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—may be difficult/impossible to reverse
Survival and Growth
Large expenditures—often requires outside financing

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

$$PV(benefits) > PV(costs)$$

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(cash inflows) > PV (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 of Useful Rules

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, reflecting time and risk)
- properly handle *mutually exclusive* projects

Mutual Exclusion

If two projects are independent, can take both

If two projects are mutually exclusive, must choose one (requires 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

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

	Expected Cash Flows		Cumulative Cash Flow	
Year	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

Net Present Value (NPV)

Definition

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

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

Decision Rule

Accept project if its NPV $\geq$ 0

Note

- Directly indicates effect on firm value, shareholder wealth
- Can handle mutual exclusion

Profitability Index (PI)

Definition

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

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

Decision Rule

Accept project if its PI $\geq$ 1

Note

- Often called benefit/cost ratio, “bang per buck”
- Cannot handle some mutual exclusion cases

Internal Rate of Return (IRR)

Definition
IRR is that (hypothetical) discount rate which forces

$$\text{PV}(\text{cash outflows}) = \text{PV}(\text{cash inflows})$$
$$0 = \text{NPV}$$
$$0 = \sum_{t=0}^{n} \frac{CF_t}{(1+\textbf{IRR})^t}$$

Decision Rule
Accept project if its IRR $\geq$ MCC

Note
- Cannot handle mutual exclusion
- Same as YTM

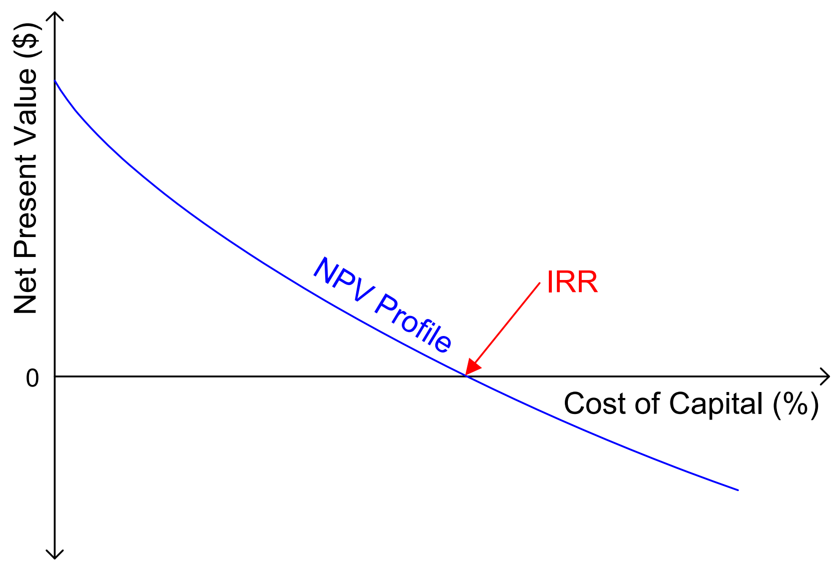
$$CF_0 = \sum_{t=1}^{n} \frac{CF_t}{(1+\textbf{IRR})^t}$$

