FIN2010 Financial Management
Capital Budgeting Techniques

Example of Capital Budgeting

- Project: Open a restaurant in CUHK (SZ)

- Question: can I make money?
  … but what exactly does “make money” mean? Most of the projects require investment at the beginning and only generate cash flows in the future.
  - Today: how do we evaluate the profitability or a project with given cash flow?
  - Next two lecture: what is the cash flow of the project?
  - Then: what are the risks of the project and how do we account for the risks?

Agenda

- Evaluating a project
  - Net present value
  - Payback period
  - Discounted payback period
  - Internal rate of return
  - Profitability index
- Multiple projects
  - Mutually exclusive projects
  - Capital rationing

Our Case Study

- Suppose we plan to rent a spot on campus and provide food service. We have two choices. The cost of capital is 12% per year.

Time	Coffee shop CF	Sandwich shop CF
0	(20,000)	(20,000)
1	15,000	6,000
2	15,000	7,000
3	13,000	6,000
4	3,000	6,000

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NPV—Decision Rule

- ***If the NPV is non-negative, accept the project***

- A ***non-negative*** 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.

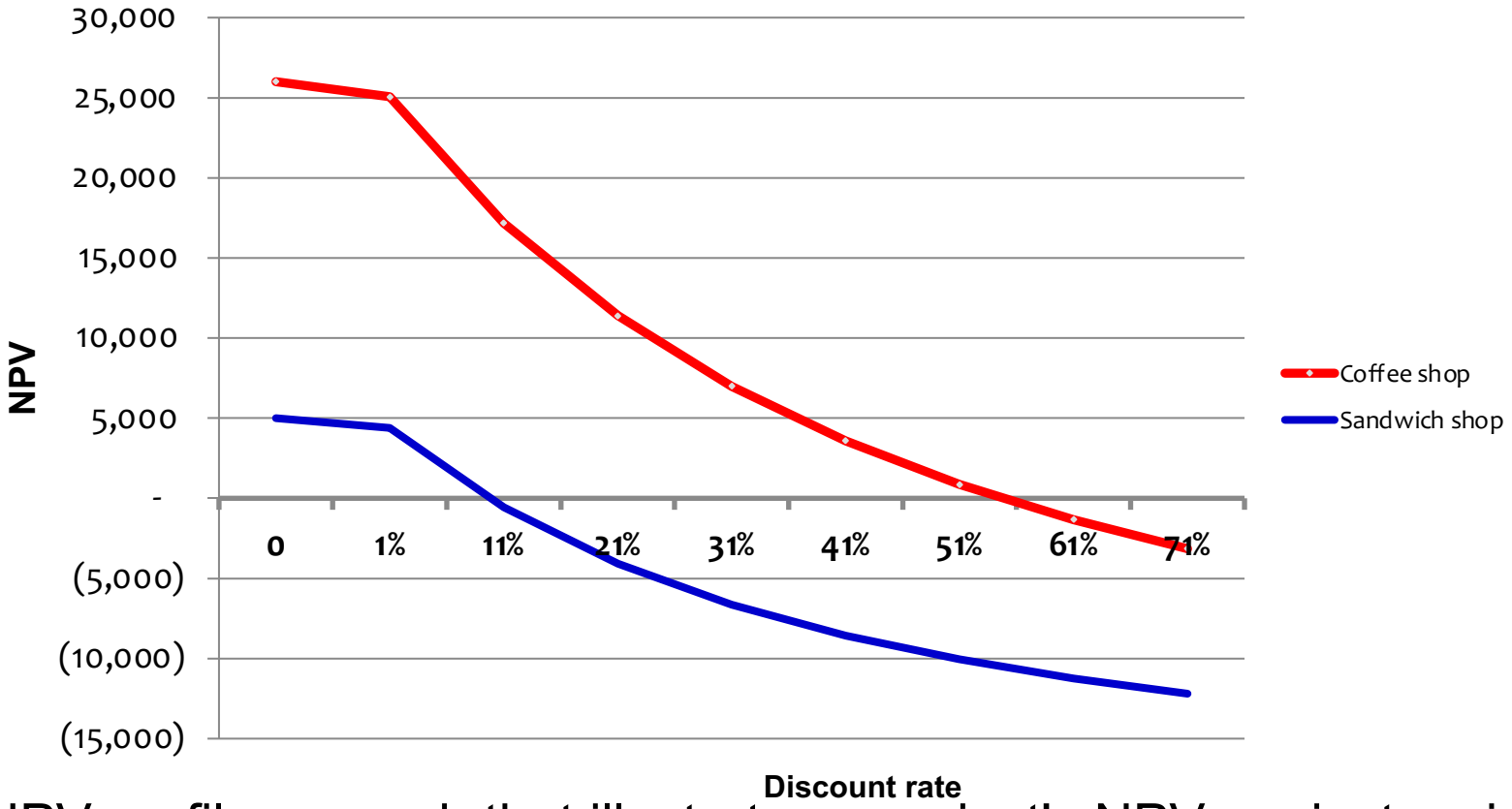
NPV—Computation

Time	*Time Discount*	Coffee shop CF	PV(CF)	Sandwich shop CF	PV(CF)
0	1	(20,000)	(20,000)	(20,000)	(20,000)
1	1.12^{-1}=0.893	15,000	13,393	6,000	5,357
2	1.12^{-2}=0.797	15,000	11,958	7,000	5,580
3	1.12^{-3}=0.712	13,000	9,253	6,000	4,271
4	1.12^{-4}=0.636	3,000	1,907	6,000	3,813
NPV			16,510		(979)

Based on the NPV decision rule, we should

- Accept the coffee shop project
- Reject the sandwich shop project

NPV Profile for the Project



NPV profile: a graph that illustrates a project's NPV against various discount rates, with the NPV on the y-axis and the cost of capital on the x-axis.

When future cash flows (CF1, CF2…) are all positive: Conditional on future cash flows, the higher discount rate, the lower NPV.

NPV—Pros and Cons

- **Advantages**
  - Easy to understand
  - Accounts for the time value of money
  - Offers information on the valued added by a project to the firm
- **Disadvantages**
  - Requires estimation of cost of capital
