimum Acceptance Criteria set by management
Average Accounting Return

• Disadvantages:
  – Ignores the time value of money
  – Uses an arbitrary benchmark cutoff rate
  – Based on book values, not cash flows and market values

• Advantages:
  – The accounting information is usually available
  – Easy to calculate
The Internal Rate of Return

- IRR: the discount rate that sets NPV to zero
- Minimum Acceptance Criteria:
  - Accept if the IRR exceeds the required return
- Ranking Criteria:
  - Select alternative with the highest IRR
- Reinvestment assumption:
  - All future cash flows assumed reinvested at the IRR
Internal Rate of Return (IRR)

- Disadvantages:
  - Does not distinguish between investing and borrowing
  - IRR may not exist, or there may be multiple IRRs
  - Problems with mutually exclusive investments

- Advantages:
  - Easy to understand and communicate
IRR: Example

Consider the following project:

\[
NPV = 0 = -200 + \frac{50}{(1 + IRR)} + \frac{100}{(1 + IRR)^2} + \frac{150}{(1 + IRR)^3}
\]

The internal rate of return for this project is 19.44%.
If we graph NPV versus the discount rate, we can see the IRR as the x-axis intercept.

<table>
<thead>
<tr>
<th>Discount rate</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>$100.00</td>
</tr>
<tr>
<td>4%</td>
<td>$73.88</td>
</tr>
<tr>
<td>8%</td>
<td>$51.11</td>
</tr>
<tr>
<td>12%</td>
<td>$31.13</td>
</tr>
<tr>
<td>16%</td>
<td>$13.52</td>
</tr>
<tr>
<td>20%</td>
<td>($2.08)</td>
</tr>
<tr>
<td>24%</td>
<td>($15.97)</td>
</tr>
<tr>
<td>28%</td>
<td>($28.38)</td>
</tr>
<tr>
<td>32%</td>
<td>($39.51)</td>
</tr>
<tr>
<td>36%</td>
<td>($49.54)</td>
</tr>
<tr>
<td>40%</td>
<td>($58.60)</td>
</tr>
<tr>
<td>44%</td>
<td>($66.82)</td>
</tr>
</tbody>
</table>
Calculating IRR with Spreadsheets

• You start with the cash flows the same as you did for the NPV.

• You use the IRR function:
  – You first enter your range of cash flows, beginning with the initial cash flow.
  – You can enter a guess, but it is not necessary.
  – The default format is a whole percent – you will normally want to increase the decimal places to at least two.
Problems with IRR

- Multiple IRRs
  - Projects with inlay and outlays over time have more than one viable IRR

- Are We Borrowing or Lending
  - Cash inflow and outflow changes accordingly

- The Scale Problem
  - Size of cash flows can distort results

- The Timing Problem
  - When cash flows are paid or received matter
Mutually Exclusive vs. Independent

- Mutually Exclusive Projects: only ONE of several potential projects can be chosen, e.g., acquiring an accounting system.
  - RANK all alternatives, and select the best one.

- Independent Projects: accepting or rejecting one project does not affect the decision of the other projects.
  - Must exceed a MINIMUM acceptance criteria
There are two IRRs for this project. Which one should we use?
Modified IRR

• Calculate the net present value of all cash outflows using the borrowing rate.
• Calculate the net future value of all cash inflows using the investing rate.
• Find the rate of return that equates these values.
• Benefits: single answer and specific rates for borrowing and reinvestment
The Scale Problem

Would you rather make 100% or 50% on your investments?

What if the 100% return is on a $1 investment, while the 50% return is on a $1,000 investment?