Relationship between NPV, IRR and PI

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

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

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



Example Data

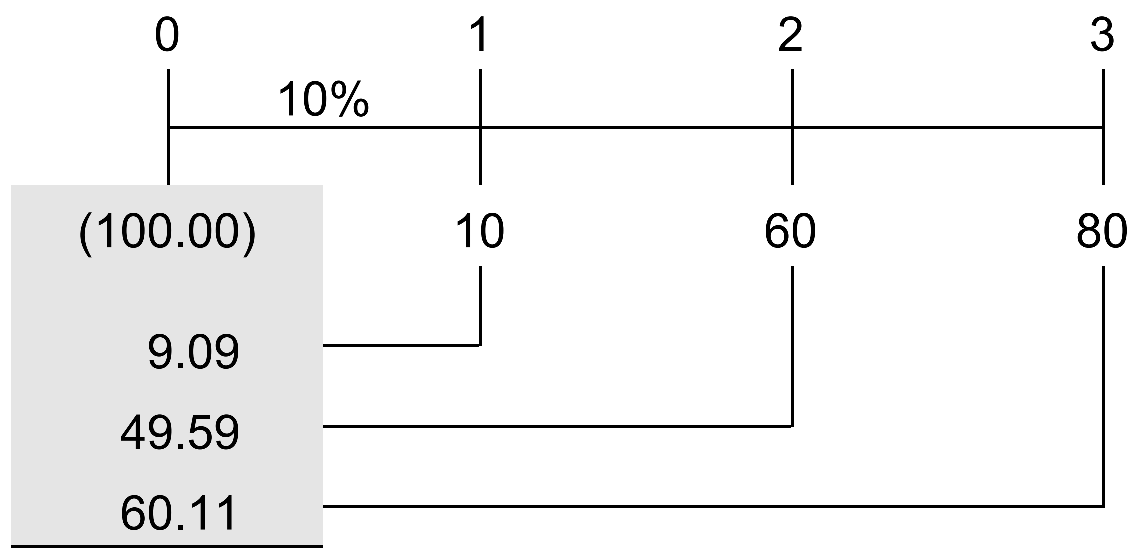
Marginal Cost of Capital (MCC) = 10%

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

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

Practice: NPV

Project L

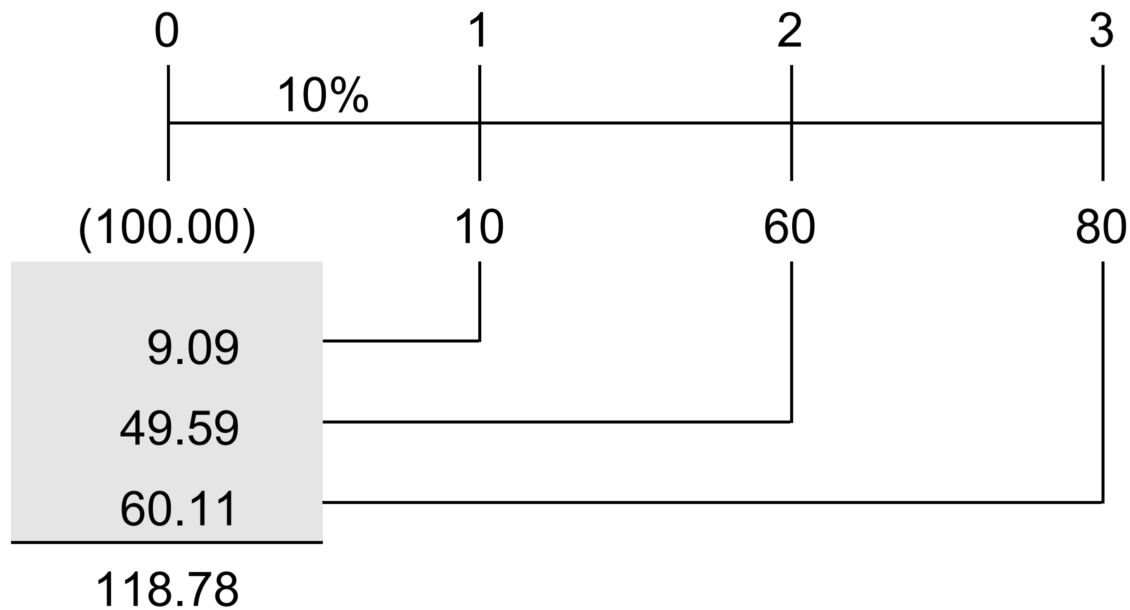


Decision

	Project L	Project S
NPV		
Accept?		

