

# Capital Budgeting

## Definition

Planned Expenditure on Long-term Assets (including intangibles)

## Issue

Which investment projects should be accepted?

## Importance

Wealth Creation

Strategic—determines industry

Prolonged consequences

Survival and Growth

Large expenditures—outside financing

## Purpose

Maximize shareholder wealth by investing in all projects which are *worth more than they cost*, i.e., for which

$$PV(\text{benefits}) > PV(\text{costs})$$

# Project Analysis

## Process

Parallel to security valuation:

1. Estimate project's cash flows
2. Estimate cash flows' risk and determine required return
3. Compare PVs of inflows and outflows
4. Accept project if  $PV(\text{cash inflows}) > PV(\text{cash outflows})$

Note: These investment opportunities are often *created*

## Other Uses for these Techniques

Mergers and Acquisitions

Spinoffs (Disinvestment)

Bond Refunding

Lease-Purchase Analysis

# Investment Decision Rules

## Requirements

To be worth using, a rule must:

- consider *all* of a project's cash flows and *only* its cash flows
- use appropriate discount rate (opportunity cost, from market)
- properly handle *mutually exclusive* projects

## Mutual Exclusion

If two projects are independent, can take both

If two projects are mutually exclusive, must choose one (require ranking)

- May arise due to redundancy or capital rationing
- Very common

## Selected Rules

Accounting (Book) Rate of Return

Payback Period

Discounted Payback Period

Net Present Value (NPV) ★

Profitability Index (PI)

Internal Rate of Return (IRR)

Modified Internal Rate of Return (MIRR)

Discounted-Cash-Flow (DCF) methods

# Payback Period

$$0 = \sum_{t=0}^{PP} CF_t$$

Year	Expected Cash Flows		Cumulative Cash Flow	
	Project A	Project B	Project A	Project B
0	(10,000)	(10,000)	(10,000)	(10,000)
1	6,000	5,000	(4,000)	(5,000)
2	4,000	5,000	0	0
3	3,000		3,000	0
4	2,000		5,000	0
5	1,000		6,000	0

# Discounted Payback Period

$$0 = \sum_{t=0}^{\text{DPP}} \frac{CF_t}{(1 + \text{MCC})^t}$$

MCC = 10%

Year	Expected Cash Flows		Cumulative PV	
	Project A	Project B	Project A	Project B
0	(10,000)	(10,000)	(10,000)	(10,000)
1	6,000	5,000	(4,545)	(5,455)
2	4,000	5,000	(1,240)	(1,322)
3	3,000		1,014	(1,322)
4	2,000		2,380	(1,322)
5	1,000		3,001	(1,322)

# Net Present Value (NPV)

## Definition

$$\mathbf{NPV} = PV(\text{cash inflows}) - PV(\text{cash outflows})$$

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

## Decision Rule

Accept project if its  $\mathbf{NPV} \geq 0$

# Internal Rate of Return (IRR)

## Definition

IRR is that (hypothetical) discount rate which forces

$$PV(\text{cash outflows}) = PV(\text{cash inflows})$$

$$0 = NPV$$

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

## Decision Rule

Accept project if its  $IRR \geq MCC$

Note: Same as YTM

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

# Modified Internal Rate of Return (MIRR)

## Definition

MIRR is that (hypothetical) discount rate which forces

PV (cash outflows) = PV (terminal value)

$$\sum_{t=0}^n \frac{COF_t}{(1 + \text{discount rate})^t} = \frac{\sum_{t=0}^n CIF_t (1 + \text{reinvestment rate})^{n-t}}{(1 + \mathbf{MIRR})^n}$$

