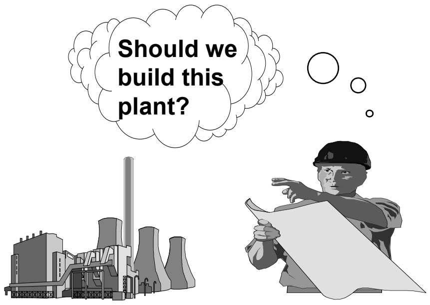
Lecture 9
Capital Budgeting: Evaluating Cash Flows

- Overview
- Decision Rules
  - Payback, discounted payback
  - NPV
  - IRR, MIRR
- Credit Rationing



What is Capital Budgeting?

Capital Budgeting :

- is the process of analyzing projects and deciding which ones to include in the capital budget.
- involves analysis of potential additions to operating assets that add to the firm’s value.
- usually long-term decisions that involve large expenditures.

Steps in Capital Budgeting

1. Cash Flow Estimation and Risk Analysis
   - Estimate the cash flows (inflows & outflows) of a project.
   - Assess the risk of cash flows.
2. Evaluating Cash Flows
   - Determine r = WACC for the project.
   - Use decision rules to rank projects.

Independent vs. Mutually Exclusive

Projects are:

- Independent if the cash flows of one are unaffected by the acceptance of the other.
- Mutually Exclusive if the cash flows of one is adversely impacted by the acceptance of the other.

  Accepting one means rejecting the other.

  e.g. GSM vs. CDMA (mobile phone network)

Decision Rules for Ranking Projects

1. Payback Period
2. Discounted Payback Period

(both provide an indication of the risk and liquidity)

3. Net Present Value (NPV)

   (provides a direct measure of the $ benefit)

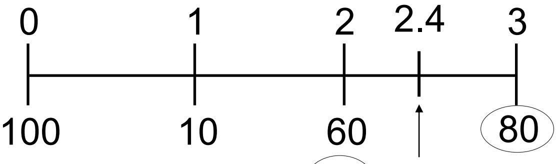
4. Internal Rate of Return (IRR)
5. Modified Internal Rate of Return (MIRR)

   (measure profitability in rate of return)

What is Payback Period?

- Payback period is the expected number of years required to recover a project's cost (original investment).
- Naturally, the shorter the payback period the better.
- Consider two projects *L* ("long") and *S* ("short"), both with initial costs incurred in period 0 and yield a positive cash flow in the three (3) subsequent periods.

Payback for Project *L*
(Long: Most CFs in “out” years)

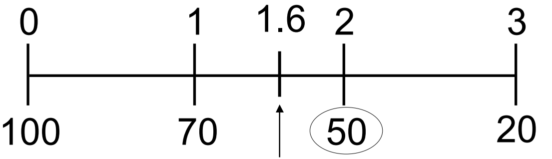


	0	1	2	2.4	3
CF_t	-100	10	60		80
Cumulative	-100	-90	-30	0	50

Note: The difference between -30 and 50 is 80.

Payback$_L$ = 2 + 30 / 80 = $\boxed{2.375}$ years

Payback for Project *S*
(Short: CFs come rather quickly)



	0	1	1.6	2	3
CF_t	-100	70		50	20
Cumulative	-100	-30	0	20	40

Note: The difference between -30 and 20 is 50.

Payback$_S$ = 1 + 30 / 50 = $\boxed{1.6}$ years

Strengths of Payback method:

1. Provides an indication of a project's risk and liquidity.
2. Easy to calculate and understand.

Weaknesses of Payback method:

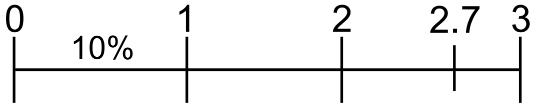
1. Ignores the TVM.
2. Ignores CFs occurring after the payback period.

The rule will bias *against* long-term projects.

Discounted Payback Period

- Discounted payback period is the number of years required to recover the investment from the discounted cash inflows.
- Use discounted instead "raw" (undiscounted) CFs.
- Same as "regular" payback method, it is a type of breakeven calculation.
- Since CFs are discounted by the project's cost of capital, this method takes the *opportunity costs of capital* into account.