Practice: PI

Project L

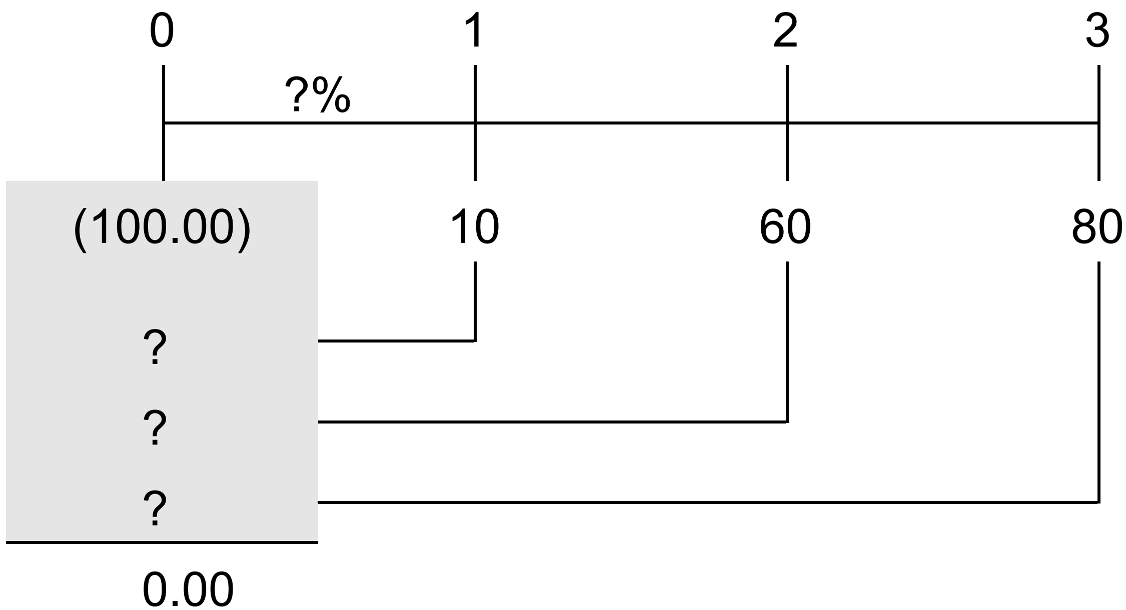


Decision

	Project L	Project S
PV (inflows)		
PV (outflows)		
PI		
Accept?		

Practice: IRR

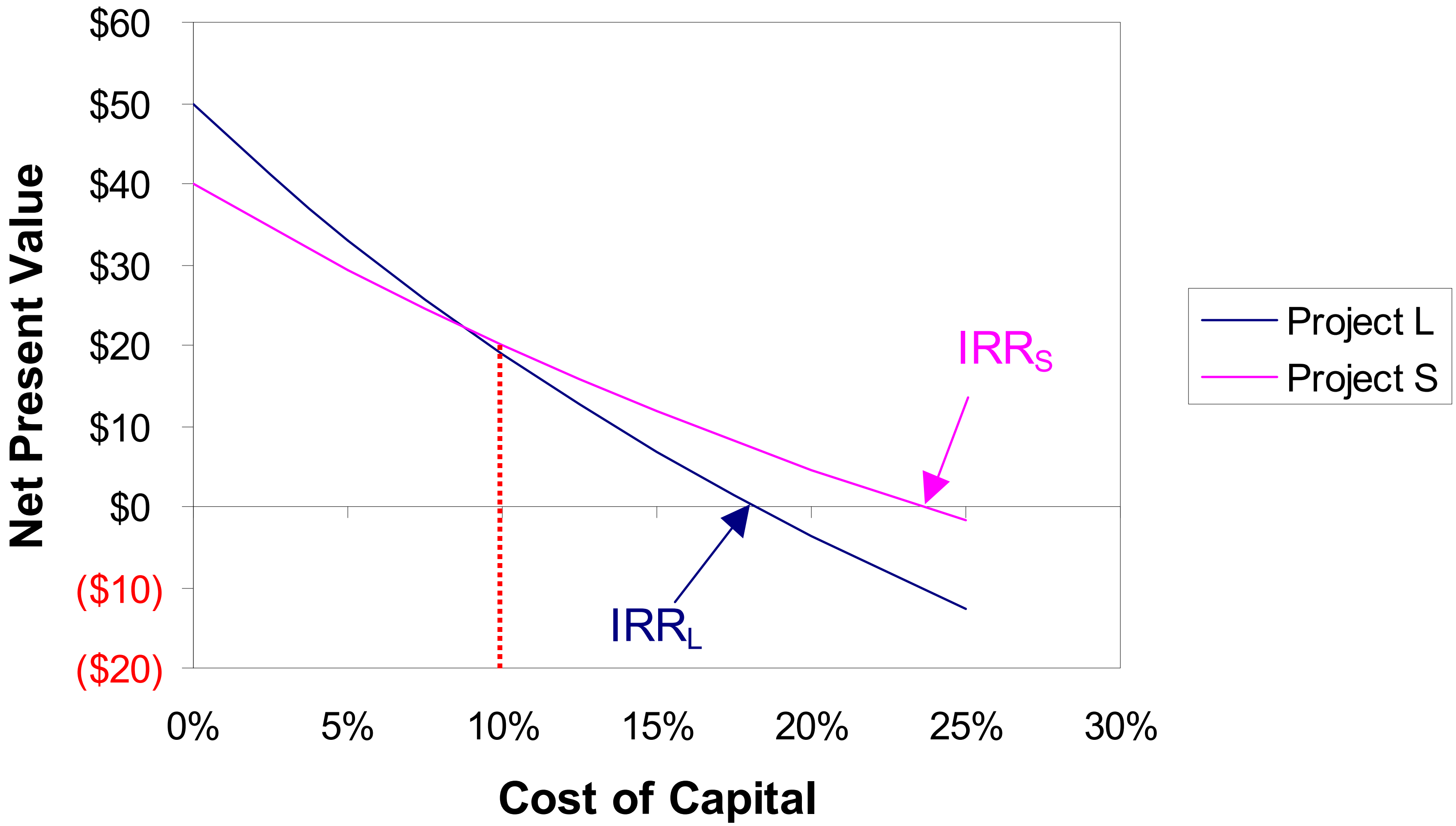
Project L



Decision

	Project L	Project S
IRR		
Accept?		

