Chapter 10
The Basics of Capital Budgeting: Evaluating Cash Flows

Why Use Net Present Value?
The Payback Period Rule
The Discounted Payback Period Rule
The Internal Rate of Return
Problems with the IRR Approach
The Profitability Index
The Practice of Capital Budgeting

Mutually Exclusive vs. Independent Project

- **Mutually Exclusive Projects:**
- **Independent Projects:**

Mutually Exclusive vs. Independent Project

- **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.**

The Net Present Value (NPV) Rule

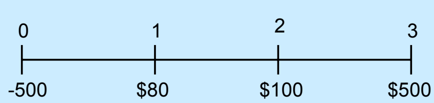
•NPV = Total PV of future CF's + Initial Investment

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

- **Estimating NPV:**
  - **1. Estimate future cash flows: how much? and when?**
  - **2. Estimate discount rate**
  - **3. Estimate initial cash outflows**
- **NPV Acceptance Rule:?**
- **Ranking Rule?**

NPV Example

Assume we the project shown below and it has a cost of capital r = 10%, with cash flows:



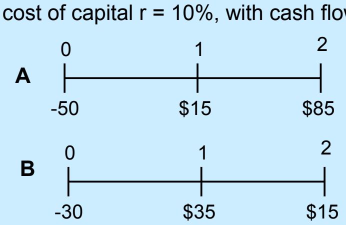
$NPV = -500 + 80/(1.10)^1 + 100/(1.10)^2 + 500/(1.10)^3$

NPV = $31.02

What's the decision rule?

NPV Example

Assume we have two projects, A & B, both have a cost of capital r = 10%, with cash flows below:



To solve find the present value of the CF's

A: NPV = $-50 + 15/(1.10)^1 + 85/(1.10)^2$

NPV_A = $33.88

B: NPV = $-30 + 35/(1.10)^1 + 15/(1.10)^2$

NPV_B = $14.21

Assuming independent projects, which do we choose? What is the decision rule?

Projects A & B

Assuming mutually exclusive projects, which do we choose? What is the decision rule?

Project A

The Payback Period Rule

- How long does it take the project to "pay back" its initial investment?
- Payback Period = no. of years to recover initial costs (investment)
- Minimum Acceptance Criteria?
- Ranking Criteria?

Payback Period Example

Assume the following cash flows:

One year: 500 - 80 = 420

Two years: 420 - 100 = 320

The last year there is $500 left to repay the $320, so it will be paid back during the third year, as

Fraction of third year = 320 / 500 = .64 years

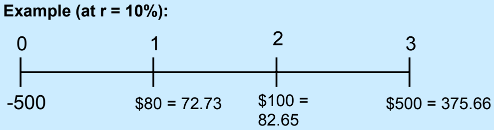
So Payback Period = 2.64 years

The Payback Period Rule (continued)

- 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 or be the best project
- Advantages:
  - Easy to understand and compute
  - Biased toward liquidity

The Discounted Payback Period Rule

- How long does it take the project to "pay back" its initial investment when you discount the cash flows?
- Example (at r = 10%):



One year: 500 - 73 = 427

Two years: 427 - 83 = 344

The last year there is $500 left to repay the $344, so it will be paid back during the third year, as

Fraction of third year = 344 / 376 = .915 years

So Payback Period = 2.92 years

The Internal Rate of Return (IRR) Rule

- IRR is the discount rate that equates the initial investment with the present value of the cash flows.
- IRR is a rate of return for the project.
- IRR is the discount rate that makes the NPV of the investment zero.
- IRR formula, solve for IRR, such that:

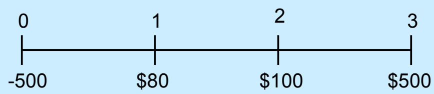
$$0 = \sum_{t=0}^{n} \frac{CF_t}{(1 + IRR)^t}$$

How do we solve for this?