## Decision Rule

Accept project if its  $\text{MIRR} \geq \text{MCC}$

Note: Can use different discount and reinvestment rates

# Relationship between NPV, IRR and PI

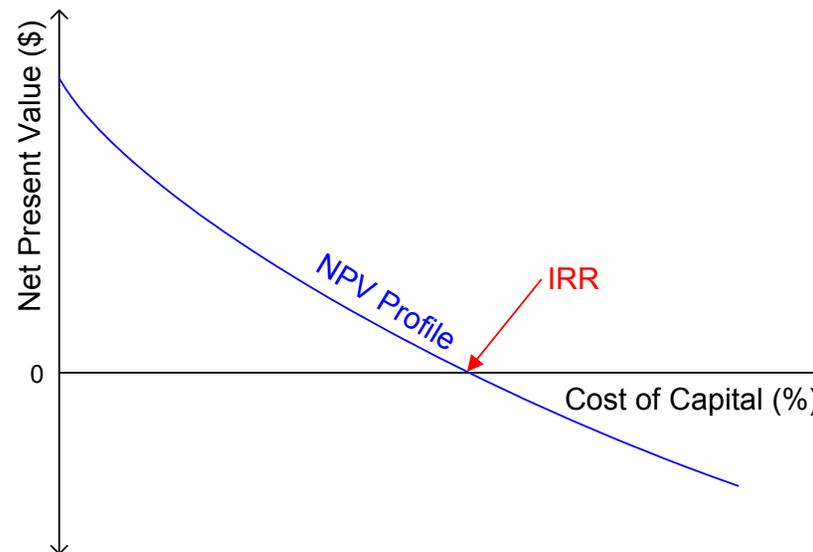
## NPV and PI

If  $NPV \geq 0$ , then  $PI \geq 1$

$$PI = \frac{NPV + PV(\text{cash outflows})}{PV(\text{cash outflows})}$$
$$= \frac{NPV}{PV(\text{cash outflows})} + 1$$

## NPV and IRR

If  $NPV \geq 0$ , then  $IRR \geq MCC$



# Example Data

Marginal Cost of Capital (MCC) = 10%

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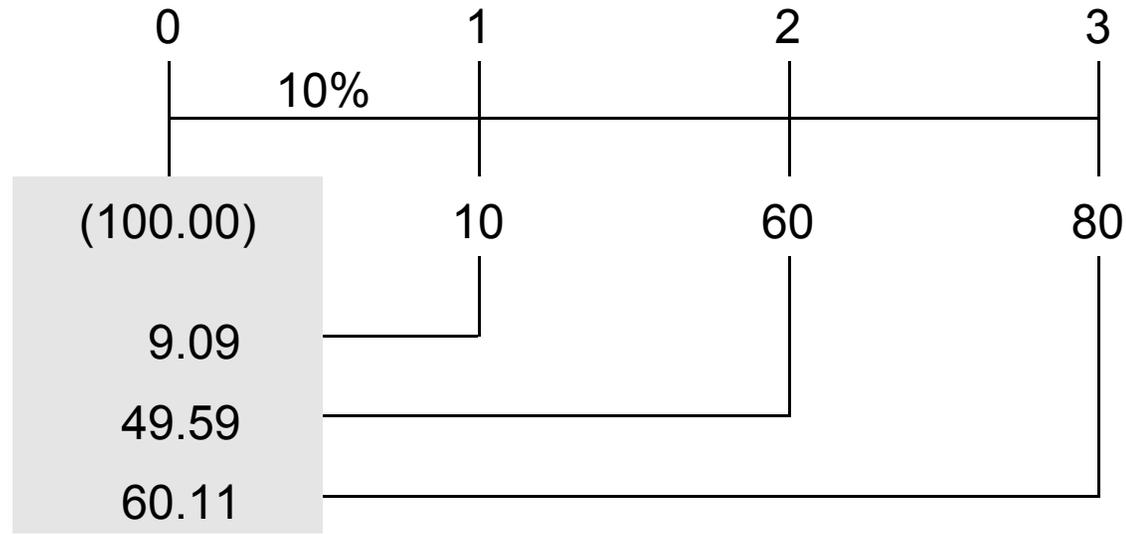
	<b>Expected Cash Flows</b>	
<b>Year</b>	<b>Project L</b>	<b>Project S</b>
0	(100)	(100)
1	10	70
2	60	50
3	80	20

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Fill in the blanks: evaluate the projects on this and the following pages.

