Chapter Outline

- Introduction:
  - Capital Budgeting and its process
  - Important terms
- capital budgeting criterion
  1) Net Present Value.
  2) The Payback Rule.
  3) The Discounted Payback.
  4) The Average Accounting Return.
  5) The Internal Rate of Return.
  6) The Modified Internal Rate of Return,
  7) The Profitability Index.
- The Practice of Capital Budgeting.

Capital Budgeting – Investment Decision

- Capital Budgeting is the decision-making process used to identify long term investment projects that add to the value of the firm.
- Capital budgeting question is probably the most important issue in corporate finance.
- Process of allocating or budgeting capital is usually more involved than deciding whether to buy a particular fixed asset.
- Examples: should we launch a new product or enter a new market? Should we replace a fixed asset or not? Should we expand our production of a specific product?
- Steps:

1. Generating good investment projects
2. Developing reliable cash flow estimates for these projects.
3. **Determining if an investment is desirable (Comparison of costs versus benefits) This is the part we will cover this week.**

Important Terms
Mutually Exclusive vs. Independent Projects

- Mutually Exclusive Projects:
  - They have the same function, or use the same resources s,o they compete against one another.
  - The acceptance of one eliminates all other projects from consideration.
- Independent Projects:
  - The acceptance or rejection of one does not directly eliminate other projects from consideration

Important Terms
Unlimited vs. Limited Funds (Capital Rationing)

- Unlimited Funds:
  - When the firm has enough funds to invest in ALL projects that meet their capital budgeting criterion, they are said to be operating without a fund's constraint, or without capital rationing.
  - In the case of unlimited funds, all independent projects that provide positive return (meet their capital budgeting criterion) should be accepted.
  - With mutually exclusive projects the one that provides the highest positive return should be accepted. (only one should be accepted)
- Limited Funds or Capital Rationing:
  - When the total initial cost of all acceptable projects is greater than the total funds available to the firm to invest in capital projects.
- We will assume no funds constraints in the first part of our discussion of capital budgeting.

Important Terms
Conventional vs. Non-conventional Cash Flow Pattern

- Conventional Cash Flow Pattern:
  - A project with conventional cash flow pattern typically consists of an initial cash outflow followed by only a series of inflows.
- A non-conventional Cash Flow Pattern:
  - A project with non-conventional cash flow pattern typically has an initial outflow followed by a series of inflows and outflows (more than one change of direction)

Notations

- NPV = Net Present Value
- IRR = Internal Rate of Return
- PI = Profitability Index
- MIRR = Modified Internal Rate of Return
- IO = Initial Outlay
- CF_t = Cash Flow at time t
- r = Required Rate of Return (Discount Rate)

1. Net Present Value

- Imagine we are thinking of starting a business to produce and sell a new product—say, organic fertilizer. We can estimate the start-up costs with reasonable accuracy because we know what we will need to buy to begin production. Would this be a good investment?
- How should we estimate the value of our fertilizer business?

1. Estimate future cash flows we expect the business to product.
2. Apply basic discounted cash flow procedure to estimate the PV of those cash flows (from step 1).
3. Estimate NPV as the difference between the PV of the future cash flows and the cost of the investment.

- Recall, **discounted cash flow (DCF) valuation** is the process of valuing an investment by discounting its future cash flows.
- The task of coming up with the cash flows and the discount rate is much more challenging than the calculations of the criteria itself.
- Remember, NPV's are estimates!

Net Present Value (NPV)

- Net present value (NPV) compares the cash outlay to the present value of the cash flows from the project.
- NPV is the difference between an investment's market value and its cost (That is, a measure of how much value is created or added today by undertaking an investment).
- NPV is the most theoretically correct method.

$$Accept: NPV > 0$$
$$\text{Re } ject: NPV < 0$$

Net present value rule:

An investment should be accepted if the net present value is positive and rejected if it is negative.

$$NPV = \sum_{t=0}^{N} \frac{CF_t}{(1+i)^t} = \sum_{t=1}^{N} \frac{CF_t}{(1+r)^t} + (-CF_0) = \sum_{t=1}^{N} \frac{CF_t}{(1+i)^t} - IO$$

A positive NPV means that the project is expected to add value to the firm and will therefore increase the wealth of the owners.
Since our goal is to increase owner wealth, NPV is a direct measure of how well this project will meet our goal.

Example: Estimating NPV (Project Cash Flows ($000))

- Suppose we believe cash revenues from our fertilizer business will be $20,000 per year for 8 years. Cash costs (including taxes) will be $14,000 per year (after tax cash inflow = 20,000 - 14,000 = 6,000). We will wind down the business in eight years. The plant, property, and equipment will be worth $2,000 as salvage (after tax) at that time. The project costs $30,000 to launch. We use a 15% discount rate on new projects such as this one. Is this a good investment? If there are 1,000 shares of stock outstanding, what will be the effect on the price per share of taking this investment?

Time (years)	0	1	2	3	4	5	6	7	8
Initial cost	−$30								
Inflows		$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20
Outflows		−14	−14	−14	−14	−14	−14	−14	−14
Net inflow		$ 6	$ 6	$ 6	$ 6	$ 6	$ 6	$ 6	$ 6
Salvage									2
Net cash flow	−$30	$ 6	$ 6	$ 6	$ 6	$ 6	$ 6	$ 6	$ 8

Example: Estimating Net Present Value

$$NPV = \sum_{t=0}^{N} \frac{CF_t}{(1+i)^t} = \sum_{t=1}^{N} \frac{CF_t}{(1+r)^t} + (-CF_0) = \sum_{t=1}^{N} \frac{CF_t}{(1+i)^t} - IO$$

PV for 8 year annual Cash inflow

PV of the salvage in 8 years

$$\text{present value} = \$6000 \times \frac{\left[1 - \left(\frac{1}{1.15^8}\right)\right]}{.15} + \left(\frac{\$2000}{1.15^8}\right)$$

$$= (\$6000 \times 4.4873) + (\$2000 / 3.0590)$$

$$= \$26924 + 654$$

$$= \$27578$$

PV of future cash flows

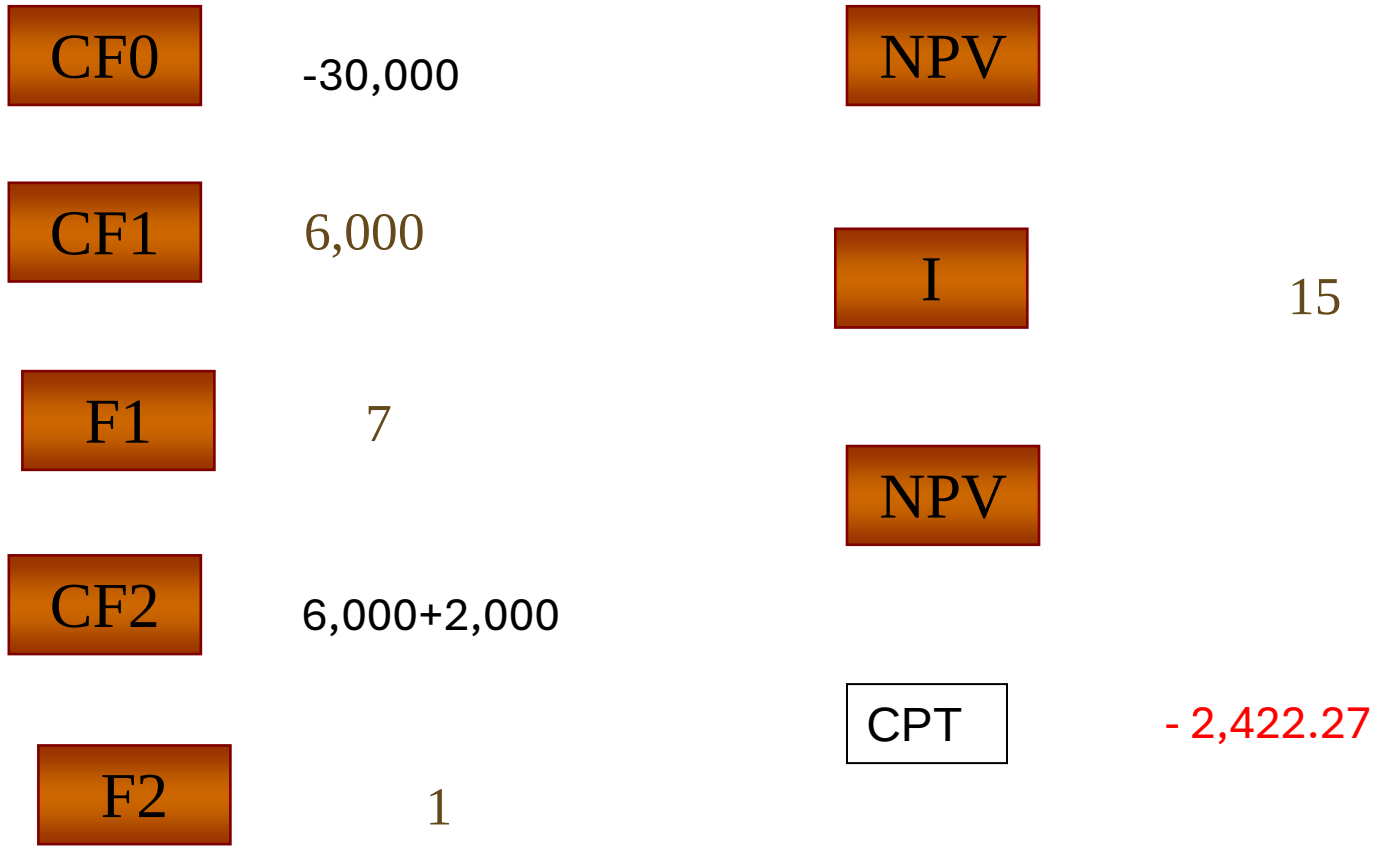
Cost today

Number of shares o/s

$$\text{NPV} = 27578 - 30000 = -\$2422$$

- **This is *not* a good investment!** Estimated impact of taking this project is a loss of value of $2,422 ÷ 1,000 = **$2.42 per share**

Use the cash flow menu: use enter and down arrow.