  - May not include managerial options embedded in the project (we will discuss this in topic 15)

Payback Period—Definition

How long does it take to get the initial cost back in a nominal sense?

- To compute,
  - Estimate the cash flows
  - Subtract the future cash flows from the initial cost until the initial investment has been recovered (i.e., the first time the cumulative CF turns positive)

- Decision Rule – ***Accept if the payback period is less than some preset limit***

Accept if the payback period is less than some preset limit

Payback Period—Computation

Suppose we want to recover the cost within 2 years.

Time	Coffee shop CF	Cumulative CF	Sandwich shop CF	Cumulative CF
0	(20,000)	(20,000)	(20,000)	(20,000)
1	15,000	(5,000)	6,000	(14,000)
2	15,000	10,000	7,000	(7,000)
3	13,000	23,000	6,000	(1,000)
4	3,000	26,000	6,000	5,000

- Coffee shop's **payback period** = less than 2 years
- Sandwich shop's **payback period** = less than 4 years

- We should accept the coffee shop and reject the sandwich shop according to the payback period rule!

Payback Period - Pros and Cons

- **Advantages**
  - Easy to understand
  - No need to forecast long term cash flows
- **Disadvantages**
  - Ignores the time value of money
  - Requires an arbitrary cutoff point
  - Ignores cash flows beyond the cutoff date
  - Biased against long-term projects, such as research and development

Discounted Payback Period—Definition

- Compute the ***present value*** of each cash flow and then determine how long it takes to pay back on a discounted basis

- Decision Rule - ***Accept the project if it pays back on a discounted basis within the specified time***

Computing Discounted Payback for the Project

Suppose we want to recover the cost within 2 years.

Time	Coffee shop CF	PV(CF)	Cumulative PV	Sandwich shop CF	PV(CF)	Cumulative CF
0	-20,000	-20,000	-20,000	-20,000	-20,000	-20,000
1	15,000	13,393	-6,607	6,000	5,357	-14,643
2	15,000	11,958	5,351	7,000	5,580	-9,063
3	13,000	9,253	14,604	6,000	4,271	-4,792
4	3,000	1,907	16,510	6,000	3,813	-979

- Coffee shop's **discounted payback period** = less than 2 years
- Sandwich shop's **discounted payback period** = more than 4 years

- We should accept the coffee shop and reject the sandwich shop according to the discounted payback period rule!