## Practice: NPV

### Project L

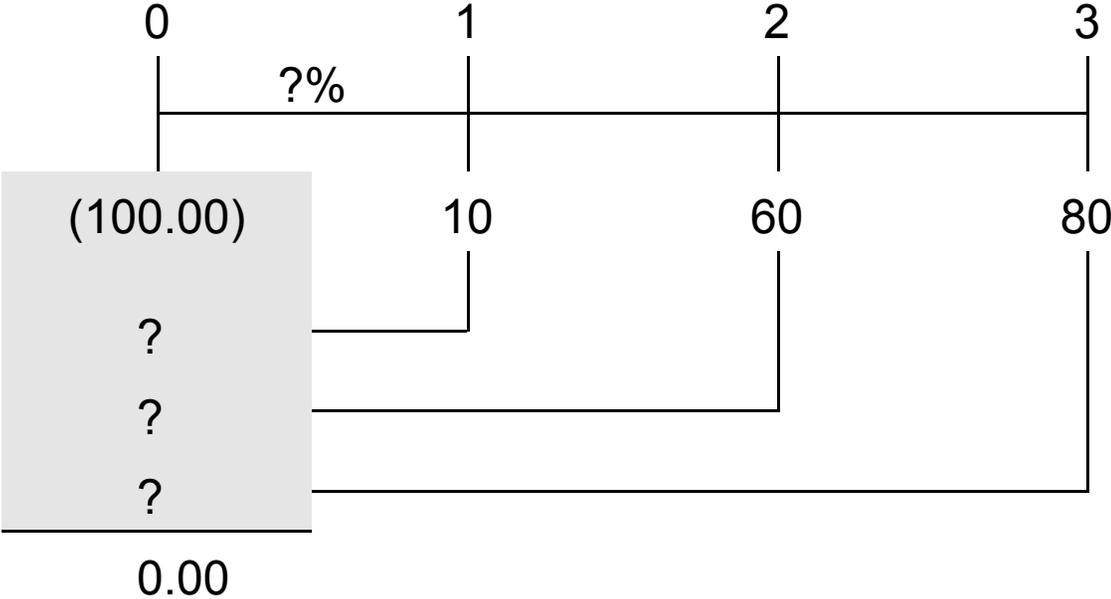


### Decision

	Project L	Project S
NPV		
Accept?		