Example: Using the NPV Rule

Suppose we are asked to decide whether a new consumer product should be launched. Based on projected sales and costs, we expect that the cash flows over the five-year life of the project will be $2,000 in the first two years, $4,000 in the next two, and $5,000 in the last year. It will cost about $10,000 to begin production. We use a 10 percent discount rate to evaluate new products. What should we do here?

Given the cash flows and discount rate, we can calculate the total value of the product by discounting the cash flows back to the present:

$$\text{Present value} = \$2,000/1.1 + \$2,000/1.1^2 + \$4,000/1.1^3 + \$4,000/1.1^4 + \$5,000/1.1^5$$

$$= \$1,818 + 1,653 + 3,005 + 2,732 + 3,105$$

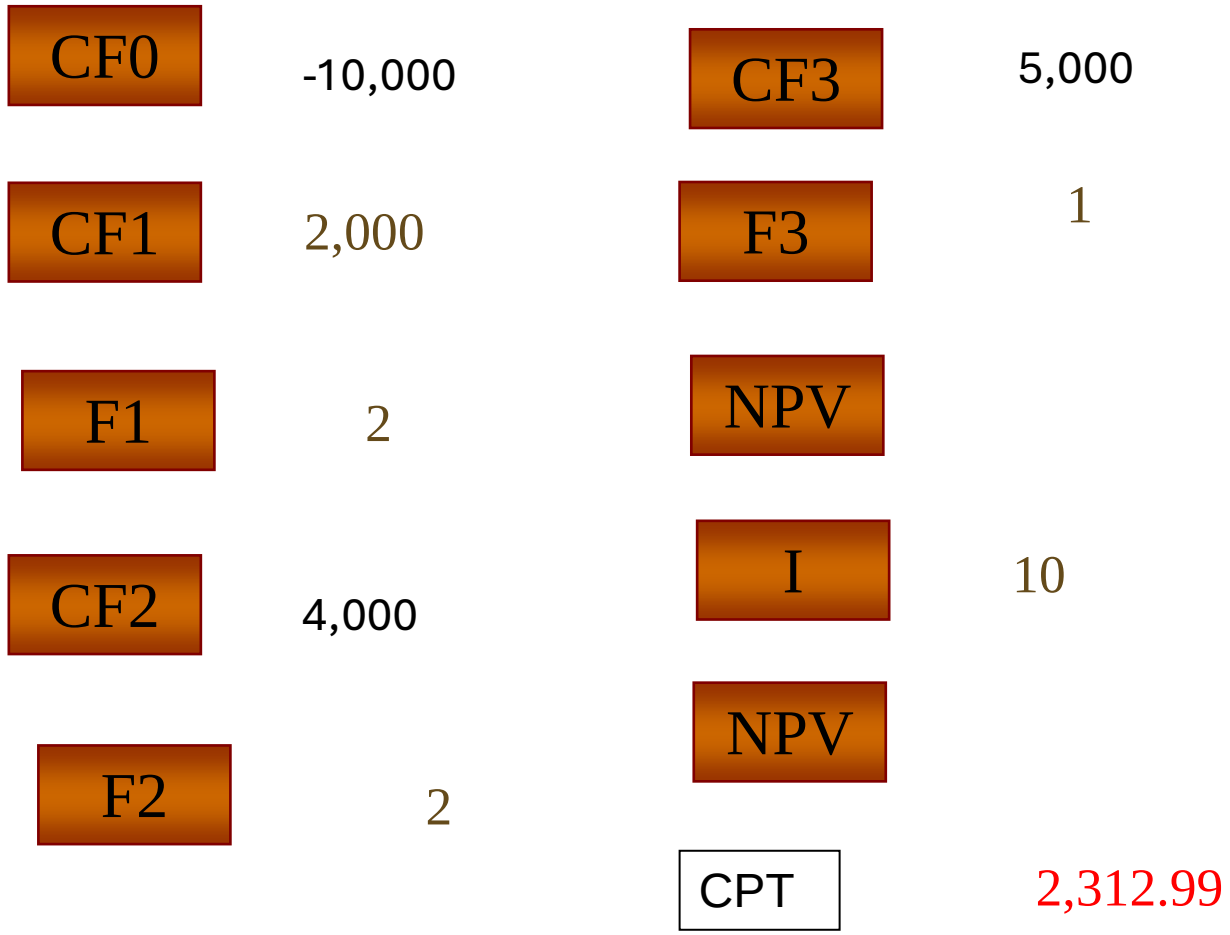
$$= \$12,313$$

The present value of the expected cash flows is $12,313, but the cost of getting those cash flows is only $10,000, so the

NPV is $12,313 − 10,000 = $2,313.

This is positive; so, based on the net present value rule, we should take on the project.

Use the cash flow menu: use enter and down arrow.



Practice: Using the NPV Rule

Your company is considering two projects L & S. Each will have a cost of $1,000 today and will generate the following cash flow over the next three years:

	L(long)	S(short)
Year 1	100	700
Year 2	600	500
Year 3	800	200
	($330.53)	($292.95)

Discount rate : 5%

Calculate NPV for each project.
Which projects if any should be accepted and why?

2. The Payback Rule

Payback period is the amount of time required for an investment to generate cash flows sufficient to recover its initial cost.

Based on the payback rule, an investment is acceptable if its calculated payback period is less than some prespecified number of years determined by management.

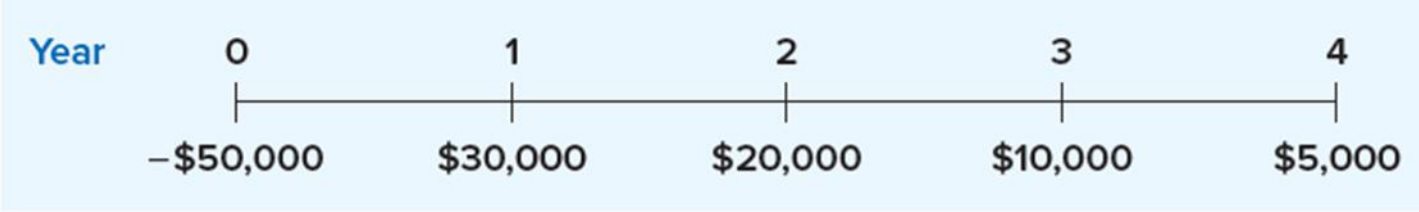
Example: The Payback Rule

Payback period is the amount of time required for an investment to generate cash flows sufficient to recover its initial cost. Payback period is a kind of "break-even" measure.

Based on the payback rule, an investment is acceptable if its calculated payback period is less than some prespecified number of years determined by management.

Below, find the cash flows from a proposed investment. How many years do we have to wait until the accumulated cash flows from this investment equal or exceed the cost of the investment?

- Initial investment is $50,000.
- After the first year, the firm has recovered $30,000, leaving $20,000.
- Cash flow in the second year is exactly $20,000, so payback period for this investment is **exactly two years.**



The Payback Rule

Table below, illustrates cash flows for five different projects.

- Figures shown as Year 0 cash flows are costs of the investments.

Year	A	B	C	D	E
0	−$100	−$200	−$200	−$200	−$ 50
1	30	40	40	100	100
2	40	20	20	100	−50,000,000
3	50	10	10	−200	
4	60		130	200	

Note the following:

- Payback for project A is easily calculated as 2.6 years.
- Project B never pays back.
- Project C has a payback of exactly 4 years.
- Project D has two different payback periods – 2 years and 4 years – both of which are correct.
- Project E pays back in 6 months.

The Payback Rule: Disadvantages

When compared to the NPV rule, the payback period rule has some rather severe shortcomings:

- Time value of money is completely ignored.
- Payback rule fails to consider any risk differences.
- It ignores cash flow beyond payback period
- No economic rationale for looking at payback in the first place, so we have no guide for how to pick the cutoff (It is basically an subjective arbitrary number set by management)

  - Suppose we have somehow decided on an appropriate payback period of two years or less. Consider the two investments, Long and Short, in the table below. Both projects cost $250.

Year	Long	Short
0	−$250	−$250
1	100	100
2	100	200
3	100	0
4	100	0

What is the payback on the two projects?