Discounted Payback Period—Pros and Cons

Advantages

- Includes time value of money
- Easy to understand
- Does not accept negative NPV projects when all future cash flows are positive

Disadvantages

- May reject positive NPV projects
- Requires an arbitrary cutoff point
- Ignores cash flows beyond the cutoff point
- Biased against long-term projects, such as R&D and new products

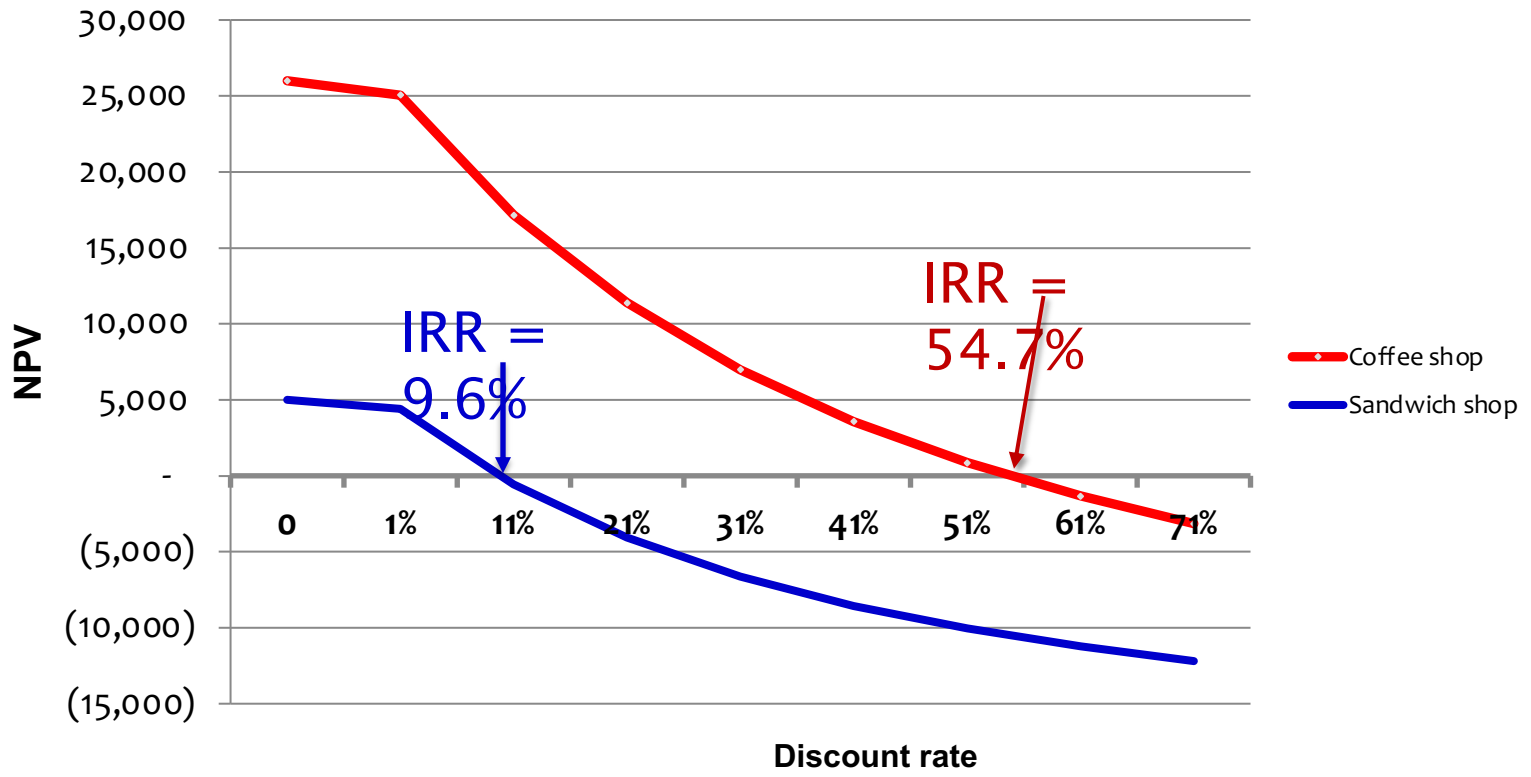
Internal Rate of Return (IRR)—Definition

- Definition: IRR is the return that makes the NPV = 0
- Decision Rule - ***Accept the project if the IRR is no less than a required rate of return***
  - This required rate of return is often called the ***hurdle rate***

- This is the most important alternative to NPV. It is often used in practice and is intuitively appealing.