Discounted Payback Period: *L*

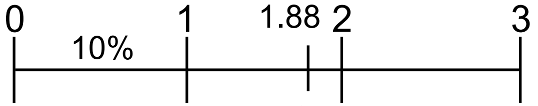


CF_t	-100	10	60	80
$PVCF_t$	-100	9.09	49.59	60.11
Cumulative	**-100**	**-90.91**	**-41.32**	**18.79**

Discounted payback $= 2 + \boxed{41.32} / \boxed{60.11} = \boxed{2.7 \text{ yrs}}$

Recover investment + Capital costs in 2.7 yrs.

Discounted Payback Period: *S*



CF_t	-100	70	50	20
$PVCF_t$	-100	63.64	41.32	15.03
Cumulative	**-100**	**-36.36**	**4.96**	**19.99**

Discounted payback $= 1 + \boxed{36.36} / \boxed{41.32} = \boxed{1.88 \text{ yrs}}$

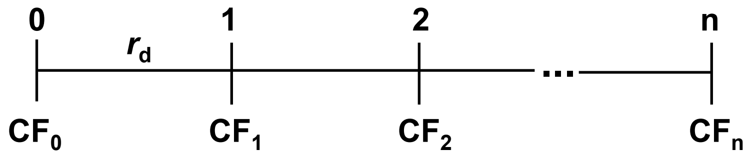
Recover investment + Capital costs in 1.88 yrs.

Discounted Payback Period

- In the above examples, we assume that the required rate of return (r_d) of both projects is 10%.
- Suppose the company has a policy that requires all investment projects to have a discount payback period of no more than 2 years.
- Under this policy, the company should accept project *S* and reject *L*.

Net Present Value (NPV)

NPV is the sum of the PVs of inflows and outflows.



$$NPV = \frac{CF_0}{(1+r)^0} + \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \cdots + \frac{CF_n}{(1+r)^n}$$

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

Net Present Value (NPV)

Cost (an outflow) is negative and often is CF_0.

$$NPV = \frac{-CF_0}{(1+r)^0} + \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \cdots + \frac{CF_n}{(1+r)^n}$$

$$= \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} - CF_0 .$$

Note:

- the summation starts at t=1 in this formulation
- the NPV function in Excel uses this formulation

Rationale for the NPV Method

NPV = PV inflows – Cost

= Net gain in wealth.

Independent Projects:

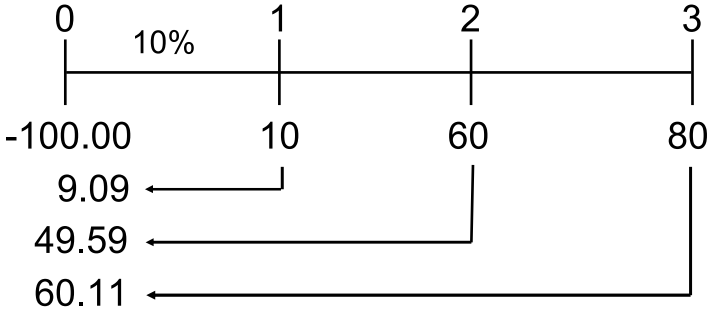
- Accept all projects with NPV > $0

Mutually Exclusive Projects:

- Choose the with one higher NPV – the one that adds most value.

What is the NPV of Project *L*?

Project *L*:



9.09

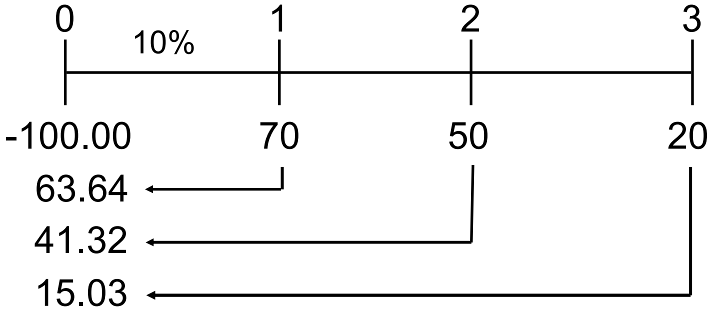
49.59

60.11

$18.79 = NPV_L

What is the NPV of Project *S*?

Project *S*:



63.64

41.32

15.03

$19.99 = NPV_S

NPV_L = $18.79

Using NPV method, which project(s) should be accepted?

If Projects *S* and *L* are

- Mutually Exclusive:

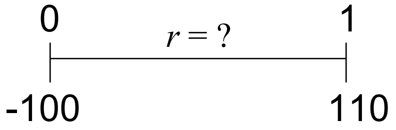
  accept *S* because $NPV_S > NPV_L$.

- Independent:

  accept both because NPV > 0 for both.