- The payback on Long is $\frac{250}{100} = 2.5$ years. oR $2 + \frac{(250-200)}{100} = 2.5$ years

cost

Sum of previous years accumulated cash to get to the 2 years

Following year cash

- The payback on Short is $1 + ((250 - \$100/\$200) = 1.75$ years.

cost

Sum of previous years accumulated cash to get to the 1 year

Following year cash

Is the payback period rule guiding us to the right decisions?

With a cutoff of two years, the payback period rule dictates that Short is acceptable and Long is not.

Year	Long	Short
0	−$250	−$250
1	100	100
2	100	200
3	100	0
4	100	0

- Suppose we require a 15% return on this type of investment.

$$\text{NPV}\left(\text{Short}\right) = -\$250 + \$100/1.15 + \$200/1.15^2 = -\$11.81$$

$$\text{NPV}\left(\text{Long}\right) = -\$250 + \$100 \times \left\{\left[1 - \left(1/1.15^4\right)\right]/.15\right\} = \$35.50$$

The NPV of Short is negative, while the NPV for Long is positive.

Using a payback period rule will tend to bias us toward shorter-term investments.

The Payback Rule's good qualities

Payback period rule is often used by large and sophisticated companies when they are making relatively minor decisions for the following reasons:

- Many decisions do not warrant detailed analysis because the cost of the analysis would exceed the possible loss from a mistake.
- Because it is biased toward short-term projects, it is biased toward liquidity.
- Cash flows that are expected to occur later in a project's life are probably more uncertain, and the payback period rule (in a crude sense) adjusts for the extra riskiness of later cash flows by ignoring them altogether.

The Payback Rule: Advantages and Disadvantages

Advantages	Disadvantages
1. Easy to understand.	1. Ignores the time value of money.
2. Adjusts for uncertainty of later cash flows. (Ignores cash flow beyond the payback period and timing of cash flow within the payback period)	2. Requires an arbitrary cut-off point.
3. Biased toward liquidity.	3. Ignores cash flows beyond the cut-off date.
	4. Biased against long-term projects, such as research and development, and new projects.

Practice: Using the Payback Period

Your company is considering two projects L & S. Each will have a cost of $1,000 today and will generate the following cash flow over the next three years:

	L(long)	S(short)
Year 1	100	700
Year 2	600	500
Year 3	800	200
	(2.38 years)	(1.6 years)

Discount rate : 5%

Calculate The payback period for each project assuming a cut-off of 2 years
Which projects if any should be accepted and why?

3. The Discounted Payback

- **Discounted payback** is the length of time required for an investment's discounted cash flows to equal its initial cost.

Based on the discounted payback rule, an investment is acceptable if its discounted payback is less than some prespecified number of years.

Example: Discounted Payback Period Rule

- Suppose we require a 12.5% return on new investments. We have an investment that costs $300 and has cash flows of $100 per year for five years. To get the discounted payback, we have to discount each cash flow at 12.5% and then start adding them.

Year	Cash Flow Undiscounted
1	$100
2	100
3	100
4	100
5	100

Cost: $300

Year	Cash Flow Undiscounted	Cash Flow Discounted	Accumulated Cash Flow Undiscounted	Accumulated Cash Flow discounted
1	$100	$89	$100	$ 89
2	100	79	200	168
3	100	70	300	238
4	100	62	400	301
5	100	55	500	356

Discounted payback period = 3 + (300-238)/301 = 3.06 years

Discounted payback is the time it takes to break even in an economic or *financial sense*.

In other words, we get our money back, **along with interest we could have earned elsewhere**, in four years.

If a project ever pays back on a discounted basis, then it must have a positive NPV when using same discount rate.

If we use discounted payback rule, we won't accidentally take any projects with negative estimated NPV.

Discounted payback Rule is rarely used in practice because it is not any simpler than NPV.

Discounted Payback Advantages and Disadvantages

- All things considered, the discounted payback is a compromise between a regular payback and NPV, lacking simplicity of the first and conceptual rigor of the second.
- Advantages and disadvantages of the discounted payback rule are summarized in the following table:

Advantages	Disadvantages
1. Includes time value of money.	1. May reject positive NPV investments.
2. Easy to understand.	2. Requires an arbitrary cut off point.
3. Does not accept negative estimated NPV investments.	3. Ignores cash flows beyond the cut off date.
4. Biased toward liquidity.	4. Biased against long-term investments, such as research and development, and new projects.

Practice: Discounted Payback Period

	L(long)	S(short)
• Year 0	-1000	-1000
• Year 1	100	700
• Year 2	600	500
• Year 3	800	200
	(2.52 years)	(1.74 years)

- Discount rate 5%
- Calculate the discounted payback period.
- Cutoff date 2 years.

4. The Average Accounting Return

Average accounting return (AAR) is an investment's average net income divided by its average book value.

There are different definitions of A A R, but in one form or another, the AAR is always defined as some measure of average accounting profit divided by some measure of average accounting value.

Based on the average accounting return rule, a project is acceptable if its average accounting return exceeds a target average accounting return.

$$\text{AAR} = \frac{\text{Average net income}}{\text{Average book value}}$$

Example: The Average Accounting Return

Suppose we are deciding whether to open a store in a new shopping mall. The required investment in improvements is $500,000. The store would have a five-year life because everything reverts to the mall owners after that time. The required investment would be 100% depreciated (straight-line) over five years (Book value zero at end of 5 years)

Projected Net Income over the next five years is given in this table >>>>>>>

Year	Net Income
1	100,000
2	150,000
3	50,000
4	0
5	50,000

$$\text{Average net income} = \frac{\$100000 + 150000 + 50000 + 0 + 50000}{5} = \$50000$$

We started out with a book value of $500,000 (the initial cost) and ended up at $0

$$\text{Average book value} = \frac{\$500000 + 0}{2} = \$250000$$

- Average accounting return is: $$AAR = \frac{\text{Average net income}}{\text{Average book value}} = \frac{\$\mathbf{50000}}{\$\mathbf{250000}} = .\mathbf{20} \text{ or } 20\%$$

If the firm has a target AAR of less than 20 percent, then this investment is acceptable; otherwise, it is not.

Average accounting return rule is:

Based on the average accounting return rule, a project is acceptable if its average accounting return exceeds a target average accounting return.

Issues with Average Accounting Return

- Use of this rule has a number of problems.
- Chief drawback is that the AAR is not a rate of return in any meaningful economic sense, but rather the ratio of two accounting numbers, and therefore is not comparable to the returns offered in financial markets.
- One reason A A R is not a true rate of return is that it ignores time value.

  - Lacks an objective cut-off period.

    Target AAR may be specified by calculating AAR for the firm as a whole and using this as a benchmark.

  - Does not look at cash flow and market value, but instead focuses on net income and book value, which are poor substitutes.

Average Accounting Return Advantages and Disadvantages

Advantages	Disadvantages
1. Easy to calculate.	1. Not a true rate of return; time value of money is ignored.
2. Needed information will usually be available.	2. Uses an arbitrary benchmark cut-off rate.
	3. Based on accounting (book) values, not cash flows and market values.

5. The Internal Rate of Return

Internal rate of return (IRR) is the discount rate that makes the NPV of an investment zero.

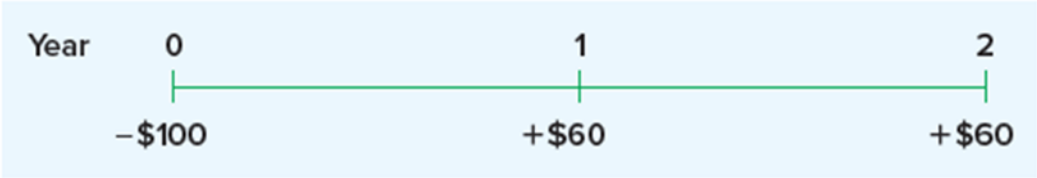
(Present value of future cash flow = Cost)

We want this rate to be an "internal" rate (i.e., it depends only on the cash flows of a particular investment, not on rates offered elsewhere).

Based on the IRR rule, an investment is acceptable if its IRR exceeds the required rate of return (cost of capital).

Example: The Internal Rate of Return

- Suppose you were now looking at an investment that costs $100 and has a cash flow of $60 per year for two years. What is the return on this investment?



Set the NPV equal to zero and solve for the discount rate:

- $NPV = 0 = -\$100 + \$60/(1+\text{IRR}) + \$60/(1+\text{IRR})^2$.

Only way to find IRR in general is by trial and error, either by hand or by calculator.

In this case, the cash flows form a two-period, $60 annuity. To find unknown rate, we can try different rates until we get the answer:

- At 0% rate, NPV = $120 − 100 = $20.

$$\text{At } 10\% \text{ discount rate, NPV} = -\$100 + \$60/1.1 + \$60/1.1^2 = \$4.13.$$

- These (and other possibilities) are summarized on the next slide.