IRR—Computation

- Computers use a trial-and-error process to find IRR
  - Guides on Excel and financial calculator at the end



- We should accept the coffee shop and reject the sandwich shop according to the IRR rule!

IRR—Caveats

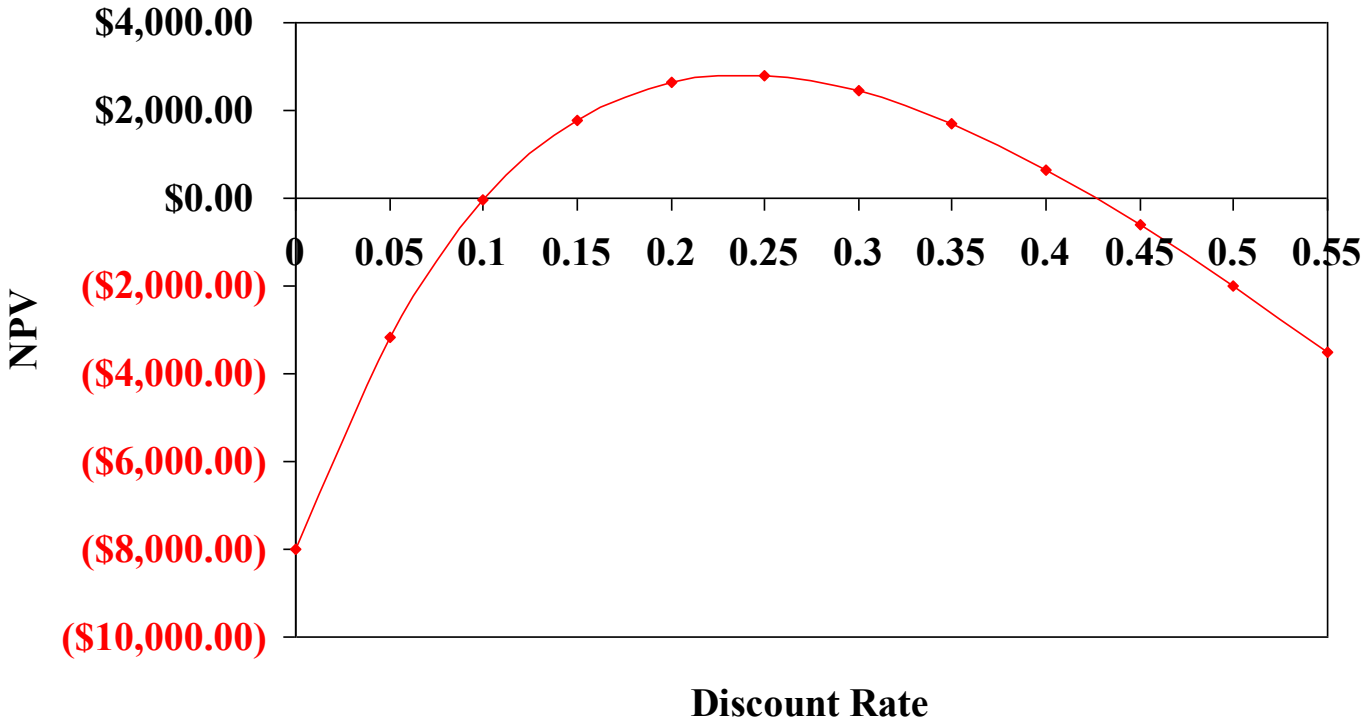
- NPV and IRR will generally give us the same result.
  - Given the required rate of return R, $NPV > 0 \Leftrightarrow IRR > R$
- However, if we have unconventionally cash flows, there might be multiple IRRs or no IRR.
  - Conventional cash flows: outflow first (investment), inflow later (profit). In this case, IRR is unique.
  - Unconventional cash flows: when cash flows switch signs more than once, IRR may not be unique!
  - Maximum possible IRRs = Number of times CFs change signs

Example—Multiple IRRs

- Consider a project with negative cash flow at the end

Time	CF
0	(90,000)
1	132,000
2	100,000
3	-150,000

- $IRR_1 = 10.11\%, IRR_2 = 42.66\%$



Which IRR should we use?