Internal Rate of Return (IRR)

- Consider a (very) simply investment that costs $100 today and pays $110 a year later.



- What is the rate of return on this investment?
- The answer is simple: 10%

  $100(1+r) = 110 \rightarrow r = 0.1$

Internal Rate of Return (IRR)

- Notice that the NPV of this investment is:

$$NPV = -100 + \frac{110}{1 + r}$$

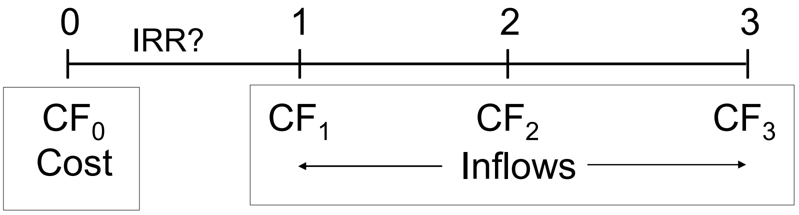
- If the discount rate is 10%

$$NPV = -100 + \frac{110}{1 + 0.1} = 0$$

- IRR is simply the discount rate at which the investment's NPV = 0.

Internal Rate of Return (IRR)

- A simple investment project:



That is, find the r at which NPV = 0.

$$NPV = \frac{CF_0}{(1+r)^0} + \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \frac{CF_3}{(1+r)^3} = 0$$

How to find IRR

- There is no formula for solving the IRR, so we need to use a financial calculator or Excel.
- IRR: Enter CFs, NPV = 0, solve for *r*.

$$\sum_{t=0}^{n} \frac{CF_t}{\left(1+\boxed{IRR}\right)^t} = \boxed{0}.$$

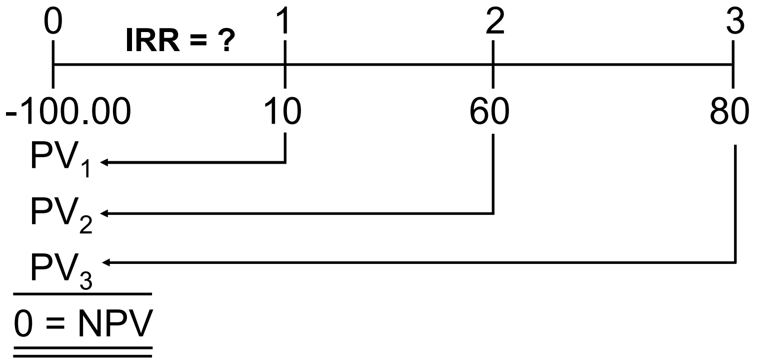
- NPV: Enter *r*, solve for NPV.

$$\sum_{t=0}^{n} \frac{CF_t}{\left(1+\boxed{r}\right)^t} = \boxed{NPV}.$$

IRR Acceptance Criteria

- Is an investment with, say, an IRR = 15% a good investment?
- It depends on *r*, the project's cost of capital (i.e. its required rate of return).
- Acceptance criteria:
  - Accept the project if **IRR > *r* → NPV > 0**
  - Reject the project if **IRR < *r* → NPV < 0**

What is the IRR of Project *L*?



0 1 2 3

IRR = ?

-100.00 10 60 80

PV_1

PV_2

PV_3

0 = NPV

Finding the IRR of Project *L*

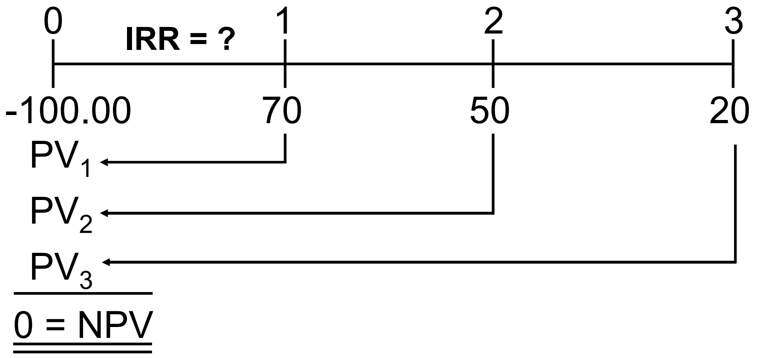
We want to find the r at which NPV = 0.

$$0 = \frac{-100}{(1+r)^0} + \frac{10}{(1+r)^1} + \frac{60}{(1+r)^2} + \frac{80}{(1+r)^3}$$

Enter CFs in CFLO, then press IRR:

IRR_L = 18.13%.