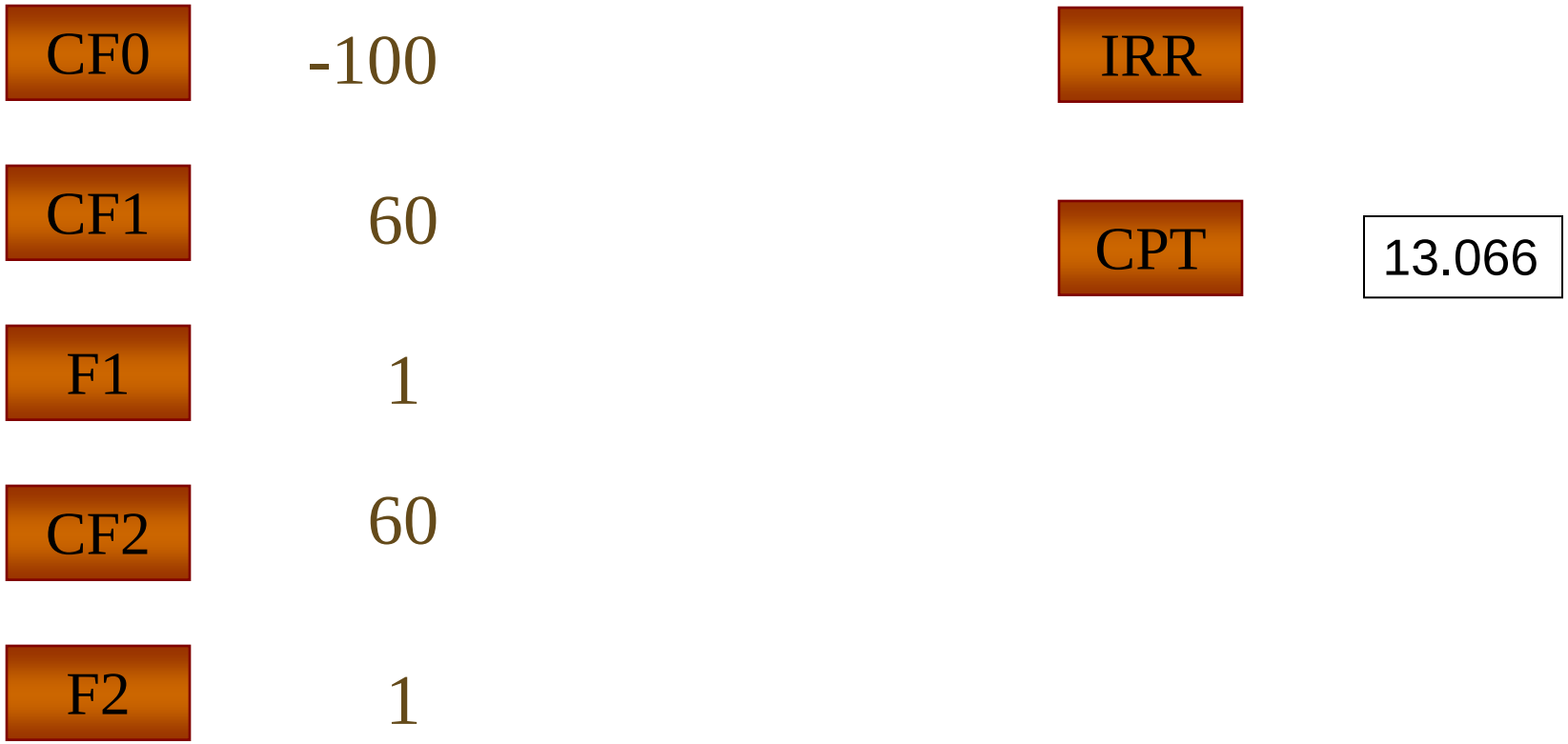
NPV appears to be zero with a discount rate between 10% and 15%, so the IRR is somewhere in that range.

- IRR is about 13.1%.

Discount Rate	NPV
0%	$ 20.00
5	11.56
10	4.13
15	– 2.46
20	– 8.33

- If our required return were less than 13.1%, we would take this investment, but if required return exceeded 13.1%, we would reject it.

Use the cash flow menu: use enter and down arrow.



Practice: IRR

	L(long)	S(short)
• Year 0	-1000	-1000
• Year 1	100	700
• Year 2	600	500
• Year 3	800	200
	(18.13%)	(23.56%)

- Cost of capital 10%
- Calculate IRR

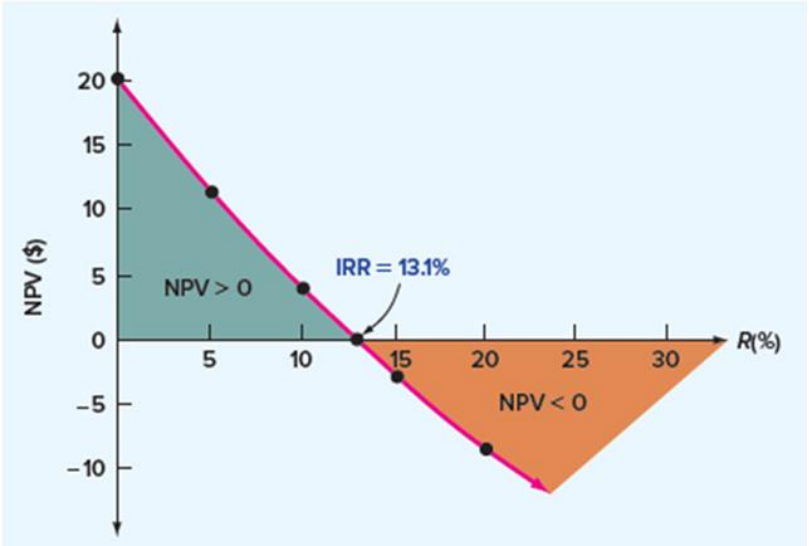
IRR and NPV

IRR rule and NPV rule lead to identical decisions if the following conditions are met:

- Project's cash flows must be conventional.
- Project must be independent (Not mutually exclusive).

Easiest way to illustrate relationship between NPV and IRR is to plot the numbers we calculated for the table on the previous slide.

Net present value profile is a graphical representation of relationship between an investment's NPV's and various discount rates.



Example: Calculating the IRR

A project has a total up-front cost of $435.44. The cash flows are $100 in the first year, $200 in the second year, and $300 in the third year. What's the IRR? If we require an 18 percent return, should we take this investment?

We'll describe the NPV profile and find the IRR by calculating some NPV's at different discount rates.

Discount Rate	NPV
0%	$164.56
5	100.36
10	46.15
15	.00
20	− 39.61

The NPV is zero at 15 percent, so 15 percent is the IRR. If we require an 18 percent return, then we should not take the investment. The reason is that the NPV is negative at 18 percent NPV is −$24.47. The IRR rule tells us the same thing in this case. We shouldn't take this investment because its 15 percent return is below our required 18 percent return.

Use the cash flow menu: use enter and down arrow.

CF0	- 435.44
CF1	100
F1	1
CF2	200
F2	1
CF3	300
F3	1
IRR	
CPT	15

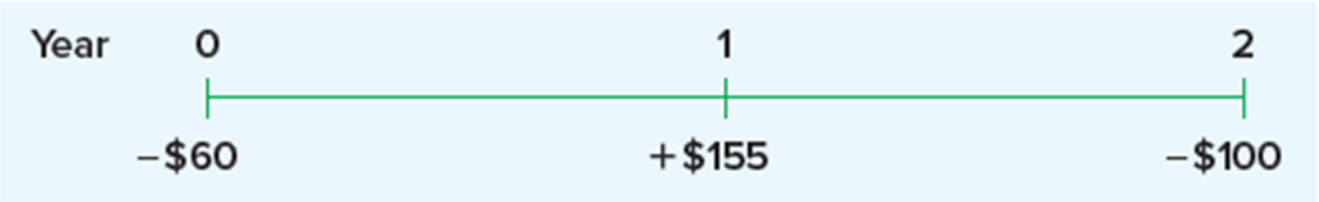
Problems with the IRR

Tow major practical problems when using IRR as a decision criteria:

a) When dealing with nonconventional cash flows.
   possibility of multiple IRRs or no IRR
b) When comparing mutually exclusive projects
   Ranking of projects can be different than ranking under NPV

a) Problems with the IRR: Nonconventional Cash Flows

- Suppose we have a strip-mining project that requires a $60 investment. Our cash flow in the first year will be $155. In the second year, the mine will be depleted, but we will have to spend $100 to restore the terrain.
- The cash flows for this project are shown below:



To find the IRR on this project, calculate the NPV at various rates:

Discount Rate	NPV
0%	−$5.00
10	− 1.74
20	− .28
30	.06
40	− .31

Use the cash flow menu: use enter and down arrow.