• remember that NPV is directly a function of cash flow size whereas IRR is not!
The Timing Problem

Project A

<table>
<thead>
<tr>
<th>Time (Years)</th>
<th>Cash Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-$10,000</td>
</tr>
<tr>
<td>1</td>
<td>$10,000</td>
</tr>
<tr>
<td>2</td>
<td>$1,000</td>
</tr>
<tr>
<td>3</td>
<td>$1,000</td>
</tr>
</tbody>
</table>

Project B

<table>
<thead>
<tr>
<th>Time (Years)</th>
<th>Cash Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-$10,000</td>
</tr>
<tr>
<td>1</td>
<td>$1,000</td>
</tr>
<tr>
<td>2</td>
<td>$1,000</td>
</tr>
<tr>
<td>3</td>
<td>$12,000</td>
</tr>
</tbody>
</table>
The Timing Problem

NPV

- Project A
- Project B

10.55% = crossover rate
12.94% = IRR$_B$
16.04% = IRR$_A$
Calculating the Crossover Rate

Compute the IRR for either project “A-B” or “B-A”

<table>
<thead>
<tr>
<th>Year</th>
<th>Project A</th>
<th>Project B</th>
<th>Project A-B</th>
<th>Project B-A</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>($10,000)</td>
<td>($10,000)</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>1</td>
<td>$10,000</td>
<td>$1,000</td>
<td>$9,000</td>
<td>($9,000)</td>
</tr>
<tr>
<td>2</td>
<td>$1,000</td>
<td>$1,000</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>3</td>
<td>$1,000</td>
<td>$12,000</td>
<td>($11,000)</td>
<td>$11,000</td>
</tr>
</tbody>
</table>

NPV:

$$\text{NPV} = \sum_{t=0}^{n} \frac{C_t}{(1+r)^t}$$

where:
- $C_t$ is the cash flow at time $t$,
- $r$ is the discount rate,
- $n$ is the number of periods.

For the given data:

- Project A: $C_0 = ($10,000), C_1 = $10,000, C_2 = $1,000, C_3 = $1,000
- Project B: $C_0 = ($10,000), C_1 = $1,000, C_2 = $1,000, C_3 = $12,000

The crossover rate is the discount rate where the NPV of the two projects is equal. From the graph, we can see that the crossover rate is approximately 10.55%.
NPV versus IRR

• NPV and IRR will generally give the same decision.
• Exceptions:
  – Non-conventional cash flows – cash flow signs change more than once
  – Mutually exclusive projects
    • Initial investments are substantially different
    • Timing of cash flows is substantially different
The Profitability Index (PI)

\[ \text{PI} = \frac{\text{Total PV of Future Cash Flows}}{\text{Initial Investment}} \]

- **Minimum Acceptance Criteria:**
  - Accept if \( \text{PI} > 1 \)

- **Ranking Criteria:**
  - Select alternative with highest PI
The Profitability Index

• Disadvantages:
  – Problems with mutually exclusive investments

• Advantages:
  – May be useful when available investment funds are limited
  – Easy to understand and communicate
  – Correct decision when evaluating independent projects
The Practice of Capital Budgeting

• Varies by industry:
  – Some firms use payback, others use accounting rate of return.

• The most frequently used technique for large corporations is IRR or NPV.
Example of Investment Rules

Compute the IRR, NPV, PI, and payback period for the following two projects. Assume the required return is 10%.

<table>
<thead>
<tr>
<th>Year</th>
<th>Project A</th>
<th>Project B</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-$200</td>
<td>-$150</td>
</tr>
<tr>
<td>1</td>
<td>$200</td>
<td>$50</td>
</tr>
<tr>
<td>2</td>
<td>$800</td>
<td>$100</td>
</tr>
<tr>
<td>3</td>
<td>-$800</td>
<td>$150</td>
</tr>
</tbody>
</table>
## Example of Investment Rules