What is the IRR of Project *S*?



Enter CFs in CFLO, then press IRR:

IRR_S = 23.56% **IRR_L = 18.13%**

Using IRR, which projects should be accepted?

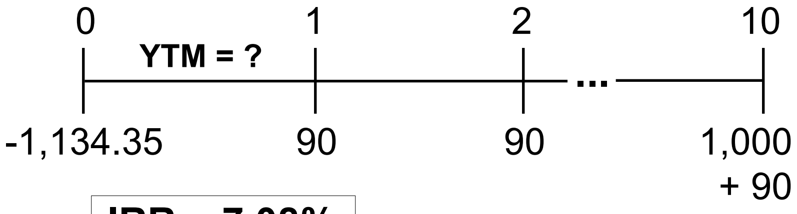
- Suppose the firm’s WACC = 10% (i.e. the required return is 10%).
- If *S* and *L* are **independent**,
  - accept both because both IRR_S & IRR_L > WACC = 10%.
- If *S* and *L* are **mutually exclusive**,
  - accept *S* because IRR_S > IRR_L .

Rationale of the IRR Method

- IRR: This rate of return is "internal" because it is based on the cash flows of the investment only (and not some external interest rate).
- If IRR **>** WACC, then the project's rate of return is greater than its cost → some return is left over to boost stockholders' returns.
- Since IRR is the discount rate at which NPV = 0 a project will be profitable if it is greater than the cost of capital necessary to finance the project.

IRR and YTM

- What is the relationship between a project's IRR and a bond's YTM ?
- They are the same thing – a bond's YTM is the IRR of its expected CF.
- Example:



IRR = 7.08%

IRR and YTM

- Check:

$$P = \sum_{t=1}^{10} \frac{90}{(1+0.0708)^t} + \frac{1{,}000}{(1+0.0708)^{10}}$$

$$= 90\left(\frac{1}{0.0708} - \frac{1}{0.0708(1.0708)^{10}}\right) + \frac{1{,}000}{1.0708^{10}}$$

$$= 90(14.1243 - 7.1266) + 504.564$$

$$= 1{,}134.35$$

IRR vs. NPV

- The relationship between IRR and NPV can be illustrated with a **NPV profile**.
- A NPV profile tells us the NPV of a project at different discount rates.
- The higher the discount rate, the lower the NPV will be.
- The discount rate at which NPV=0 is the IRR.

NPV Profiles of Projects *L* and *S*

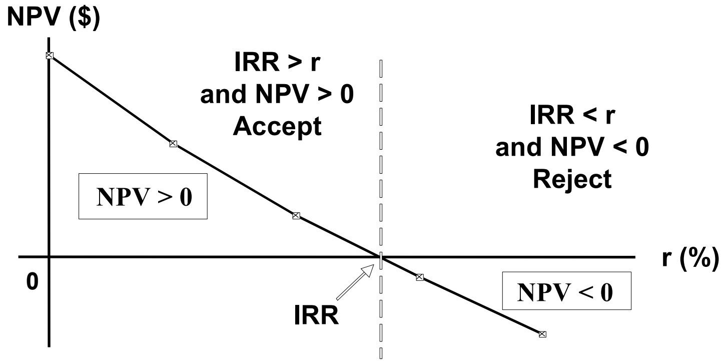
	r	NPV_L	NPV_S
	0.0%	$50.00	$40.00
	5.0%	$33.05	$29.29
	10.0%	$18.78	$19.98
	15.0%	$6.67	$11.83
IRR_L ⟶	18.1%	$0.00	$7.26
	20.0%	($3.70)	$4.63
IRR_S ⟶	23.6%	(-$10.27)	$0.00

IRR vs. NPV

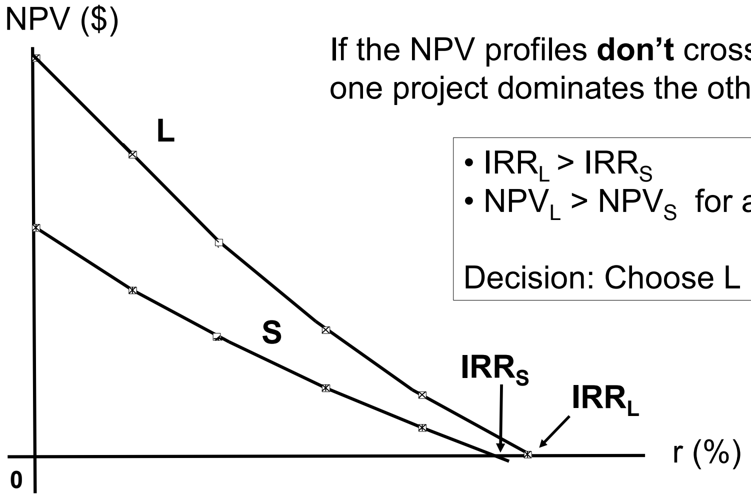
- Do the **IRR rule** and the **NPV rule** always lead to the same decision in project evaluation?
- It depends on whether the projects are independent or mutually exclusive.
  - For independent projects, yes.
  - For mutually exclusive projects, not always the case.