NPV Profiles



DCF Methods Are Not Independent

$$\text{NPV}\begin{Bmatrix} > \\ = \\ < \end{Bmatrix} 0 \Leftrightarrow \text{IRR}\begin{Bmatrix} > \\ = \\ < \end{Bmatrix} MCC \Leftrightarrow \text{MIRR}\begin{Bmatrix} > \\ = \\ < \end{Bmatrix} MCC \Leftrightarrow \text{PI}\begin{Bmatrix} > \\ = \\ < \end{Bmatrix} 1$$

Independent projects

- Good/Bad ⇒ Accept/Reject
- NPV, IRR, MIRR and PI give same (correct) decision

Mutually exclusive projects

- Good/Better ⇒ Rank
- NPV, IRR, MIRR 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%

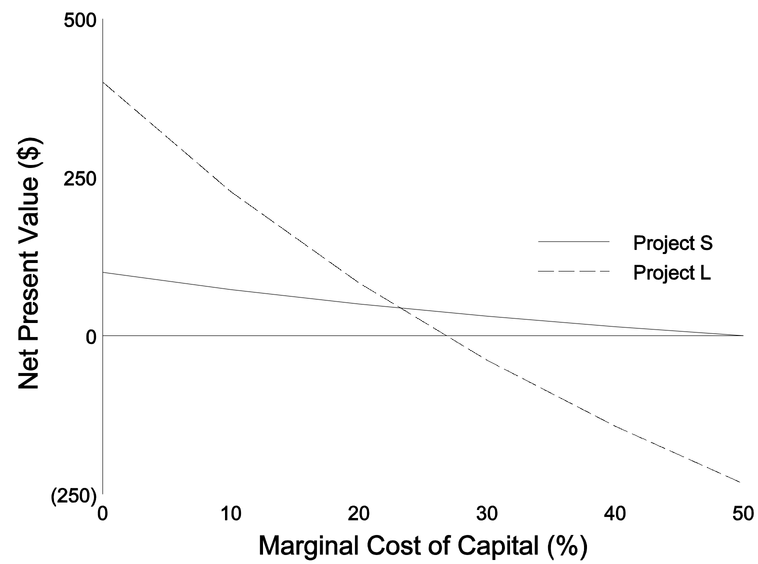
Year	Project S	Project L	Project Δ
0	(200)	(1,500)	(1,300)
1	300	1,900	1,600
NPV	$72.73	$227.27	$154.55
PI	1.36	1.15	1.12
IRR	50.00%	26.67%	23.08%
MIRR	50.00%	26.67%	23.08%
Accept?			

Possible Conflict

Between: NPV v. others

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

Remedies: NPV, "Project Δ"



Mutual Exclusion: Differences in Timing

MCC = 10%

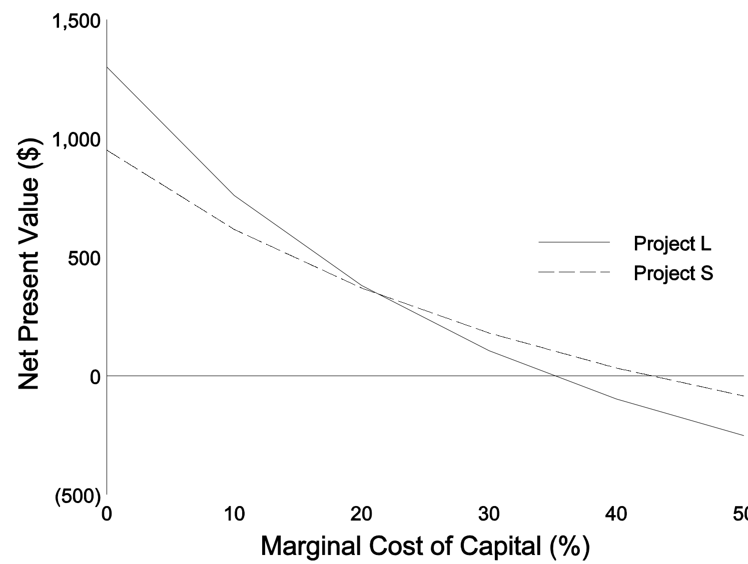
Year	Project L	Project S	Project Δ
0	(1,000)	(1,000)	0
1	100	650	(550)
2	200	650	(450)
3	2,000	650	1,350
NPV	$758.83	$616.45	$142.37
PI	1.76	1.62	1.16
IRR	34.84%	42.57%	21.01%
MIRR	32.78%	29.10%	15.69%
Accept?			