CF0	- 60
CF1	155
F1	1
CF2	-100
F2	1

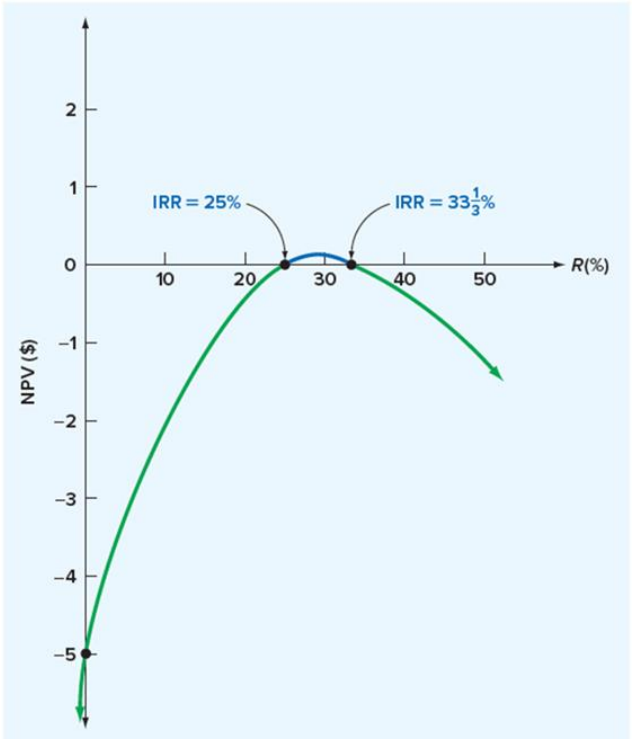
IRR

CPT 25

- What's the IRR? To find out, we draw the NPV profile.
- Notice the NPV is zero when the discount rate is 25%, as well as when it is 33.33%.

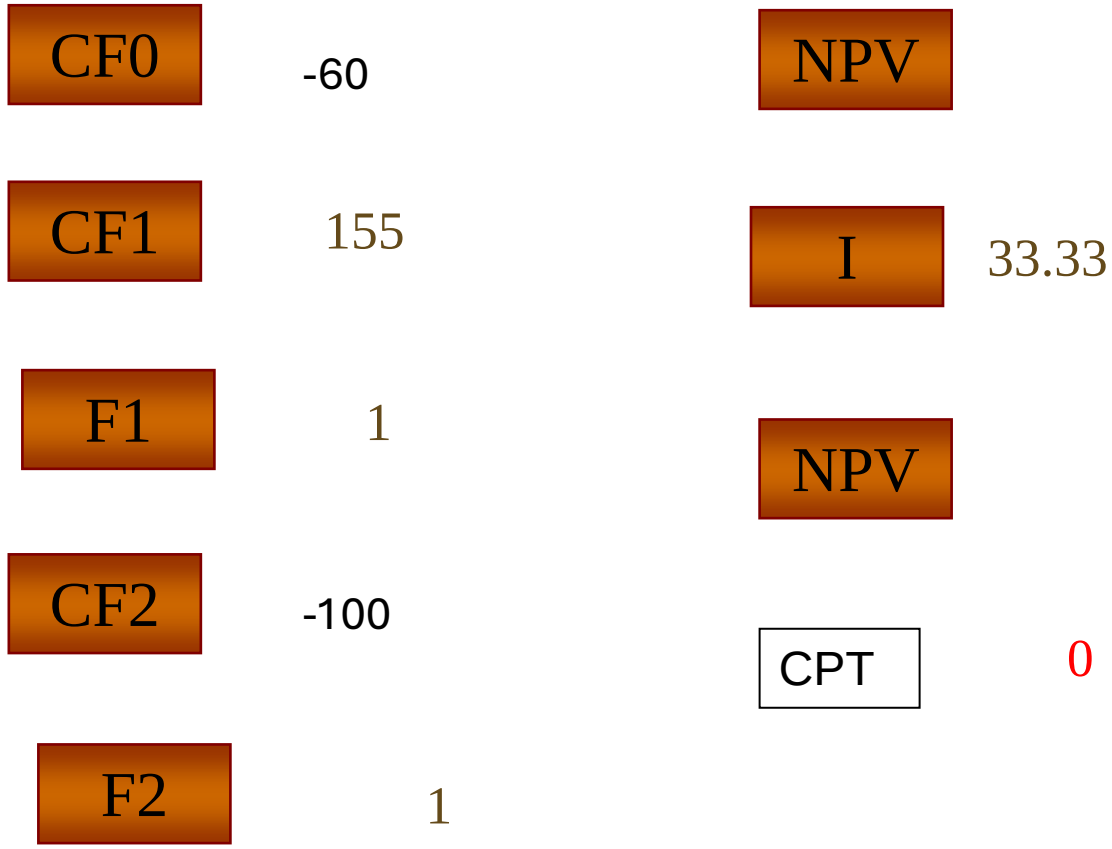
- Which of these is correct?
- Both or neither; there is no unambiguously correct answer.

- <u>Multiple rates of return problem is the possibility that more than one discount rate will make the NPV of an investment zero. This is often the case when cash flows are nonconventional.</u>
- We should take this investment only if our required rate of return is between 25% and 33.33%. (That is when NPV > 0)



To verify the value of the 2nd IRR, calculate NPV at 33.33%.

Remember that IRR is the rate that sets NPV to equal to zero.

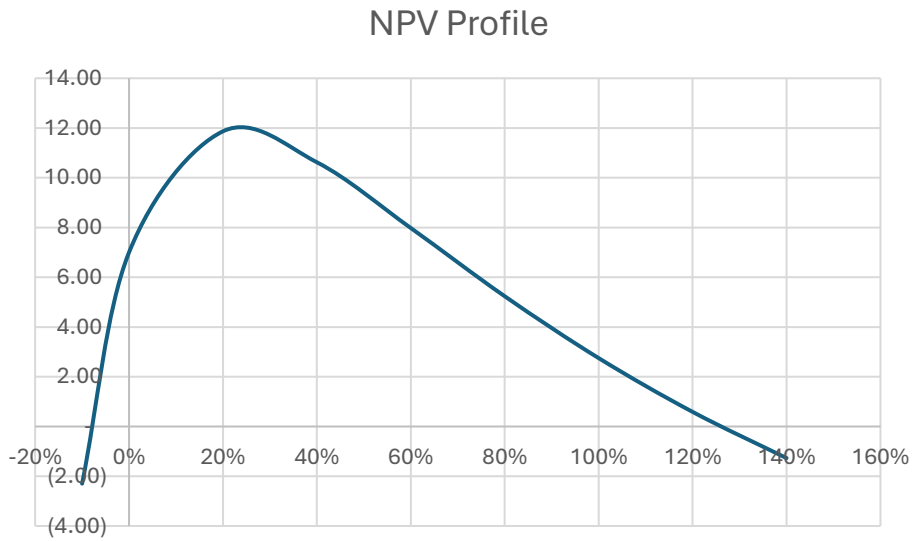


Practice: Multiple IRR

cost of capital		12%
year	cash	
0	(20,000.00)	
1	35,000.00	
2	30,000.00	
3	2,000.00	
4	(40,000.00)	

a) Calculate NPV. (at 12% NPV= $11,170
b) Calculate both IRRs (Note IRR can be negative) (-8.19%, 126%)

rate	NPV
-10%	(2.30)
0%	7.00
20%	11.87
40%	10.62
60%	7.98
80%	5.24
100%	2.75
120%	0.59
140%	(1.27)



Example: No IRR

You are looking at an investment that requires you to invest $51 today. You'll get $100 in one year, but you must pay out $50 in two years. What is the IRR on this investment?

You're on the alert now for the nonconventional cash flow problem, so you probably wouldn't be surprised to see more than one IRR. If you start looking for an IRR by trial and error, it will take you a long time. The reason is that there is no IRR. The NPV is negative at every discount rate, so we shouldn't take this investment under any circumstances. What's the return on this investment? Your guess is as good as mine.

Use the cash flow menu: use enter and down arrow.

CF0	- 51
CF1	100
F1	1
CF2	-50
F2	1

IRR

CPT

Error 7

What is the maximum number of IRRs?

We've seen that it's possible to get more than one IRR. If you wanted to make sure that you had found all of the possible IRR's, how could you do it?

In our example with the 25 percent and 33.33 percent IRR's, could there be yet another IRR? The cash flows flip from negative to positive, then back to negative, for a total of two sign changes. Therefore, the maximum number of IRR's is two, and we don't need to look for any more. Note that the actual number of IRR's can be less than the maximum.

b) Problems with the IRR: Mutually Exclusive Investments

Mutually exclusive investment decisions is a situation in which taking one investment prevents the taking of another.

- Two projects that are not mutually exclusive are *independent*.

Given two or more mutually exclusive investments, which one is the best? The best one is the one with the largest NPV.

- Consider the following cash flows from two mutually exclusive investments.

Year	Investment A	Investment B
0	−$100	−$100
1	50	20
2	40	40
3	40	50
4	30	60

Calculating IRR for project A

CF0	- 100
CF1	50
F1	1
CF2	40
F2	1
CF3	40
F3	1
CF4	30
F4	1

IRR

CPT 24

Calculating IRR for project B

CF0	- 100
CF1	20
F1	1
CF2	40
F2	1
CF3	50
F3	1
CF4	60
F4	1

IRR

CPT 21.03

Calculating NPV for A at 5%

CF0 -100

CF1 50

F1 1

CF2 40

F2 1

CF3 40

F3 1

CF4 30

F4 1

NPV

I 5

NPV

CPT 43.13

Calculating NPV for B at 5%

CF0 -100

CF1 20

F1 1

CF2 40

F2 1

CF3 50

F3 1

CF4 60

F4 1

NPV

I 5

NPV

CPT 47.88

	Investment A	Investment B
NPV @ 5%	$43.13	$47.88
IRR	24%	21.03%

	Investment A	Investment B
NPV @ 15%	$17.18	$14.82
IRR	24%	21.03%

Since A & B are mutually exclusive projects, only one can be accepted.
When using NPV method we would accept Project B (higher positive NPV)
When using IRR method we would accept Project A (higher IRR)
In this case NPV and IRR rank the two projects differently.