<table>
<thead>
<tr>
<th></th>
<th>Project A</th>
<th>Project B</th>
</tr>
</thead>
<tbody>
<tr>
<td>$CF_0$</td>
<td>-$200.00</td>
<td>-$150.00</td>
</tr>
<tr>
<td>$PV_0$ of $CF_{1-3}$</td>
<td>$241.92</td>
<td>$240.80</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>NPV</strong></th>
<th>$41.92</th>
<th>$90.80</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IRR</strong></td>
<td>0%, 100%</td>
<td>36.19%</td>
</tr>
<tr>
<td><strong>PI</strong></td>
<td>1.2096</td>
<td>1.6053</td>
</tr>
</tbody>
</table>
### Example of Investment Rules

**Payback Period:**

<table>
<thead>
<tr>
<th>Time</th>
<th>CF</th>
<th>Cum. CF</th>
<th>Cum. CFCF</th>
<th>Cum. CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-200</td>
<td>-200</td>
<td>-150</td>
<td>-150</td>
</tr>
<tr>
<td>1</td>
<td>200</td>
<td>0</td>
<td>50</td>
<td>-100</td>
</tr>
<tr>
<td>2</td>
<td>800</td>
<td>800</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>-800</td>
<td>0</td>
<td>150</td>
<td>150</td>
</tr>
</tbody>
</table>

Payback period for project B = 2 years.
Payback period for project A = 1 or 3 years?
## NPV and IRR Relationship

<table>
<thead>
<tr>
<th>Discount rate</th>
<th>NPV for A</th>
<th>NPV for B</th>
</tr>
</thead>
<tbody>
<tr>
<td>-10%</td>
<td>-87.52</td>
<td>234.77</td>
</tr>
<tr>
<td>0%</td>
<td>0.00</td>
<td>150.00</td>
</tr>
<tr>
<td>20%</td>
<td>59.26</td>
<td>47.92</td>
</tr>
<tr>
<td>40%</td>
<td>59.48</td>
<td>-8.60</td>
</tr>
<tr>
<td>60%</td>
<td>42.19</td>
<td>-43.07</td>
</tr>
<tr>
<td>80%</td>
<td>20.85</td>
<td>-65.64</td>
</tr>
<tr>
<td>100%</td>
<td>0.00</td>
<td>-81.25</td>
</tr>
<tr>
<td>120%</td>
<td>-18.93</td>
<td>-92.52</td>
</tr>
</tbody>
</table>
NPV Profiles

- **NPV Profiles**
  - **NPV**
    - $400
    - $300
    - $200
    - $100
    - $0
    - $(-150)
    - $(-200)
  - **Discount rates**
    - 0%
    - 15%
    - 30%
    - 45%
    - 70%
    - 100%
    - 130%
    - 160%
    - 190%
  - **Cross-over Rate**
  - **IRR**
    - $IRR_1(A)$
    - $IRR(B)$
    - $IRR_2(A)$

- **Projects**
  - **Project A**
  - **Project B**

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Prof. Ali Nejadmalayeri
Summary – Discounted Cash Flow

• Net present value
  – Difference between market value and cost
  – Accept the project if the NPV is positive
  – Has no serious problems
  – Preferred decision criterion

• Internal rate of return
  – Discount rate that makes NPV = 0
  – Take the project if the IRR is greater than the required return
  – Same decision as NPV with conventional cash flows
  – IRR is unreliable with non-conventional cash flows or mutually exclusive projects

• Profitability Index
  – Benefit-cost ratio
  – Take investment if PI > 1
  – Cannot be used to rank mutually exclusive projects
  – May be used to rank projects in the presence of capital rationing
Summary – Payback Criteria

- **Payback period**
  - Length of time until initial investment is recovered
  - Take the project if it pays back in some specified period
  - Does not account for time value of money, and there is an arbitrary cutoff period

- **Discounted payback period**
  - Length of time until initial investment is recovered on a discounted basis
  - Take the project if it pays back in some specified period
  - There is an arbitrary cutoff period

- **Average Accounting Return**
  - Measure of accounting profit relative to book value
  - Similar to return on assets measure
  - Take the investment if the AAR exceeds a specified return level
  - Serious problems and should not be used