Independent Projects

For independent projects NPV and IRR always lead to the same Accept / Reject decision.



Mutually Exclusive Projects: Case I

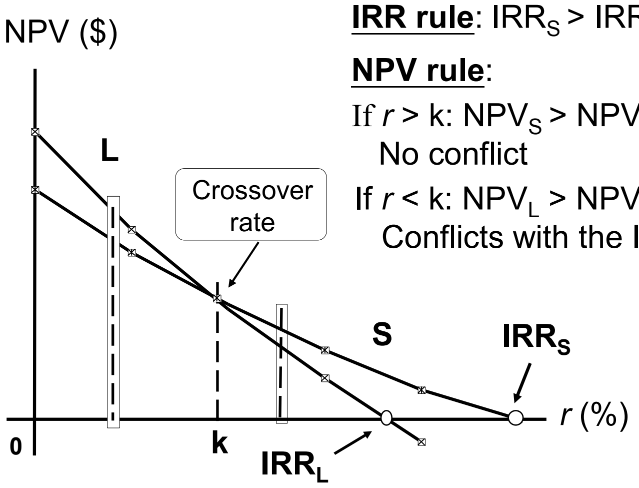


If the NPV profiles **don't** cross, one project dominates the other.

- IRR$_L$ > IRR$_S$
- NPV$_L$ > NPV$_S$ for all *r*

Decision: Choose L

Mutually Exclusive Projects: Case II

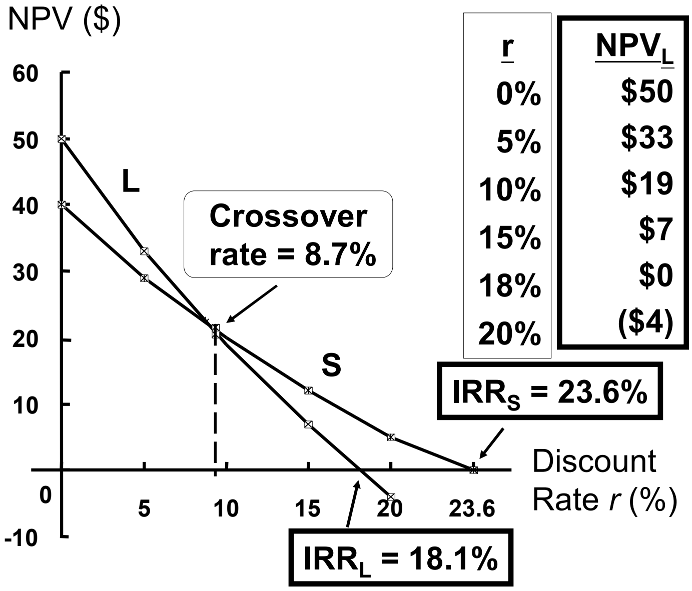


IRR rule: $IRR_S > IRR_L$ → Choose S

NPV rule:

If r > k: $NPV_S > NPV_L$ → Choose S
No conflict

If r < k: $NPV_L > NPV_S$ → Choose L
Conflicts with the IRR rule!



r	**NPV_L**	**NPV_S**
0%	**$50**	**$40**
5%	**$33**	**$29**
10%	**$19**	**$20**
15%	**$7**	**$12**
18%	**$0**	**$7**
20%	**($4)**	**$5**

To Find the Crossover Rate

1. Find cash flow differences between the projects at each rate (*r*).
2. Enter these differences in the financial calculator, then press IRR.
3. Can subtract *S* from *L* or vice versa, but better to have the first ΔCF positive.
4. In our example, the crossover rate = 8.68%, rounded to 8.7%.

Two Reasons Why NPV Profiles Tend to Cross at Higher *r*

1. Size (scale) differences. Smaller projects free up funds at *t* = 0 for other investment. The higher the opportunity cost (*r*) the more valuable these funds are, so high *r* favors smaller projects.