IRR for A (24%) is larger than the IRR for B (21%), but in comparing the NPV's, the higher NPV investment depends on our required return.

If our required return is 5%, B has the higher NPV, but if our required return is 15%, A has the higher NPV, and NPV and IRR would select the same project A.

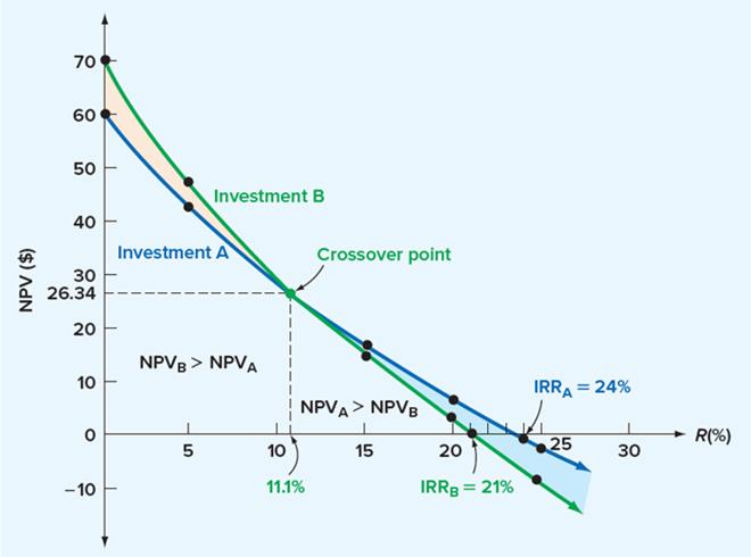
When we have mutually exclusive projects, we shouldn't rank them based on their returns (IRR). We should look at NPV and us it to rank projects and select the one with highest positive NPV

mutually exclusive investments can be illustrated by plotting the investments' NPV profiles.

- NPV profiles cross at about 11.07%.
- At any discount rate less than 11.1%, the NPV for B is higher.
- In this range, taking B benefits us more than taking A, even though A's IRR is higher.

- At any rate greater than 11.1%, Investment A has the greater NPV.

Discount Rate	NPV(A)	NPV(B)
0%	$60.00	$70.00
5	43.13	47.88
10	29.06	29.79
15	17.18	14.82
20	7.06	2.31
25	− 1.63	− 8.22



Calculating Crossover rate

- In the NPV profiles cross at about 11 percent. How can we determine just what this crossover point, exactly, is? The crossover rate, by definition, is the discount rate that makes the NPV's of two projects equal.
    1. Find cash flow differences between the projects (Incremental cash flows)
    2. Calculate IRR for these incremental cash flows.

    Can subtract A from B or vice versa
    NPV should be the same for both projects at the crossover rate. Difference in cash flows
    Incremental cash flows

Investement A	Investment B	Difference in cash flows Incremental cash flows A-B
-100	-100	0
50	20	30
40	40	0
40	50	-10
30	60	-30

Step 1 – find incremental cash flows between the two projects

Step 2 – find IRR for those cash flows

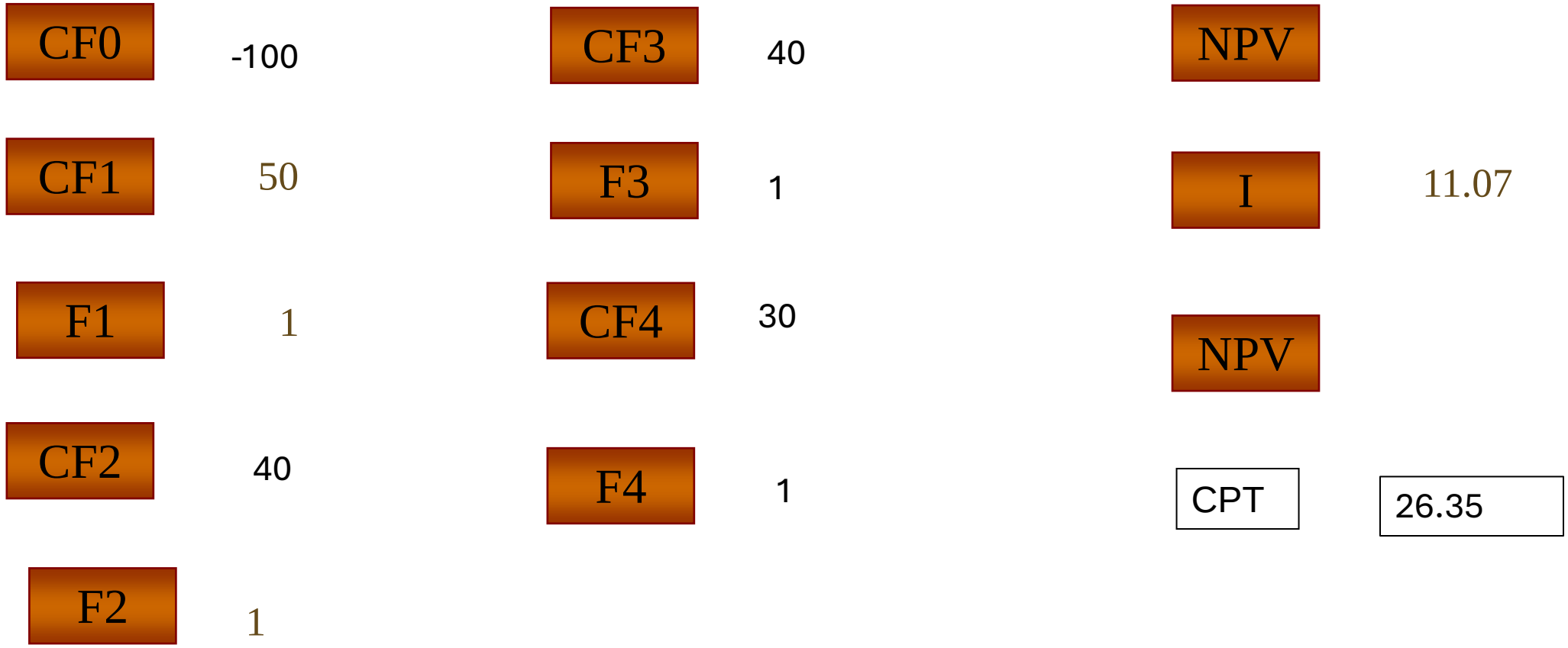
Calculating the crossover point (rate)

Find IRR for the incremental cash flows

CF0	0
CF1	30
F1	1
CF2	0
F2	1
CF3	-10
F3	1
CF4	-30
F4	1
IRR	
CPT	11.07

Calculating NPV at the crossover point (rate 11.07%) for project A

NPV (A) = NPV (B) at crossover



Calculating NPV at the crossover point (rate 11.07%) for project B

NPV (A) = NPV (B) at crossover

CF0	-100	CF3	50	NPV	
CF1	20	F3	1	I	11.07
F1	1	CF4	60	NPV	
CF2	40	F4	1	CPT	26.34
F2	1				

Practice – Mutually Exclusive projects and crossover point

	L(long)	S(short)
• Year 0	-1000	-1000
• Year 1	100	700
• Year 2	600	500
• Year 3	800	200

- Cost of capital 5%. Which project should you select? Why
- calculate the crossover point and NPV at the crossover. (8.68%, $223.22)

- From previous practice problem we found that:

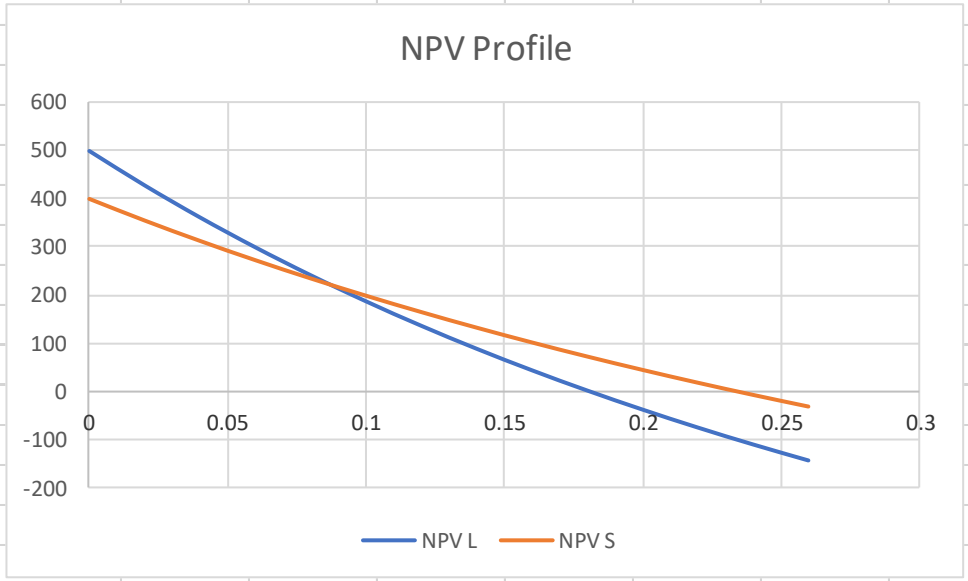
	L	S
NPV @ 5%	$ 330.53	$ 292.95
IRR	18.13%	23.56%