- None!

- When evaluating a project with non-conventional cash flow, you should not use IRR at all.
  - IRR tries to answer the question: what is the rate of return given my initial investment and future profits.
  - If the cash flows do not fit this pattern, then IRR becomes difficult to interpret.

IRR—Pros and Cons

Advantages

- Generates a rate of return (so does not require you to estimate a required of return)
- Easy to compare between projects
- Accounts for the time value of money
- Closely related to NPV, often leading to identical decisions

Disadvantages

- Difficult to calculate
- Does not offers information on the valued added of a project
- May have multiple IRRs

Profitability Index—Definition

- Definition: PI = NPV / Initial Investment + 1
- Decision rule - ***Accept the project if PI is no less than 1***
  - This is the same as NPV≥0

- Measures the benefit per unit cost, based on the time value of money
- A profitability index of 1.1 implies that for every $1 of investment, we create an additional $0.10 in value
- This measure can be very useful in situations in which we have limited capital

Profitability Index—Computation

Time	Coffee shop CF	PV(CF)	Sandwich shop CF	PV(CF)
0	(20,000)	(20,000)	(20,000)	(20,000)
1	15,000	13,393	6,000	5,357
2	15,000	11,958	7,000	5,580
3	13,000	9,253	6,000	4,271
4	3,000	1,907	6,000	3,813
NPV		16,510		(979)
Investment		20,000		20,000
PI		1.8255		0.9511
		$=\frac{16510}{20000}+1$		$=\frac{-979}{20000}+1$

Based on the profitability index decision rule, we should

- Accept the coffee shop project
- Reject the sandwich shop project

Profitability Index—Pros and Cons

- **Advantages**
  - Closely related to NPV, generally leading to identical decisions
  - Easy to understand and communicate
  - May be useful when available investment funds are limited
- **Disadvantages**
  - Does not provide information on value creation
  - Cannot be used on project with unconventional cash flows

Summary of Decisions for the Project

Criteria	Benchmark	Coffee shop	Sandwich
Net Present Value	0	16510	-979
Payback Period	2	<2	<4
Discounted Payback Period	2	<2	>4
Internal Rate of Return	12%	54.7%	9.6%
Profitability Index	1	1.83	0.95

