15.401 Recitation
8: Capital Budgeting
Learning Objectives

- Review of Concepts
  - NPV
  - Payback Period
  - IRR
  - Profitability index
- Examples
  - Bart’s Super-Widget*

* Bart’s Super-Widget by Bart Raeymaekers
Review: capital budgeting

Decision:
- Accept or reject a project
- Compare two projects

Decision rule:
- NPV, IRR, payback period, etc.

Information
- Cash flow projection
- Risk projection
- Tax regulation
Review: NPV

- **Net present value (NPV) of a project** is
  \[ \text{NPV} = \sum_{t=0}^{\infty} \frac{\text{CF}_t}{(1 + r_t)^t} > 0 \]

- Decision should be based on **after-tax cash flow** instead of **accounting earnings**.

- Operating profit = operating revenue – operating expenses without depreciation

- \[ \text{CF} = (1 - \tau) \times \text{operating profit} - \text{capital expenditure} + \tau \times \text{depreciation} \]
  \( (\tau \text{ is the tax rate}) \)
Review: NPV

- Decision rule:
  - Independent projects: take all projects with NPV>0
  - Mutually exclusive projects: take projects with the highest NPVs

- The NPV rule dominates all other rules because it takes into account the maximum amount of information, including timing of all cash flows and risks, and makes the correct decision based on value creation.
Review: payback period

- The **payback period** is the minimum $T$ such that

$$\sum_{t=1}^{T} CF_t \geq CF_0 = I_0$$

- $T$ is the minimum number of period required to “recover” the initial investment, $I_0$.

- Decision rule:
  - Independent projects: take all projects with a payback period less than a fixed threshold $T^*$.
  - Mutually exclusive projects: take the project with the lowest payback period.
Review: payback period

- **Pro:**
  - Easy to calculate

- **Con:**
  - Ignores cash flows after the payback period
  - Ignores time value of money

- **Discounted payback period:** minimum $T$ such that

$$\sum_{t=1}^{T} \frac{CF_t}{(1 + r_t)^t} \geq CF_0 = I_0$$

  - Problem: still ignores cash flows after the payback period
Review: IRR

- The **internal rate of return (IRR)** is the discount rate that satisfies
  \[ 0 = \sum_{t=0}^{\infty} \frac{CF_t}{(1 + IRR)^t} \]
- IRR is the implied rate of return of the project.
- Decision rule:
  - Independent projects: take the projects with IRR > r*, where r* is the required rate of return.
  - Mutually exclusive projects: take the project with the highest IRR (provided it is greater than r*).
Review: IRR

- IRR gives the same decision as NPV if
  - Cash outflow occurs only at time 0
  - Only one project is under consideration
  - Required cost of capital is the same for all periods
  - Threshold rate is set to the required cost of capital

- Potential problem:
  - IRR may not exist
  - There may be multiple IRRs for a single cash flow.
  - IRR rule gives the wrong decision for mutually exclusive projects.
Review: profitability index

- The profitability index of a project is
  \[
  \text{PI} = \frac{1}{I_0} \sum_{t=1}^{\infty} \frac{\text{CF}_t}{(1+r_t)^t}
  \]

- Decision rule:
  - Independent projects: take all projects with PI > 1.
  - Mutually exclusive projects: take the project with the highest PI.

- PI gives the same decision as NPV if
  - Cash outflow occurs only at time 0
  - There is only one project under consideration.
Example: Bart’s Super-Widget

- **Project overview:**
  - Bart Co., a profitable widget maker, has developed an innovative new product called the Super-Widget. The company has invested $300,000 in R&D to develop the product and expects that it will capture a large share of the market.

- **Capital requirement:**
  - Bart Co. will have to invest $750,000 in new equipment. The machines have a useful life of 5 years, with an expected salvage value of $0.

Courtesy of Bart Raeymaekers. Used with permission.
Example: Bart’s Super-Widget

- **Revenue projection:**
  - Over the next five years, unit sales are expected to be (5, 8, 12, 10, 6) thousand units.
  - Prices in the first year will be $480, and then will grow 2% annually.