# Practice: IRR

## Project L

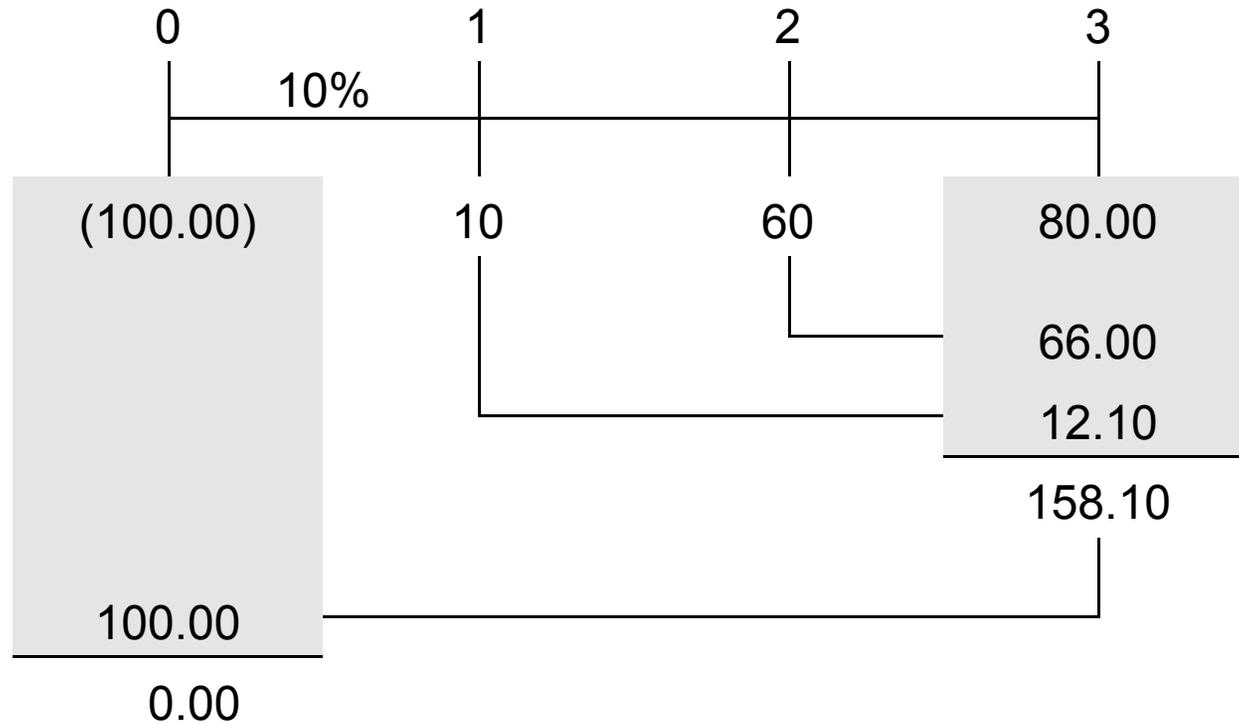


## Decision

	Project L	Project S
IRR		
Accept?		