Financial calculator or trial and error

IRR Example

Assume we have the same project as before and it Has a cost of capital r = 10%, with cash flows below:



To solve, find the IRR that makes the initial investment equal the discounted cash flows:

$0 = -500 + 80/(1+IRR)^1 + 100/(1+IRR)^2 + 500/(1+IRR)^3$

IRR = 12.61%

What's the decision rule?

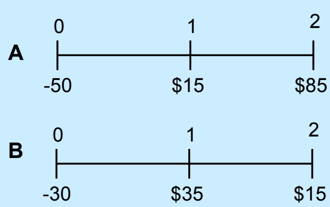
Internal Rate of Return

- **Minimum Acceptance Criteria?:**
- **Ranking Criteria?**

- **Disadvantages:**
  - **IRR may not exist or there may be multiple IRR**
  - **Problems with mutually exclusive projects**
- **Advantages:**
  - **Easy to understand and communicate**

Another IRR Example

Assume we have the same two projects, A & B, both have a cost of capital r = 10%, with cash flows below:



IRR Example

To solve find the IRR that makes the initial investment equal the discounted cash flows:

A: $0 = -50 + 15/(1+IRR)^1 + 85/(1+IRR)^2$

$IRR_A = 46.24\%$

B: $0 = -30 + 35/(1+IRR)^1 + 15/(1+IRR)^2$

$IRR_B = 50.00\%$

Assuming independent projects, which do we choose? What is the decision rule?

Projects A & B

Assuming mutually exclusive projects, which do we choose? What is the decision rule?

Project B

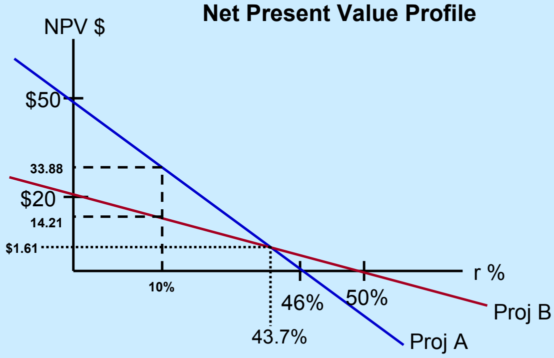
NPV and IRR

- **For the second set of projects (A & B):**
- **Which project did we choose for NPV?**
- **Which project did we choose for IRR?**
- **Why?**
- **Let's look at the Net Present Value Profile**
- **This is a graph that relates NPV with varying discount rates.**
- **First calculate the NPV of the projects at several different discount rates, then plot these values on a graph.**
- **We already have 3 values for Project's A & B**

Net Present Value Profile

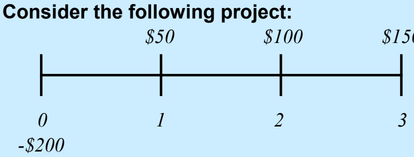
- **NPV_A = $33.88 at r = 10%**
  at the IRR_A = 46%, the NPV_A = ??
  At 0% discount rate the NPV_A = ??
  NPV_A = 15 + 85 -50 = $50
  So we have 3 values for A!
- **NPV_B = $14.21 at r = 10%**
  at the IRR_B = 50%, the NPV_B = ??
  At 0% discount rate the NPV_B = ??
  NPV_B = 35 + 15 - 30 = $20
  So we also have 3 values for B!

Net Present Value Profile



The Internal Rate of Return: Example

Consider the following project:



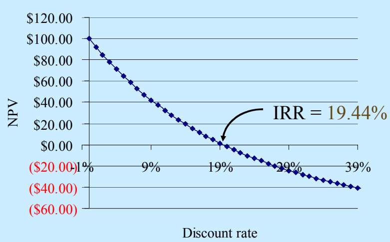
$$NPV = 0 = \frac{\$50}{(1+IRR)} + \frac{\$100}{(1+IRR)^2} + \frac{\$150}{(1+IRR)^3}$$

The internal rate of return for this project is 19.44%

The NPV Payoff Profile for This Example

If we graph NPV versus discount rate, we can see the IRR as the x-axis intercept.