- **Operating expenses:**
  - Sales and administrative costs will be $150,000/year.
  - Production costs will be $500/unit in the first year, but will decline by 8% every year thereafter.
  - The tax rate is 35% and the after-tax cost of capital is 12%.

Courtesy of Bart Raeymaekers. Used with permission.
## Example: Bart’s Super-Widget

### Revenue and Cost

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<tr>
<th></th>
<th>t=1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<tbody>
<tr>
<td><strong>Revenue</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Units</td>
<td>5,000</td>
<td>8,000</td>
<td>12,000</td>
<td>10,000</td>
<td>6,000</td>
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<tr>
<td>Price/Unit</td>
<td>480</td>
<td>490</td>
<td>499</td>
<td>509</td>
<td>520</td>
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<tr>
<td>Total</td>
<td>2,400,000</td>
<td>3,916,800</td>
<td>5,992,704</td>
<td>5,093,798</td>
<td>3,117,405</td>
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<tr>
<td><strong>Expenses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>SG&amp;A</td>
<td>150,000</td>
<td>150,000</td>
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<tr>
<td>Cost/Unit</td>
<td>500</td>
<td>460</td>
<td>423</td>
<td>389</td>
<td>358</td>
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<tr>
<td>Total</td>
<td>(2,650,000)</td>
<td>(3,830,000)</td>
<td>(5,228,400)</td>
<td>(4,043,440)</td>
<td>(2,299,179)</td>
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<tr>
<td><strong>Op. Profit</strong></td>
<td>(250,000)</td>
<td>86,800</td>
<td>764,304</td>
<td>1,050,358</td>
<td>818,226</td>
</tr>
</tbody>
</table>

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Example: Bart’s Super-Widget

- **Depreciation and Tax**

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<tr>
<td>Op. Profit</td>
<td>(250,000)</td>
<td>86,800</td>
<td>764,304</td>
<td>1,050,358</td>
<td>818,226</td>
</tr>
<tr>
<td>Depreciation</td>
<td>(150,000)</td>
<td>(150,000)</td>
<td>(150,000)</td>
<td>(150,000)</td>
<td>(150,000)</td>
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<tr>
<td>EBIT</td>
<td>(400,000)</td>
<td>(63,200)</td>
<td>614,304</td>
<td>900,358</td>
<td>668,226</td>
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<tr>
<td>Taxes @35%</td>
<td>140,000</td>
<td>22,120</td>
<td>(215,006)</td>
<td>(315,125)</td>
<td>(233,879)</td>
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<td>Net income</td>
<td>(260,000)</td>
<td>(41,080)</td>
<td>399,298</td>
<td>585,233</td>
<td>434,347</td>
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Example: Bart’s Super-Widget

**Cash Flow**

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<th>3</th>
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<tbody>
<tr>
<td>Net income</td>
<td>(260,000)</td>
<td>(41,080)</td>
<td>399,298</td>
<td>585,233</td>
<td>434,347</td>
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</tr>
<tr>
<td>CAPEX</td>
<td>(1,000,000)</td>
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</tr>
<tr>
<td>Cash flow</td>
<td>(1,000,000)</td>
<td>(110,000)</td>
<td>108,920</td>
<td>549,298</td>
<td>735,233</td>
<td>584,347</td>
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<tr>
<td>PV @ 12%</td>
<td>(1,000,000)</td>
<td>(98,214)</td>
<td>86,830</td>
<td>390,979</td>
<td>467,254</td>
<td>331,574</td>
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<td>NPV</td>
<td>$178,423</td>
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Example: Bart’s Super-Widget

- Reminder:
  - $\text{CF} = \text{after-tax operating income} + \text{depreciation tax shield} - \text{capital expenditure}$
    
    $$= (1 - \tau) \times \text{operating income} + \tau \times \text{depreciation} - \text{capital expenditure}$$

- The accounting net income is taxed even if it is negative.

- Depreciation is not a cash flow but reduces taxes.