2. Timing differences. A project with faster payback provides more CF in early years for reinvestment. If *r* is high, early CF is especially good, so $NPV_S > NPV_L$.

Reinvestment Rate Assumptions

- Since the cash flows are assumed to "stay" in the project until the end, they are in a sense being "reinvested".
- NPV assumes that the CFs are reinvested at *r* (the opportunity cost of capital).
- IRR assumes that the CFs are reinvested at IRR.
- Reinvest at opportunity cost (*r)* is more realistic, so the NPV method is better.

Modified Internal Rate of Return (MIRR)

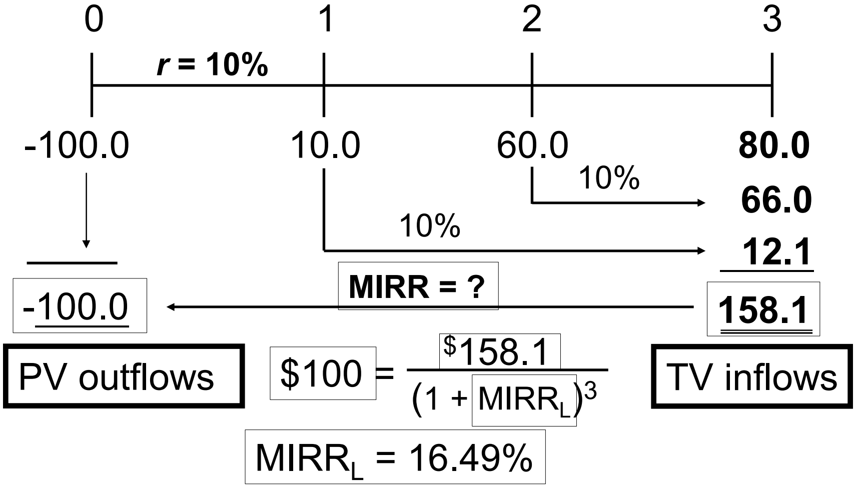
- While the NPV is a better measure of a project's profitability, executives tend to prefer the IRR because it is intuitively more appealing in evaluating & comparing investment projects.
- We can modify the IRR to make it a better indicator of **relative profitability**, hence more useful in capital budgeting.
- The idea is to "modify" the cash flows first, then calculate an IRR using the modified cash flows.

Modified IRR

- One approach is to
  - compound all inflows to the end of the project at WACC (call this “Terminal Value”), and
  - discount all outflows back to the present at the WACC
- MIRR is the discount rate that equates the PV of the terminal value (TV) and the PV of the costs of a project.

$$\text{PV of Cost} = \frac{\text{Terminal Value}}{(1+\text{MIRR})^{n}}.$$

MIRR for Project *L* (*r* = 10%)



0 1 2 3

***r* = 10%**

-100.0 10.0 60.0 **80.0**

10%

66.0

10%

12.1

MIRR = ?

-100.0

158.1

PV outflows

$$\$100 = \frac{\$158.1}{(1+\text{MIRR}_L)^3}$$

TV inflows

$\text{MIRR}_L = 16.49\%$

$$\$100 = \frac{{}^{\$}158.1}{(1+\text{MIRR}_L)^3}$$

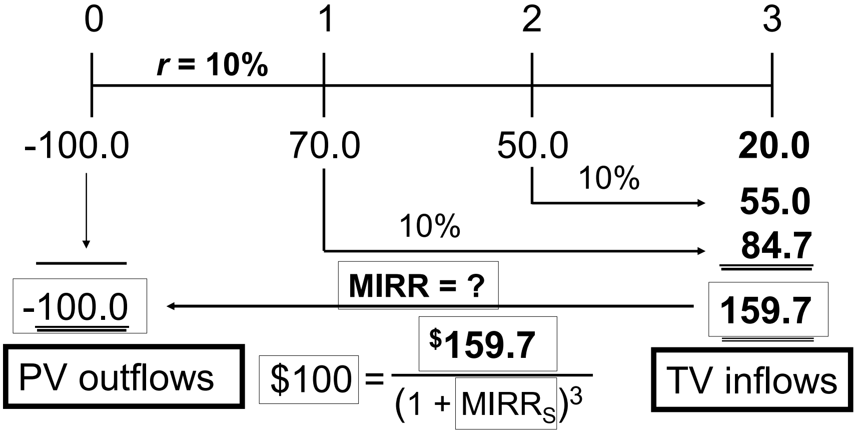
$$(1+\text{MIRR}_L)^3 = \frac{{}^{\$}158.1}{{}^{\$}100}$$

$$1+\text{MIRR}_L = (1.581)^{1/3}$$

$$\text{MIRR}_L = 1.164959 - 1$$

$$\text{MIRR}_L = 0.164959$$

MIRR for Project *S* (*r* = 10%)



0 1 2 3

***r* = 10%**

-100.0 70.0 50.0 **20.0**

10% **55.0**

10% **84.7**

MIRR = ?