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

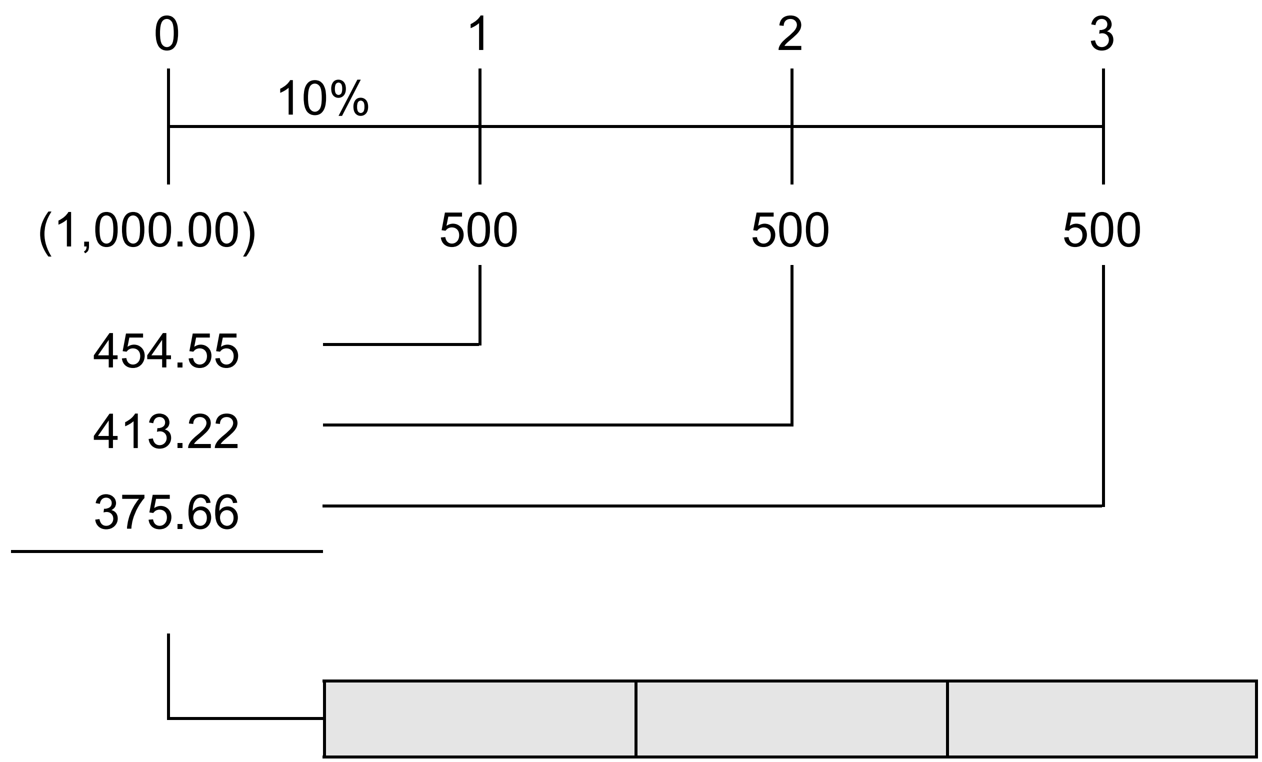
Different Lives: Replacement Chain

MCC = 10%

	Project S			
Year	**Original**	**Replacement**	**Combined**	**Project L**
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

Case	*Possible* Conflict	Cause	Remedies
Scale	NPV v. others	absolute v. relative measures of benefit	NPV Project Δ
Timing	IRR v. others	different reinvestment rates assumed	NPV Project Δ MIRR
Lives	NPV v. NPV	different reinvestment opportunities assumed	replacement chain EAA