# Practice: MIRR

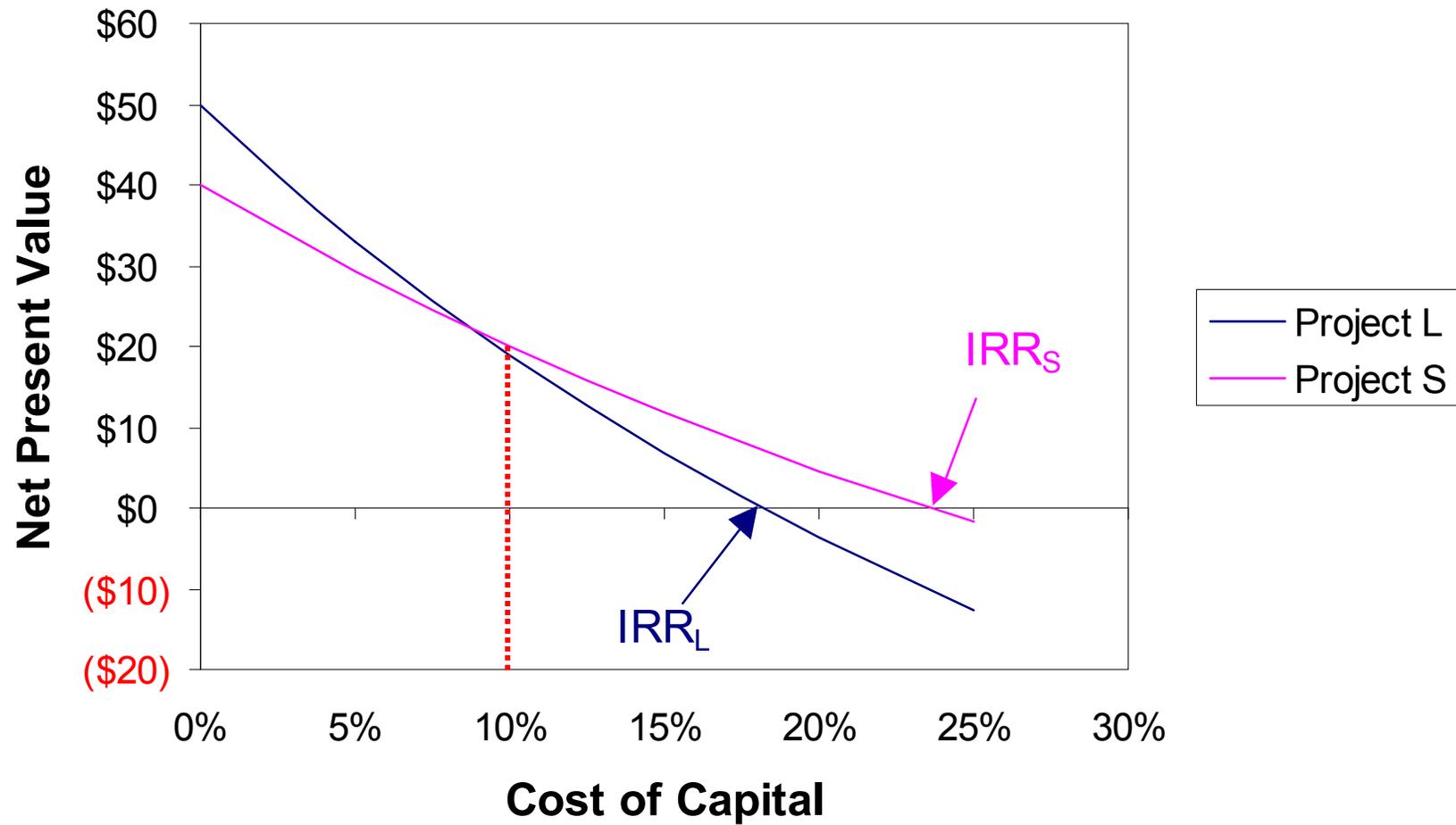
## Project L



## Decision

	Project L	Project S
PV (Costs)		
TV <sub>3</sub>		
MIRR		
Accept?		

# NPV Profiles



# DCF Methods Are Not Independent

$$\text{NPV} \left\{ \begin{array}{l} > \\ = \\ < \end{array} \right\} 0 \Leftrightarrow \text{IRR} \left\{ \begin{array}{l} > \\ = \\ < \end{array} \right\} \text{MCC} \Leftrightarrow \text{MIRR} \left\{ \begin{array}{l} > \\ = \\ < \end{array} \right\} \text{MCC} \Leftrightarrow \text{PI} \left\{ \begin{array}{l} > \\ = \\ < \end{array} \right\} 1$$

## Independent projects

- Good/Bad  $\Rightarrow$  Accept/Reject
- NPV, IRR, and PI give same decision

## Mutually exclusive projects

- Good/Better  $\Rightarrow$  Rank
- NPV, IRR, and PI *may* give conflicting decisions, if projects differ in:

Scale	Size of investment
Timing	Early vs. late payoffs
Lives	Number of cash flows

# Mutual Exclusion: Differences in Scale

MCC = 10%

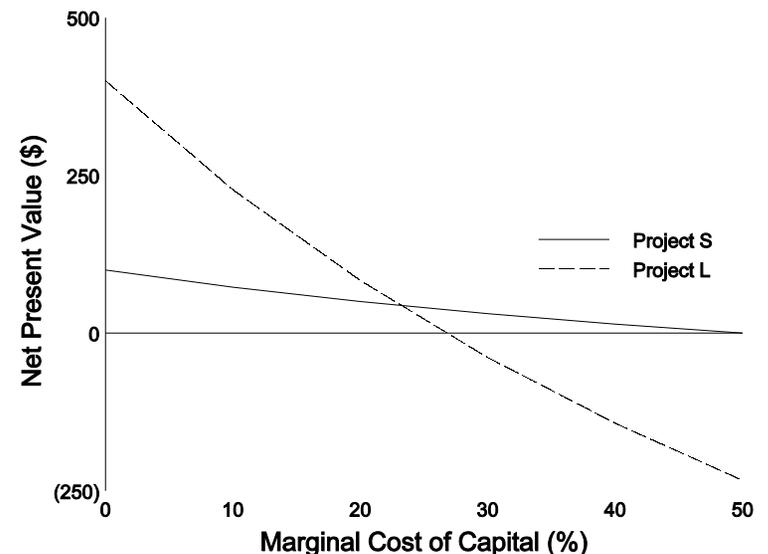
Year	Project S	Project L	Project Δ
0	(200)	(1,500)	(1,300)
1	300	1,900	1,600
NPV	\$72.73	\$227.27	\$154.55
PI	1.36	1.15	1.12
IRR	50.00%	26.67%	23.08%
MIRR	50.00%	26.67%	
Accept?			