Survey evidence on the use of capital budgeting methods

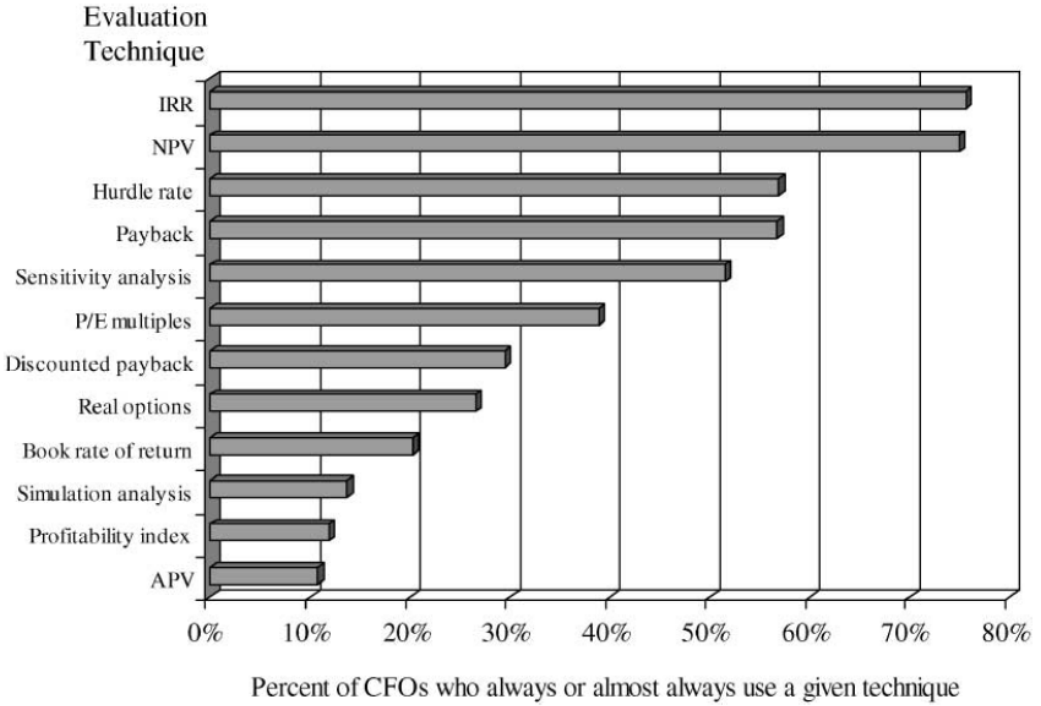


Fig. 2. Survey evidence on the popularity of different capital budgeting methods. We report the percentage of CFOs who always or almost always use a particular technique. IRR represents internal rate of return, NPV is net present value, *P/E* is the price-to-earnings ratio, and APV is adjusted present value. The survey is based on the responses of 392 CFOs.

- Source: Graham, J.R. and Harvey, C.R. (2001) The Theory and Practice of Corporate Finance: Evidence from the Field. Journal of Financial Economics, 60, 187-243.

Agenda

- Evaluating a project
  - Net present value
  - Payback period
  - Discounted payback period
  - Internal rate of return
  - Profitability index
- Multiple projects
  - Mutually exclusive projects
  - Capital rationing

Mutually Exclusive Projects

- So far we discussed whether to accept one single project
- Some projects are ***mutually exclusive***
  - If you choose one, you can't choose the other
  - E.g., you can choose to attend university at either CUHK (Shenzhen) or Southern University of Science and Technology, but not both

- Intuitively, you would use the following decision rules:
  - NPV – choose the project with the higher NPV
  - IRR – choose the project with the higher IRR
  - PI – choose the highest PI

- When the rules yield different rankings, the NPV decision rule should be followed. Potential reasons for conflict:
  - Scale of Investment
  - Cash-flow Pattern

Why Disagreement—Scale Difference

Compare a small (S) and a large (L) project. R=10%

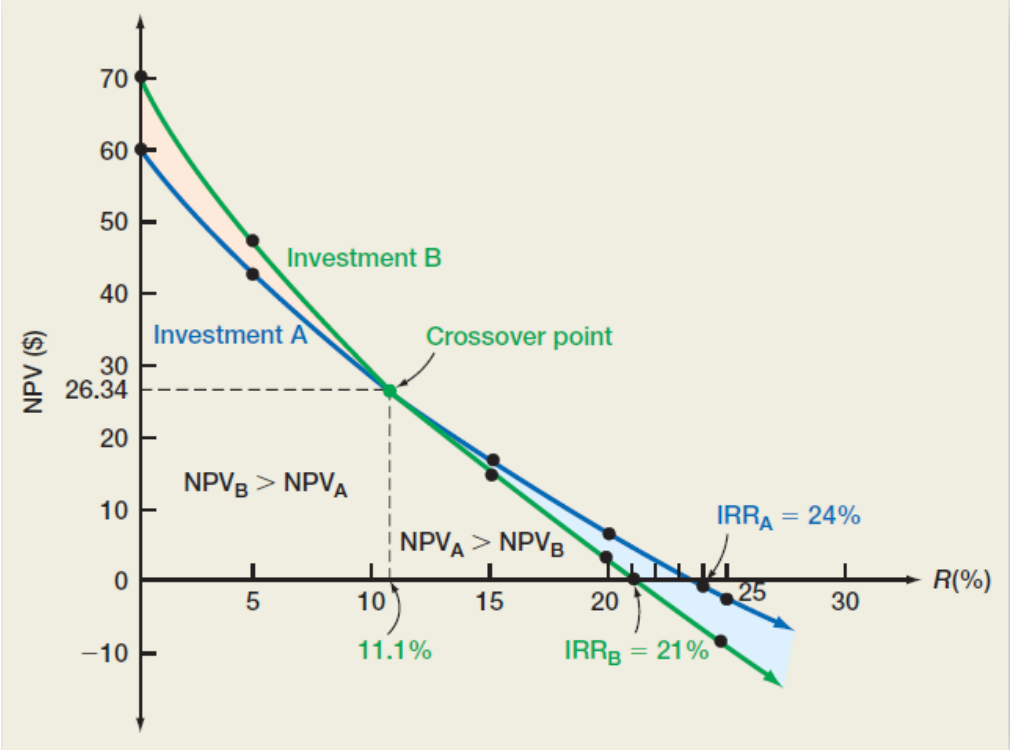
END OF YEAR	NET CASH FLOWS Project S	Project L
0	-$100	-$100,000
1	0	0
2	$400	$156,250
	IRR: 100%	**25%**
	NPV: $231	**$29,132**
	PI: 3.31	**1.29**