Discount Rate	NPV
0%	$100.00
4%	$71.04
8%	$47.32
12%	$27.79
16%	$11.65
20%	($1.74)
24%	($12.88)
28%	($22.17)
32%	($29.93)
36%	($36.43)
40%	($41.86)



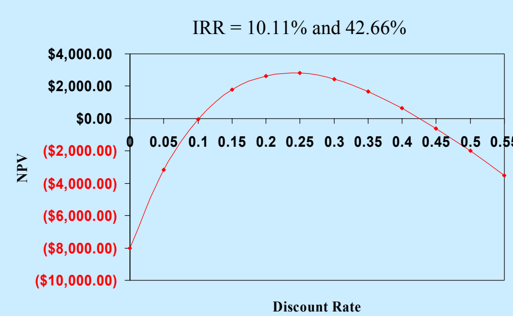
NPV versus IRR

- **So which is better, IRR or NPV?**
- **When ranking independent projects, there usually isn't a conflict.**
- **The problem arises when deciding between mutually exclusive projects.**
- **IRR may cause a problem when the size or the timing of the cash flows differ greatly.**
- **IRR may produce multiple IRR's!**
- **Occurs when sign of the cash flows change more than once.**

Another Example – Multiple IRRs

- **Suppose an investment will cost $90,000 initially and will generate the following cash flows:**
  - **Year 1: 132,000**
  - **Year 2: 100,000**
  - **Year 3: -150,000**
- **The required return is 15%.**
- **Should we accept or reject the project?**
- **NPV = $1,769.54**
- **IRR = 10.11%**

NPV Profile



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?

NPV versus IRR continued

- **The reason for the previous problems is:**
- **The Implied Reinvestment Rate Assumption**
- **What happens to the cash flows we receive each year of the project?**
- **They are reinvested!**
- **At what rate does NPV and IRR assume that the annual cash flows are reinvested?**

NPV versus IRR, which is better?

- **NPV assumes the CF's are reinvested at r, the required return**
- **IRR assumes the CF's are reinvested at the IRR**
- **So if there is a conflict, NPV always provides the correct information!**
- **So why do we even calculate IRR, if NPV always gives the right answer?**

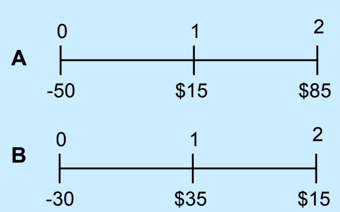
Modified Internal Rate of Return - MIRR

- **MIRR is the discount rate that equates the initial investment with the present value of the terminal value (FV or TV) of the cash inflows.**
- **MIRR solves the reinvestment rate assumption.**
- **With MIRR all of the cash inflows are reinvested at the firm's discount rate.**
- **MIRR formula, solve for MIRR, such that:**

$$\text{Cost} = \sum_{t=0}^{n} \frac{CIF_t(1 + r)^{n-t}}{(1 + MIRR)^n} = \frac{TV}{(1 + MIRR)^n}$$

MIRR Example

Assume we have the same two projects, A & B, both have a cost of capital r = 10%, with cash flows below:



MIRR Example

To solve find the MIRR that makes the initial investment equal the PV of TV of the cash inflows:

A: TV = $15(1+.10)^1 + 85 = 101.5$

$50 = 101.5 / (1 + MIRR)^2$ so MIRR = 42.48%

B: TV = $35(1+.10)^1 + 15 = 53.5$

$30 = 53.5 / (1 + MIRR)^2$ so MIRR = 33.54%

This now agrees with the NPV decision, choose Project A.

The Profitability Index (PI) Rule

$$PI = \frac{\text{Total PV of Future Cash Flows}}{\text{Initial Investent}}$$

- Profitability Index is also called the benefit/cost ratio
- PI is the present value of the future cash flows divided by the initial investment

$$PI = \frac{\sum_{t=1}^{n} \frac{CF_t}{(1+r)^t}}{CF_0}$$

PI Example

Assume we have the same project as before and it Has a cost of capital r = 10%, with cash flows below:

0	1	2	3
-500	\$80	\$100	\$500

$PI = PV / CF_0$

PI = \$531.02 / \$500

PI = 1.062

What's the decision rule?