## Possible Conflict

Between: NPV v. others

Cause: absolute (\$) v. relative (%)  
measures of benefit

Remedies: NPV, "Project Δ"



# Mutual Exclusion: Differences in Timing

MCC = 10%

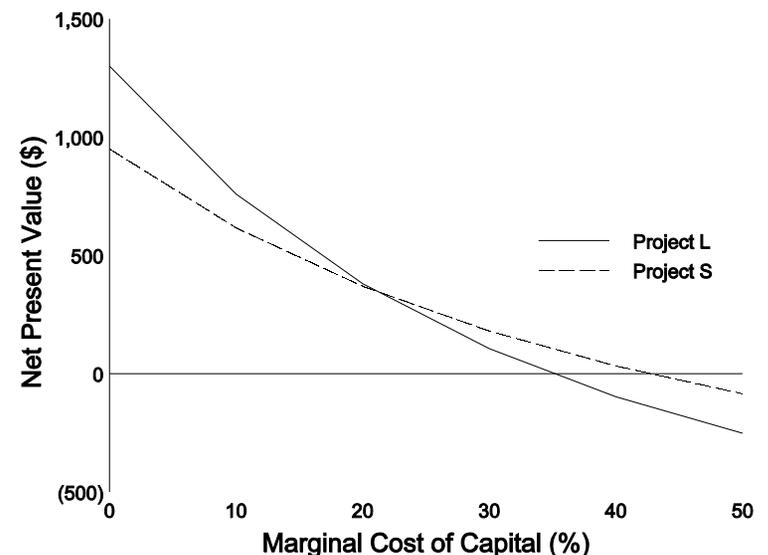
Year	Project L	Project S	Project Δ
0	(1,000)	(1,000)	0
1	100	650	(550)
2	200	650	(450)
3	2,000	650	1,350
NPV	\$758.83	\$616.45	\$142.37
PI	1.76	1.62	1.16
IRR	34.84%	42.57%	21.01%
MIRR	32.78%	29.10%	15.69%
Accept?			

## Possible Conflict

Between: IRR v. others

Cause: different reinvestment rates  
(MCC or IRR)

Remedies: NPV, "Project Δ," MIRR



# Mutual Exclusion: Differences in Lives

MCC = 10%

Year	Project S	Project L
0	(1,000)	(1,000)
1	500	300
2	500	300
3	500	300
4		300
5		300
6		300
NPV	\$243.43	\$306.58
Accept?		