-100.0

159.7

PV outflows

TV inflows

$$\$100 = \frac{{}^{\$}\mathbf{159.7}}{(1+\text{MIRR}_S)^3}$$

$$\text{MIRR}_S = 16.89\%$$

$$\$100 = \frac{^{\$}159.7}{(1+\text{MIRR}_S)^3}$$

$$(1+\text{MIRR}_S)^3 = \frac{^{\$}159.7}{^{\$}100}$$

$$1+\text{MIRR}_S = (1.597)^{1/3}$$

$$\text{MIRR}_S = 1.16887 - 1$$

$$\text{MIRR}_S = 0.1689$$

Why use MIRR versus IRR?

- MIRR correctly assumes reinvestment at opportunity cost = WACC.
- MIRR also eliminates the problem of multiple IRRs (see below).
- Managers like to compare the rates of return of different projects, and MIRR is a better rate for comparison than the IRR.

Normal Cash Flow Project:

- Cost (negative CF), followed by a series of positive cash inflows.
- Only one change of signs.

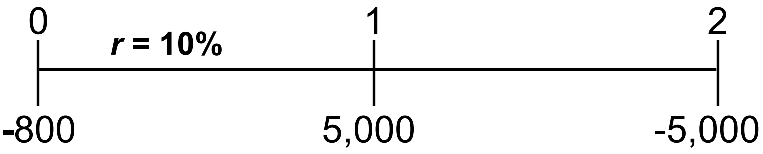
Non-normal Cash Flow Project:

- Two or more sign changes.
- Cost (negative CF), followed by a series of positive cash inflows, then cost to close project.
- Example: Nuclear power plants, strip mines.

Inflow (+) or Outflow (-) in Year

0	1	2	3	4	5	N	NN
-	+	+	+	+	+	N	
-	+	+	+	+	-		NN
-	-	-	+	+	+	N	
+	+	+	-	-	-	N	
-	+	+	-	+	-		NN

Non-normal CF: use NPV or IRR?



*Amounts in 1,000s

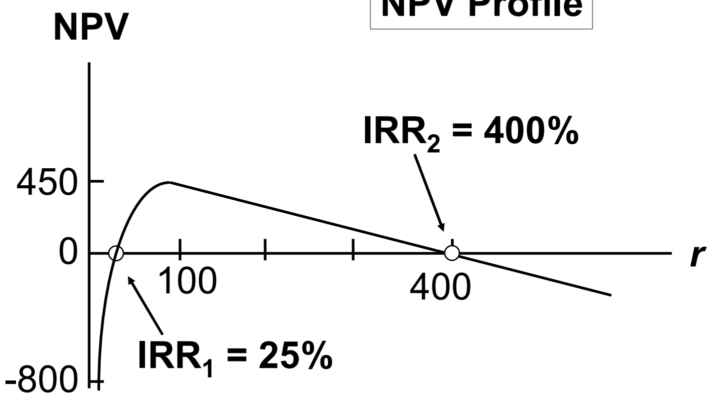
Enter CFs in CFLO, enter i = 10.

NPV = -386.78

IRR = “ERROR” Why?

We got IRR = “ERROR” because there are 2 IRRs due to non-normal CFs with two sign changes.

NPV Profile



Check:

If $r = 25\%$

$$NPV = \frac{-800}{(1+0.25)^0} + \frac{5{,}000}{(1+0.25)^1} + \frac{-5{,}000}{(1+0.25)^2}$$

$$= -800 + 4{,}000 - 3{,}200$$

$$= 0$$

If $r = 400\%$

$$NPV = \frac{-800}{(1+4)^0} + \frac{5{,}000}{(1+4)^1} + \frac{-5{,}000}{(1+4)^2}$$