Project returns \$1.06 for every \$1 invested

Another Profitability Index Example

Using the previous examples:

PV_A = \$83.88 at r = 10% and Intial Inv_A = \$50

PI_A = 83.88 / 50 = 1.678

PV_B = \$44.21 at r = 10% and Intial Inv_B = \$30

PI_B = 44.21 / 30 = 1.474

So if mutually exclusive we choose??

A because the PI is higher: $PI_A > PI_B$

If independent choose all projects with PI > 1.0

PI means that for Proj A, the project returns \$1.68 for every \$1.00 invested

Profitability Index

- Minimum Acceptance Criteria?
- Ranking Criteria?
- Disadvantages:
  - Problems with mutually exclusive investments
- Advantages:
  - Easy to understand and communicate
  - Correct decision when evaluating independent projects
  - Allows the manager to respond to the scale problem

Evaluating Projects with Unequal Lives

- If we have two mutual exclusive projects with unequal lives, to compare them we must equalize the lives.
- Use the Replacement Chain Approach
  - Find the common denominator for life of the project assuming it's repeated and then compute the NPV of the "longer" projects
- Use the Equivalent Annual Annuity
  - The EAA finds an annuity that is equivalent to the NPV of the project.
  - The EAA tells you what the project would return each year if it continued on indefinitely.
  - $EAA = NPV / PVIFA_{k,n}$

Replacement Chain Example

Project A

0	1	2	3	4
-\$500	\$100	\$300	\$200	\$200

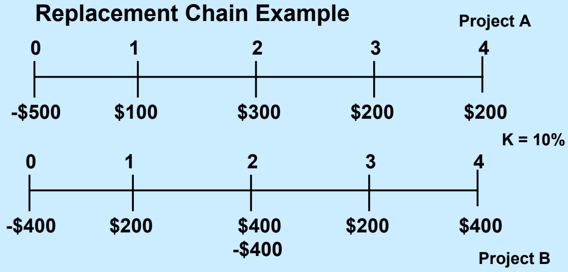
Project B **K = 10%**

0	1	2
-\$400	\$200	\$400

The initial NPV_A = \$125.71 and NPV_B = \$112.40, but since project B is repeated, you have to adjust the NPV

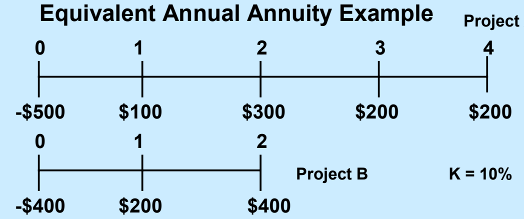
So equalize the lives of the projects. This would make Project A last 4 years and Project B lasts 4 years (repeating once). Then compute a new NPV for B based on 4 years.

Replacement Chain Example



The initial NPV_A = $125.71 and NPV_B = $112.40,
but since project B is repeated, the NPV Is also repeated.
So the actual NPV_B = $205.29 over the 4 years.
What's your decision?

Equivalent Annual Annuity Example



NPV_A = $125.71 NPV_B = $112.40

EAA_A = 125.71 / 3.1699 = $39.66
EAA_B = 112.40 / 1.7355 = $64.78

or PV = 125.71, i= 10, n = 4, and compute PMT
Which project do we prefer?

Corporate use of Capital Budgeting Methods

	Primary Technique	Secondary Technique	% Almost Always Use
IRR	65.3%	14.6%	75.6%
NPV	16.5%	30.0%	74.9%
Payback	5.0%	37.6%	56.7%
ARR	10.75	14.6%	30.3%
PI	na	na	11.9%
Other	2.5%	3.2%	na