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)   Discounted-Cash-Flow (DCF) methods
Internal Rate of Return (IRR)
Modified Internal Rate of Return (MIRR)

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

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

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

Decision Rule
Accept project if its NPV ≥ 0

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

Profitability Index (PI)

Definition

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

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

Decision Rule
Accept project if its PI ≥ 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

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

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

Note
- Cannot handle mutual exclusion
- Same as YTM

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

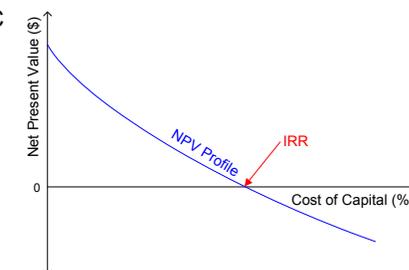## Relationship between NPV, IRR and PI

NPV and PI
If NPV ≥ 0, then PI ≥ 1

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

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

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

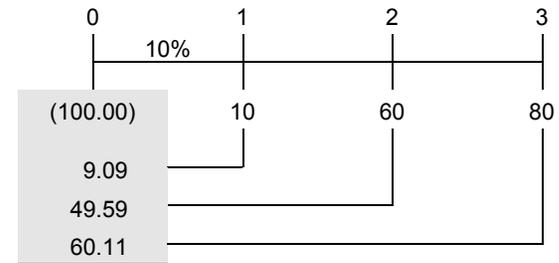## Example Data

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

Practice: NPV

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

Project L


```
        0        1        2        3
          10%
     (100.00)   10       60       80

        9.09
       49.59
       60.11
```

Decision

	Project L	Project S
NPV		
Accept?		

Practice: PI

Project L


```
        0        1        2        3
          10%
     (100.00)   10       60       80

        9.09
       49.59
       60.11
      118.78
```
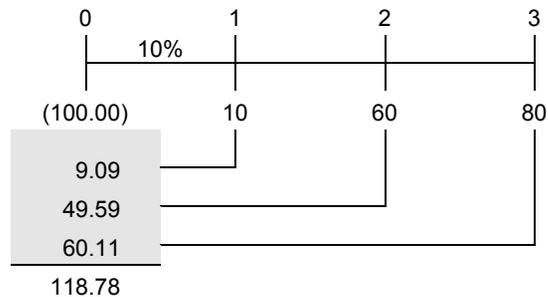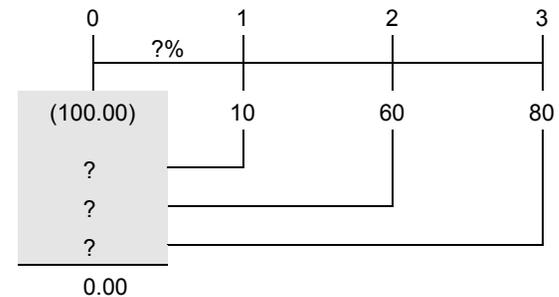
Decision

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

Practice: IRR

Project L


```
        0        1        2        3
          ?%
     (100.00)   10       60       80

         ?
         ?
         ?
       0.00
```
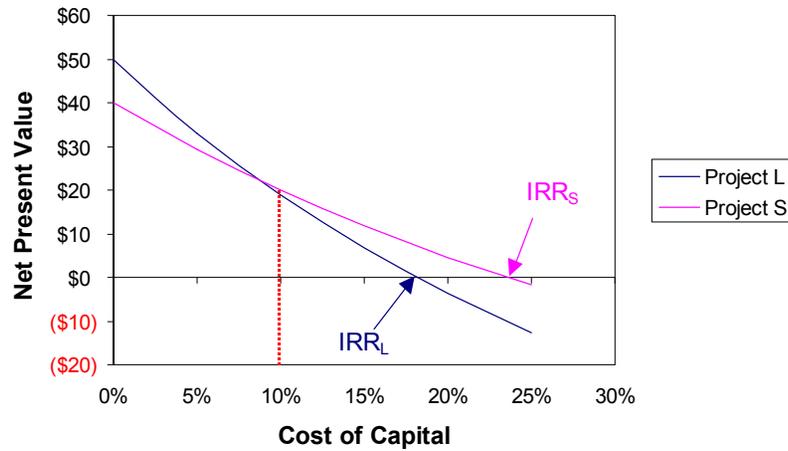
Decision

	Project L	Project S
IRR		
Accept?		

NPV Profiles

Net Present Value axis: $60, $50, $40, $30, $20, $10, $0, ($10), ($20)

Cost of Capital axis: 0%, 5%, 10%, 15%, 20%, 25%, 30%

Legend: Project L, Project S

IRR$_S$

IRR$_L$

DCF Methods Are Not Independent

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

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
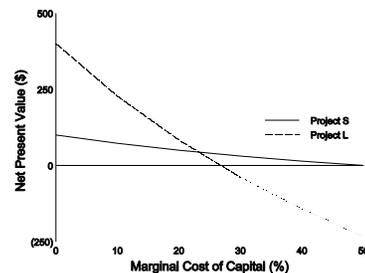
Mutual Exclusion: Differences in Scale

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"

Net Present Value ($) vs Marginal Cost of Capital (%)

Legend: Project S, Project L
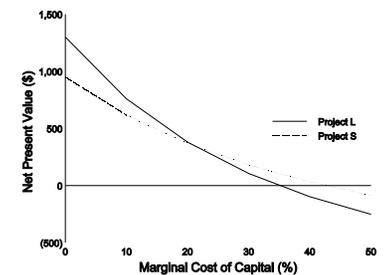
Mutual Exclusion: Differences in Timing

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

Net Present Value ($) vs Marginal Cost of Capital (%)

Legend: Project L, Project S

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

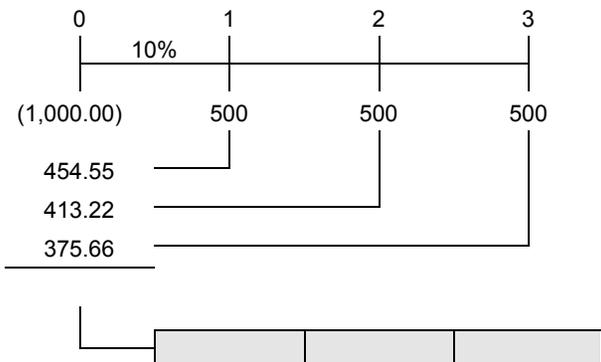Remedies: Replacement Chain, Equivalent Annual Annuity

Different Lives: Replacement Chain

MCC = 10%

Year	Project S 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

```
        0          1          2          3
        |   10%    |          |          |
        |          |          |          |
  (1,000.00)      500        500        500

   454.55
   413.22
   375.66
```

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
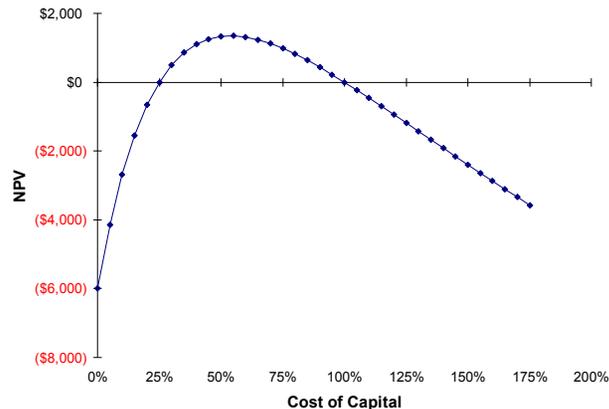As many IRRs as sign changes in cash stream
IRR irrelevant
Use NPV or MIRR

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)