$$= -800 + 1{,}000 - 200$$

$$= 0$$

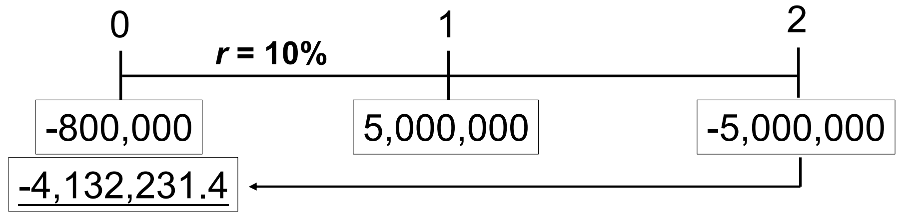
Logic behind Multiple IRRs

1. At very low discount rates, the PV of CF_2 is large & negative, so NPV < 0.
2. At very high discount rates, the PV of both CF_1 and CF_2 are low, so CF_0 dominates and again NPV < 0.
3. In between, the discount rate hits CF_2 harder than CF_1, so NPV > 0.

Result: **2 IRRs.**

Moral: Strange things can happen to the IRR when the cash flow is non-normal.

When the project has non-normal CFs and there is more than one IRR, use MIRR:



-800,000

5,000,000

-5,000,000

-4,132,231.4

-4,932,231.40 = PV of outflows @ 10%

TV of inflows @ 10% = 5,500,000

MIRR = 5.6%

Should this project be accepted?

- Since this project has multiple IRR, we cannot use IRR as a criteria.
- We should use MIRR instead.
- NO. It should be rejected because

  MIRR = 5.6% < r = 10%.
- Also, if MIRR < r, NPV will be negative.

  In this example, NPV = -$386,777.
- **So MIRR and NPV give the same conclusion**.

Suppose Projects *S* and *L* are mutually exclusive and can be repeated. If *r* = 10%, which is better?

***r* = 10%**

0	1	2	3	4
Project *S*:				
(100)	60	60		
Project *L*:				
(100)	33.5	33.5	33.5	33.5

* Amounts in 1,000s

	Project S	**Project L**
CF_0	-100,000	-100,000
CF_1	60,000	33,500
N	2	4
i	10	10
NPV	4,132	6,190

$NPV_L > NPV_S$. Does it mean *L* is better?

- Can’t say yet – the analysis based on NPV only is incomplete.
- Note that Project *S* could be repeated after 2 years to generate additional profits.
- Can use replacement chain (“common life”) analysis to make decision.

Replacement Chain Approach

Project *S* with Replication:

0	1	2	3	4
(100)	60	60		
		(100)	60	60
(100)	60	(40)	60	60

* Amounts in 1,000’s

NPV_s = \$7,547 > NPV_L (= \$6,190).

If the cost to repeat *S* in two years rises to $105,000, which is best?

Project *S* with Replication:

0	1	2	3	4
(100)	60	60		
		(105)	60	60
(100)	60	(45)	60	60

NPV_S = $3,415 < NPV_L (= $6,190).
Should choose *L* in this case.

Choosing the Optimal Capital Budget

- Finance theory says to accept all positive NPV projects.
- Two problems can occur when there is not enough internally generated cash to fund all positive NPV projects:
  - An increasing marginal cost of capital.
  - Capital rationing

Increasing Marginal Cost of Capital

- Externally raised capital (by issuing debt or equity) can have large flotation costs, which increase the cost of capital.
- Investors often perceive large capital budgets as being risky, which could drive up the cost of capital.
- If external funds will be raised, then the NPV of all projects should be estimated again using this higher marginal cost of capital.

Capital Rationing

- Capital rationing occurs when a company chooses not to fund all positive NPV projects.
- A company typically sets an upper limit on the total amount of capital expenditures that it will make in the upcoming year.
- That means not all positive NPV projects will be undertaken.
- Why would any company forego value-adding projects?
- Here are some possible reasons and solutions.

Reason: Companies want to avoid the direct (i.e., flotation costs) and indirect costs (negative reactions of the market) of raising new external capital.

Solution: Incorporate these costs into its cost of capital, then accept all projects that still have a positive NPV with the higher cost of capital and raise external equity needed to finance them.

Reason: Companies don't have enough non-monetary resources (managerial, marketing, or engineering staff) to implement all positive NPV projects.

Solution: Use linear programming to identify the set of NPV-maximizing projects, subject to the staffing constraints.

more …

Reason: Project managers have incentive to submit unreasonably high cash flow "estimates". Management can filter out "bad" projects by limiting the size of the capital budget or the total amount of projects that can be accepted.

Solution: Implement a post-audit process and tie the managers' compensation to the accuracy of the forecasts and subsequent performance of the project.