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

Examples

MCC = 10%

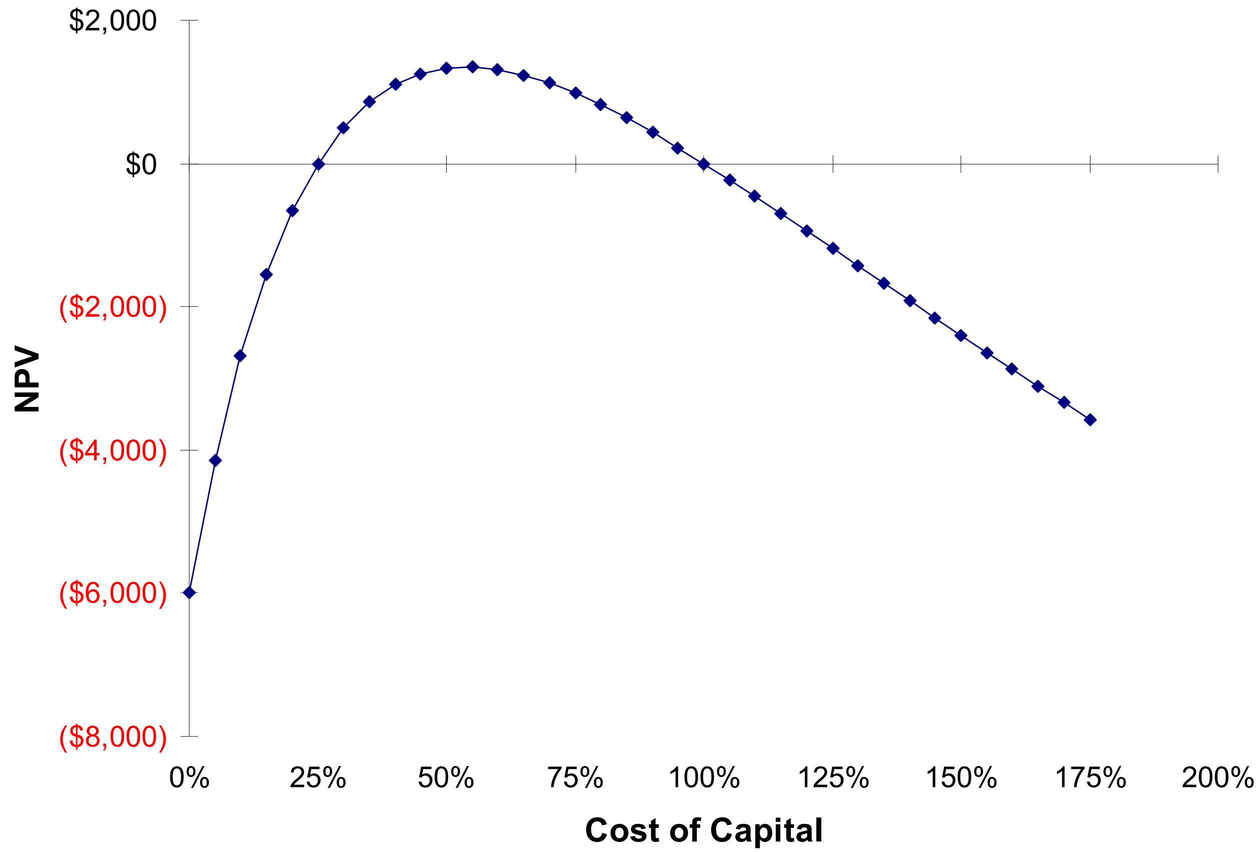
Year	Investment	Financing	Investment	Financing
0	(100)	100	(130)	130
1	130	(130)	100	(100)
NPV	$18.18	($18.18)	($39.09)	$39.09
PI	1.18	0.85	0.70	1.43
IRR	30.00%	30.00%	(23.08%)	(23.08%)
MIRR	30.00%	(15.38%)	(23.08%)	43.00%

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

Cash Flows	Cause	Remedy
inflows precede outflows	IRR a "cost"	invert IRR rule NPV, PI, MIRR
multiple sign changes	IRR a mathematical notion	NPV, PI, MIRR (IRR useless)

Capital Rationing

Definition

Dollar limit on capital budget

- Hard or Soft
- Binding or Non-binding

Problems

- If binding, violates NPV rule: can't max shareholder wealth because can't take all positive-NPV projects
- Creates mutual exclusion unnecessarily

Solution

- Relax constraint
- Find group of projects with maximum *joint* NPV (linear programming)