Finding crossover

L	S	Dif in cash flow
-1000	-1000	0
100	700	-600
600	500	100
800	200	600

Cost of ca	10%			
year	L	S		Incremental cash
0	-1000	-1000		0
1	100	700		-600
2	600	500		100
3	800	200		600
		Incremental IRR		8.68%

rate	NPV L	NPV S
0%	500.00	400.00
2%	428.60	355.32
4%	362.08	313.15
6%	300.03	273.30
8%	242.06	235.58
10%	187.83	199.85
12%	137.03	165.95
14%	89.38	133.76
16%	44.63	103.16
18%	2.56	74.04
20%	(37.04)	46.30
22%	(74.35)	19.84
24%	(109.55)	(5.40)
26%	(142.78)	(29.52)



Redeeming Qualities of the IRR

- Despite its flaws, the I R R is very popular in practice—more so than even the N P V.
- When analysing investments, people tend to prefer talking about rates of return rather than dollar values, and the I R R appears to provide a simple way of communicating information about a proposal.
- I R R may have a practical advantage over the N P V, as we can still estimate the I R R if we do not know the appropriate discount rate.

- Advantages and disadvantages of the I R R are summarized as follows:

Advantages	Disadvantages
1.Closely related to NPV, often leading to identical decisions, with few exceptions	1.May result in multiple answers or not deal with nonconventional cash flows.
2.Easy to understand and communicate.	2.May lead to incorrect decisions in comparisons of mutually exclusive investments.
3. Does not need a discount rate to calculate it	3.Does not differentiate between investing and financing projects

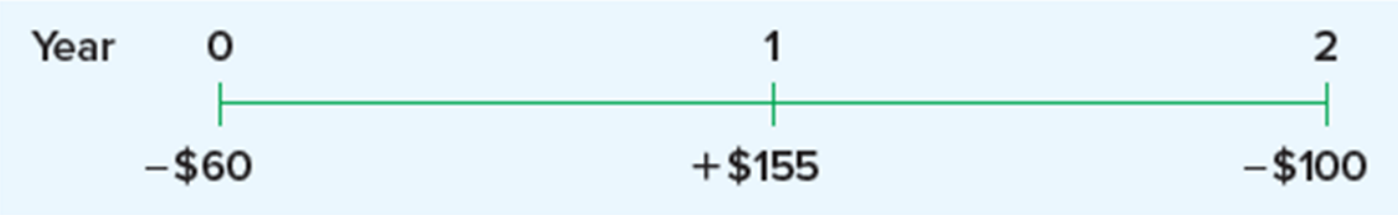
6) The Modified Internal Rate of Return (MIRR)

To address some of the problems that can crop up with the standard IRR, it is often proposed that a modified version be used.

There are several different ways to calculate a modified IRR, or MIRR, but basic idea is to modify the cash flows first and then calculate an IRR using the modified cash flows.

To illustrate, consider again the cash flows in an earlier example:

As discussed previously, there are two IRR's, 25% and 33.33%.



- Next, we will calculate three different MIRR's, all of which have the property that only one answer will result, eliminating the multiple IRR problem.

Method 1: The Discounting Approach

Discount all negative cash flows back to the present at the required return, add them to the initial cost, and then calculate the IRR.

Because only the first modified cash flow is negative, there will be only one IRR .

Discount rate used might be the required return, or it might be some other externally supplied rate.

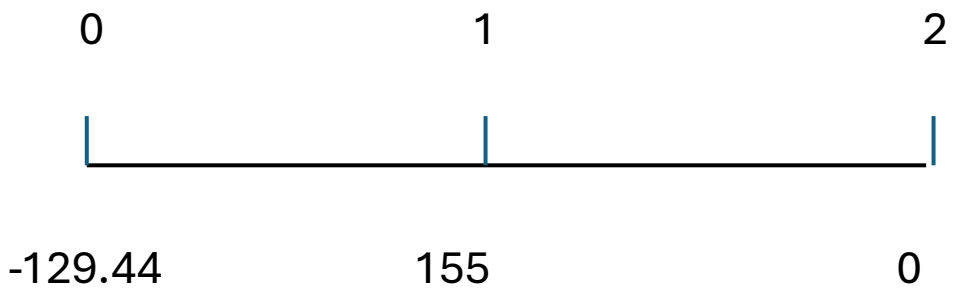
If the required return on the project is 20%, the modified cash flows look like this:

$$\text{Time } 0: -\$60 + \frac{-\$100}{1.20^2} = -\$129.44$$

$$\text{Time } 1: \$155$$

Time 2 : $ 0

- If you calculate the MIRR now, you should get 19.74%.



Calculate IRR for these new modified cash flows to get MIRR 19.75%

Modified IRR is the IRR for the new modified cash flows

CF0	-129.44
CF1	155
F1	1
CF2	0
F2	1

IRR

CPT

19.75

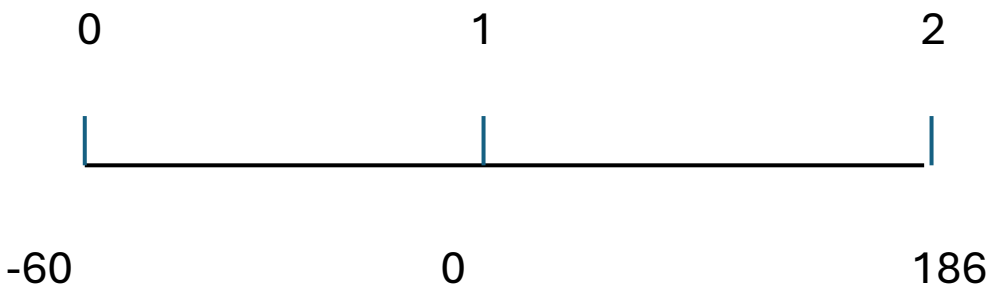
Method 2: The Reinvestment Approach

- Compound all cash flows (positive and negative) except the first outflow to the end of the project's life and then calculate the IRR.
- Rate we use could be the required return on the project, or it could be a separately specified "reinvestment rate".

Here are the modified cash flows:

- Time 0: – $60.
- Time 1: +0.
- Time 2: $-\$100 + (\$155 \times 1.2) = \$86.$

MIRR on this set of cash flows is 19.72%, a little lower than we got using the discounting approach.



Calculate IRR for these new modified cash flows to get MIRR (19.72%)

Method 3: The Combination Approach

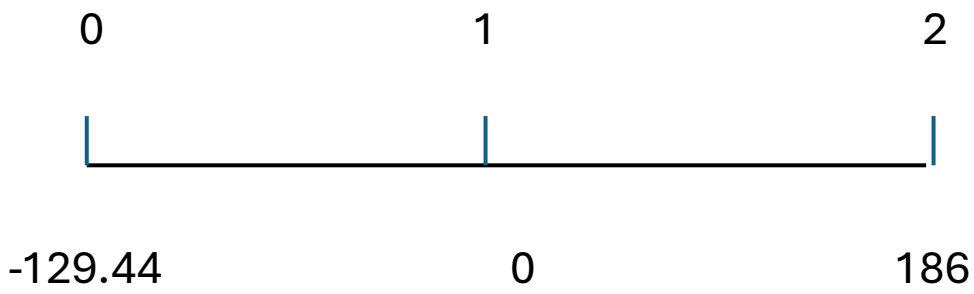
- Combination approach blends our first two methods.
- Negative cash flows are discounted back to the present, and positive cash flows are compounded to the end of the project.
- With the combination approach, the modified cash flows are as follows:

$$\text{Time } 0: -\$60 + \frac{-\$100}{1.20^2} = -\$129.44$$

$$\text{Time } 1: +0$$

$$\text{Time } 2: \$155 \times 1.2 = \$186$$

- MIRR is 19.87%, the highest of the three methods.



Calculate IRR for these new modified cash flows to get MIRR (19.86%)

MIRR vs. IRR

- MIRR's are controversial.
- On the bright side, by design, MIRR's don't suffer from the multiple rate of return problem.
- One disadvantage with MIRRs is that there are different ways of calculating them, and there is no clear reason to say one of the three methods is better than any other.
- Calculating an MIRR requires discounting, compounding, or both
- If we have the relevant discount rate, why not calculate the NPV and be done with it?
- Because an MIRR depends on an externally supplied discount (or compounding) rate, the answer you get is not truly an "internal" rate of return, which, by definition, depends on only the project's cash flows.

- MIRR can be used with nonconventional cash flows since there will be only one rate.
- MIRR cannot be used with mutually exclusive projects since it can still conflict with NPV.