## Possible Conflict

Between: NPV v. NPV

Cause: Different reinvestment opportunities

Remedies: Replacement Chain, Equivalent Annual Annuity

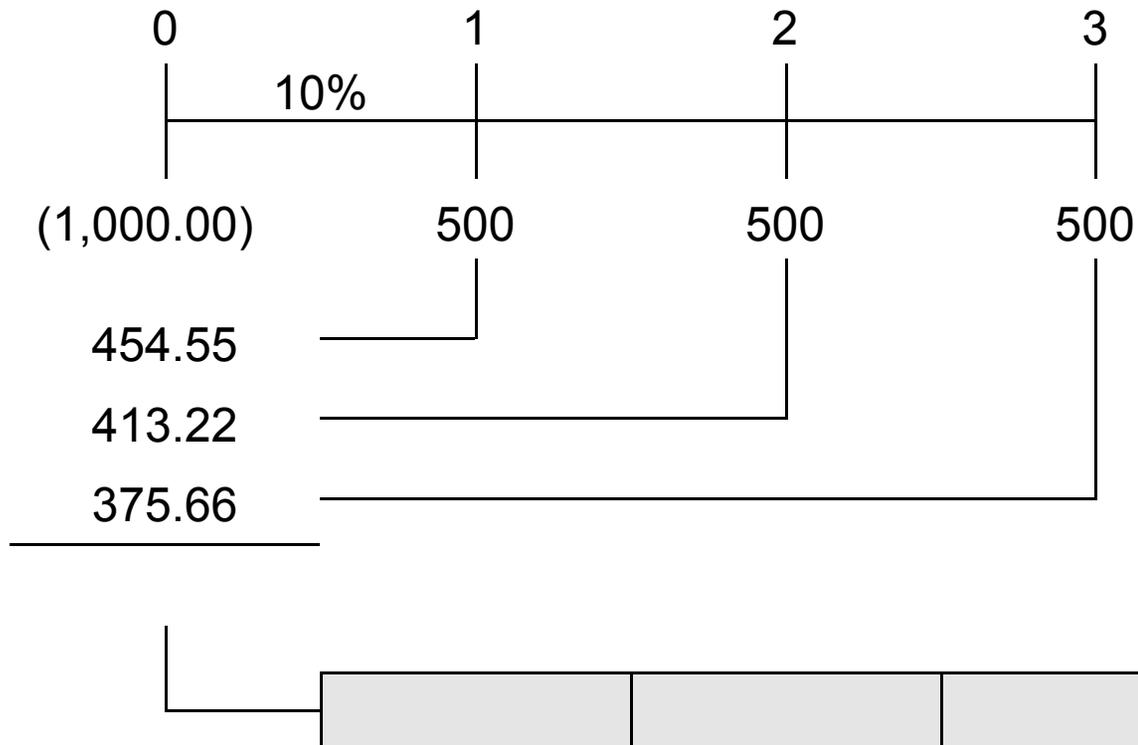
# Different Lives: Replacement Chain

MCC = 10%

Year	Project S			Project L
	Original	Replacement	Combined	
0	(1,000)		(1,000)	(1,000)
1	500		500	300
2	500		500	300
3	500	(1,000)	(500)	300
4		500	500	300
5		500	500	300
6		500	500	300
NPV	\$243.43	\$182.89	\$426.32	\$306.58
Accept?				

# Different Lives: Equivalent Annual Annuity (EAA)

## Project S



## Practice: EAA

MCC = 10%

Year	Project S	Project L
0	(1,000)	(1,000)
1	500	300
2	500	300
3	500	300
4		300
5		300
6		300
NPV	\$243.43	\$306.58
Life	3	6
EAA		
Accept?		

# Summary: Ranking Mutually Exclusive Projects

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<b>Case</b>	<b><i>Possible</i> Conflict</b>	<b>Cause</b>	<b>Remedies</b>
Scale	NPV v. others	absolute v. relative measures	NPV $\Delta$ project
Timing	IRR v. others	different reinvestment rates	NPV $\Delta$ project MIRR
Lives	NPV v. NPV	different reinvestment opportunities	replacement chain EAA

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# Other Problems with IRR: Non-normal Projects

## Definitions

Normal: Cash outflows precede inflows (costs before benefits)

Non-normal: Any other cash flow pattern

## Problem and Remedy

IRR misleading (or may not even exist)

Must *invert* IRR rule or use NPV

## Example

MCC = 10%

Year	Investment	Financing	Investment	Financing
0	(100)	100	(130)	130
1	130	(130)	100	(100)
NPV	\$18.18	(\$18.18)	(\$39.09)	\$39.09
PI	1.18	0.85	0.70	1.43
IRR	30.00%	30.00%	(23.08%)	(23.08%)
MIRR	30.00%	(15.38%)	(23.08%)	43.00%