- Based on your intuition, which one should you choose?
  - L is better because it creates more value for the investment opportunity. IRR and PI methods fail to consider the magnitude of projects

Why Disagreement—Different Cash Flow Patterns

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

	Investment A	Investment B
IRR	24%	21%
NPV @ 9%	$20.06	$30.39
PI	1.20	1.30



IRR rule: choose A.

NPV rule: decision varies with r

- If the cost of capital is [0,11.1%], choose B
- If the cost of capital = 11.1%, indifferent between A and B
- If the cost of capital > 11.1%, choose A

What should We Do with Conflicting Results?

- Always follow the NPV rule for mutually exclusive projects!
  - Goal: maximize the firm's value
  - Therefore, we should choose the 1 project that adds the most value given our project's cost of capital.

Capital Rationing

- *Capital Rationing* occurs when a constraint (or budget ceiling) is placed on the total size of capital expenditures during a particular period.
  - Example: a company only has $32,500, and can take any combination of the following 8 projects:

Project	Investment	IRR	NPV	PI
A	500	18%	50	1.1
B	5000	25%	6500	2.3
C	5000	37%	5500	2.1
D	7500	20%	5000	1.67
E	12500	26%	500	1.04
F	15000	28%	21000	2.4
G	17500	19%	7500	1.43
H	25000	15%	6000	1.24

Choosing Projects with Highest NPVs

Project	Investment	IRR	NPV	PI
F	15000	28%	21000	2.4
G	17500	19%	7500	1.43
B	5000	25%	6500	2.3
H	25000	15%	6000	1.24
C	5000	37%	5500	2.1
D	7500	20%	5000	1.67
E	12500	26%	500	1.04
A	500	18%	50	1.1

Projects ranked according to NPV

Budget: $32,500

- Projects F and G have highest NPVs and they are chosen
- Increase in shareholder's value: **$28,500**

Choosing Projects with Highest IRRs

Project	Investment	IRR	NPV	PI
C	5000	37%	5500	2.1
F	15000	28%	21000	2.4
E	12500	26%	500	1.04
B	5000	25%	6500	2.3
D	7500	20%	5000	1.67
G	17500	19%	7500	1.43
A	500	18%	50	1.1
H	25000	15%	6000	1.24

Projects ranked according to IRR

Budget: $32,500

- Projects C, F and E have highest IRRs and they are chosen
- Increase in shareholder's value: **$27,000**

Choosing Projects with Highest PIs

Project	Investment	IRR	NPV	PI
F	15000	28%	21000	2.4
B	5000	25%	6500	2.3
C	5000	37%	5500	2.1
D	7500	20%	5000	1.67
G	17500	19%	7500	1.43
H	25000	15%	6000	1.24
A	500	18%	50	1.1
E	12500	26%	500	1.04

Projects ranked according to PI

Budget: $32,500

- Projects F, B, C and D have highest PIs and they are chosen
- Increase in shareholder's value: **$38,000**

Horserace of Different Selection Criteria

Method	Projects Selected	Value Added
PI	F, B, C, D	$38,000
NPV	F, G	$28,500
IRR	C, F, E	$27,000

- PI generates the greatest increase in shareholder wealth when a limited capital budget exists for a single period.

Summary

- Net Present Value
- Payback Period
- Discounted Payback Period
- Internal Rate of Return
  - Multiple IRR problem
- Profitability Index

Evaluating a single project

- Mutual exclusive projects
  - Always use NPV!
- With limited capital
  - Sort by PI

When dealing with multiple projects