7) The Profitability Index PI

Profitability index (That is, benefit-cost ratio) is the present value of an investment's future cash flows divided by its initial cost.

$$\text{PI} = \frac{PV\ of\ future\ cash\ flows}{Today's\ cost} = \frac{PV\$Benefits}{PV\$Cost}$$

If a project has a positive N P V, then the present value of the future cash flows must be bigger than the initial investment.

Profitability index will be bigger than 1 for a positive N P V investment and less than 1 for a negative N P V investment.

- if PI > 1 accept
- If PI < 1 reject

Advantages and Disadvantages of the Profitability Index

Advantages	Disadvantages
1. Closely related to NPV, generally leading to identical decisions.	1. May lead to incorrect decisions in comparisons of mutually exclusive investments.
2. Easy to understand and communicate.	
3. May be useful when available investment funds are limited.	

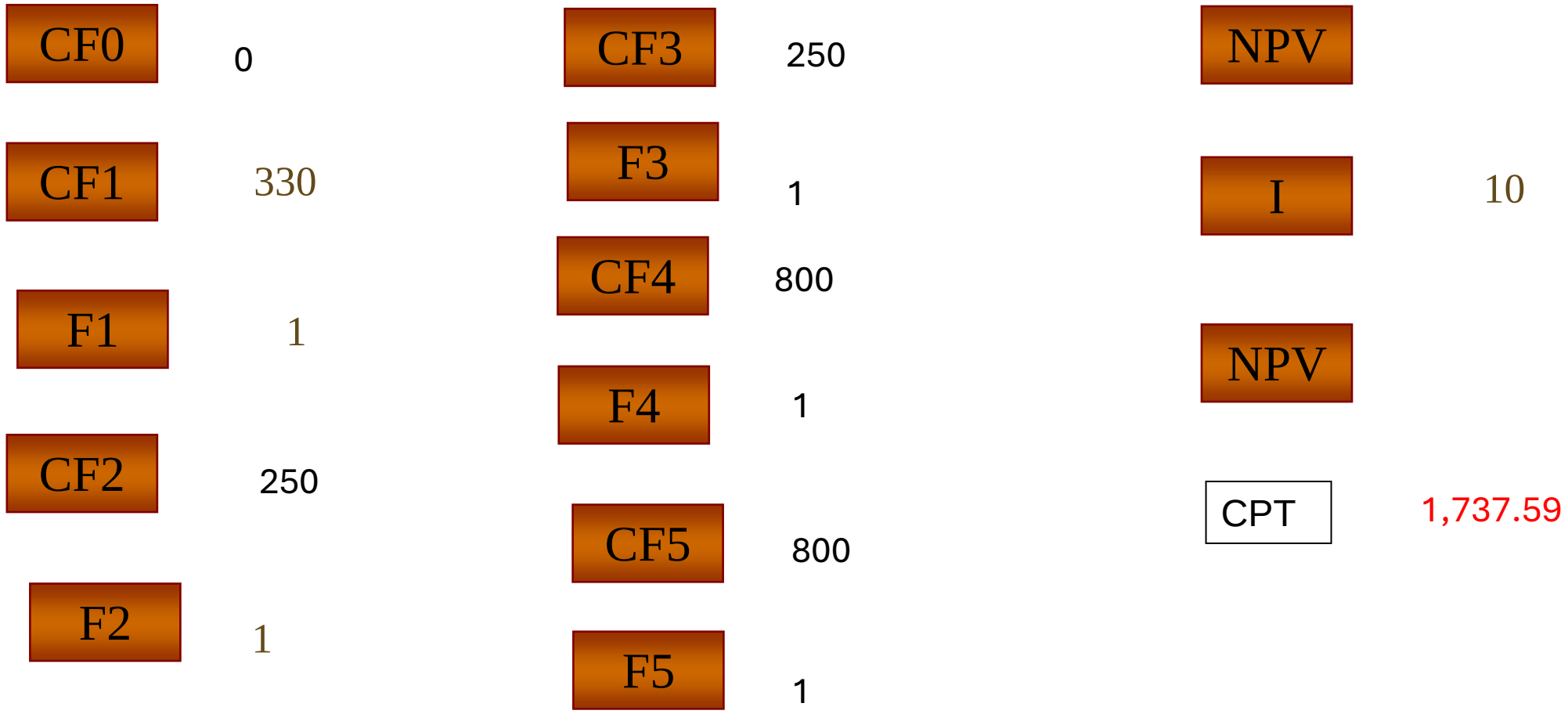
Example - PI

Consider a project that will cost $700 and generate the following cash flows over the next 5 years:

year	Cash flow
1	330
2	250
3	250
4	800
5	800

Use a discount rate of 10% to calculate PI

Step 1 : Calculate PV of future cash flows:



Step 2 divide PV of future cash flows by cost:

PI = 1,737.59/700 = 2.48

PI > 1 -----→ accept project

Practice: Profitability Index

	L(long)	S(short)
• Year 0	-1000	-1000
• Year 1	100	700
• Year 2	600	500
• Year 3	800	200
•	(1.33)	(1.29)

- Discount rate 5%
- Calculate PI for L and S

Discount rate	5%	
year	Project L	Project S
0	-1000	-1000
1	100	700
2	600	500
3	800	200
NPV	330.53	292.95
Payback period	2.38	1.6
Discounted payback period	2.52	1.74
IRR	18.13%	23.56%
PI	1.33	1.29

The Practice of Capital Budgeting

Given NPV seems to be telling us directly what we want to know, why are there are so many alternative procedures commonly used?

- In light of uncertainty about the future, we can only *estimate* the NPV, and the true NPV might be quite different.

Because the true NPV is unknown, financial managers should seek clues to help in assessing whether the estimated NPV is reliable.

Firms typically use multiple criteria for evaluating a proposal.

Large firms often have huge capital budgets.

- For 2023, ExxonMobil announced that it expected to have $23 to $25 billion in capital outlays during the year, up slightly from $22.7 billion in 2022.
- About the same time, Chevron announced planned investments of $15 to $17 billion in 2023, similar to the $16 billion it spent in 2022.
- Other companies with large capital spending budgets were General Motors, which projected capital spending of about $11 to $13 billion for 2023, and AT&T, which projected capital spending of about $24 billion for 2023.

Capital Budgeting Techniques in Practice

Percentage of CFO's Who Always or Almost Always Used a Given Technique in 2022.

Capital Budgeting Technique	Large Firms	Small Firm
Net present value (NPV)	77%	40%
Internal rate of return (IRR)	75	40
Payback period	64	66
Accounting rate of return	57	44
Profitability index	39	31

Summary of Investment Criteria
1. Discounted Cash flow Criteria:

A. *Net present value* (NPV): The NPV of an investment is the difference between its market value and its cost. The NPV rule is to take a project if its NPV is positive. NPV is frequently estimated by calculating the present value of the future cash flows (to estimate market value) and then subtracting the cost. NPV has no serious flaws; it is the preferred decision criterion.

B. *Internal rate of return* (IRR): The IRR is the discount rate that makes the estimated NPV of an investment equal to zero; it is sometimes called the discounted cash flow (DCF) return. The IRR rule is to take a project when its IRR exceeds the required return. IRR is closely related to NPV, and it leads to exactly the same decisions as NPV for conventional, independent projects. When project cash flows are not conventional, there may be no IRR or there may be more than one. More seriously, the IRR cannot be used to rank mutually exclusive projects; the project with the highest IRR is not necessarily the preferred investment.

C. *Modified internal rate of return* (MIRR): The MIRR is a modification to the I RR. A project's cash flows are modified by (1) discounting the negative cash flows back to the present, (2) compounding cash flows to the end of the project's life, or (3) combining (1) and (2). An IRR is then computed on the modified cash flows. MIRR's are guaranteed to avoid the multiple rate of return problem, but it is unclear how to interpret them; and they are not truly "internal" because they depend on externally supplied discounting or compounding rates.

D. *Profitability index* (PI): The PI, also called the benefit-cost ratio, is the ratio of present value to cost. The PI rule is to take an investment if the index exceeds 1. The PI measures the present value of an investment per dollar invested. It is quite similar to NPV; but, like IRR, it cannot be used to rank mutually exclusive projects. However, it is sometimes usedto rank projects when a firm has more positive NPV investments than it can currently finance.

Summary of Investment Criteria
2. Payback Criteria:

A. *Payback period*: The payback period is the length of time until the sum of an investment's cash flows equals its cost. The payback period rule is to take a project if its payback is less than some cutoff. The payback period is a flawed criterion, primarily because it ignores risk, the time value of money, and cash flows beyond the cutoff point.

B. *Discounted payback period*: The discounted payback period is the length of time until the sum of an investment's discounted cash flows equals its cost. The discounted payback period rule is to take an investment if the discounted payback is less than some cutoff. The discounted payback rule is flawed, primarily because it ignores cash flows after the cutoff.

Summary of Investment Criteria
3. Accounting Criteria

Average accounting return (AAR): The AAR is a measure of accounting profit relative to book value. It is not related to the IRR, but it is similar to the accounting return on assets (ROA) measure in Chapter 3. The A AR rule is to take an investment if its AAR exceeds a benchmark AAR. The AAR is seriously flawed for a variety of reasons, and it has little to recommend it.