# Other Problems with IRR: Multiple IRRs

## Problem and Remedy

As many IRRs as sign changes in cash stream

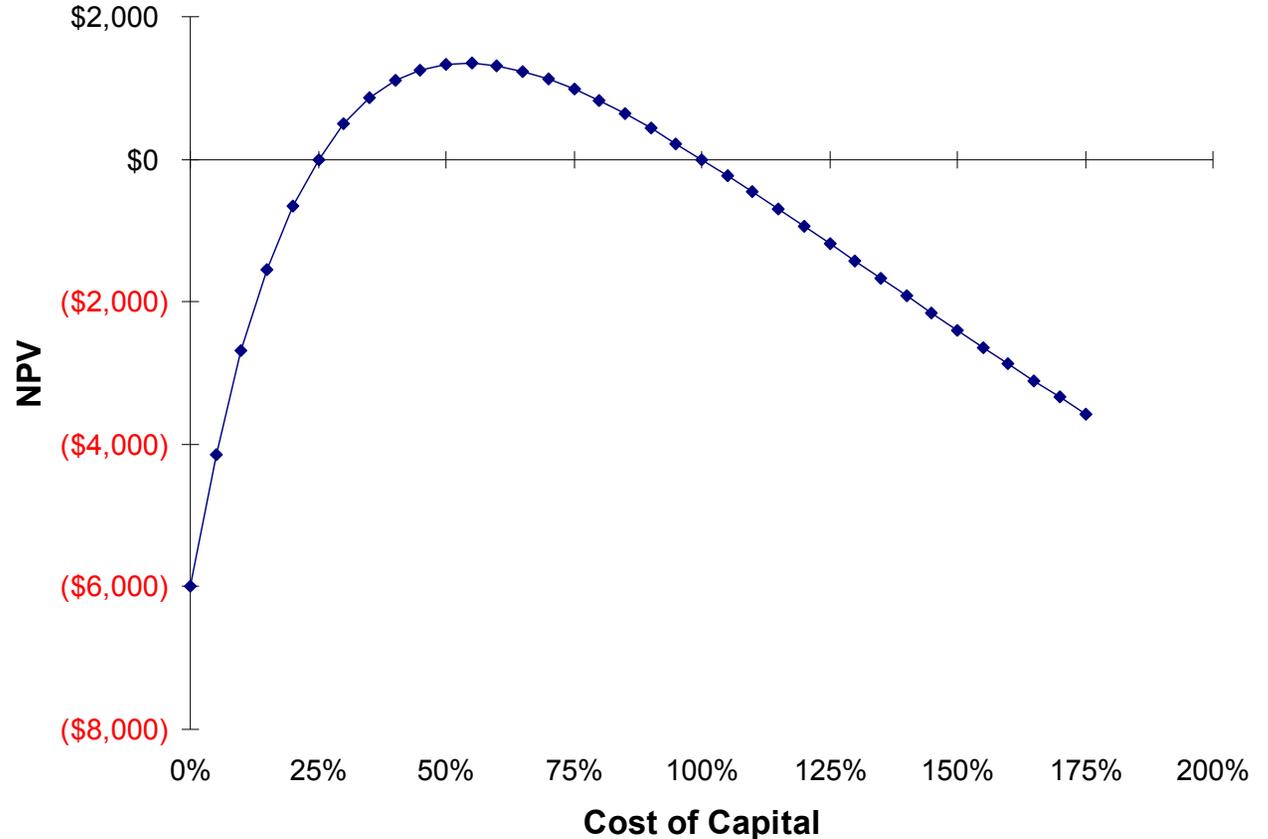
IRR irrelevant

Use NPV or MIRR

## Example

MCC = 10%

Year	Cash Flow
0	(24,000)
1	78,000
2	(60,000)
NPV	(\$2,677.69)
PI	0.96
IRR	
MIRR	7.98%



## Summary: IRR and Non-normal Cash Flows

<b>Cash Flows</b>	<b>Cause</b>	<b>Remedy</b>
inflows precede outflows	IRR a “cost”	invert IRR rule others
multiple sign changes	IRR a mathematical notion	others (IRR useless)