Chapter 8

Rate of Return Multiple Alternatives

LEARNING OUTCOMES

1. **Why incremental analysis is required in ROR**
2. **Incremental cash flow (CF) calculation**
3. **Interpretation of ROR on incremental CF**
4. **Select alternative by ROR based on PW relation**
5. **Select alternative by ROR based on AW relation**
6. **Select best from several alternatives using ROR method**

Why Incremental Analysis is Necessary

- Selecting the alternative with highest ROR may not yield highest return on ***available capital***
- Must consider ***weighted average*** of total capital available
- Capital ***not*** invested in a project is assumed to ***earn at MARR***

Example: Assume $90,000 is available for investment and MARR = 16% per year. If alternative A would earn 35% per year on investment of $50,000, and B would earn 29% per year on investment of $85,000, the weighted averages are:

Overall ROR_A = [50,000(0.35) + 40,000(0.16)]/90,000 = 26.6%

Overall ROR_B = [85,000(0.29) + 5,000(0.16)]/90,000 = 28.3%

Which investment is better, economically?

Why Incremental Analysis is Necessary

If selection basis is higher ROR:

Select alternative A (wrong answer)

If selection basis is higher overall ROR:

Select alternative B

Conclusion: Must use an incremental ROR analysis to make a consistently correct selection

Unlike PW, AW, and FW values, if not analyzed correctly, ROR values can lead to an incorrect alternative selection. This is called the ranking inconsistency problem (discussed later)

Calculation of Incremental CF

Incremental cash flow = cash flow$_B$ – cash flow$_A$

where *larger initial investment* is Alternative B

Example: Either of the cost alternatives shown below can be used in a grinding process. Tabulate the incremental cash flows.

	A	B	B - A
First cost, $	-40,000	- 60,000	-20,000
Annual cost, $/year	-25,000	-19,000	+6000
Salvage value, $	8,000	10,000	+2000

The incremental CF is shown in the (B-A) column

The ROR on the extra $20,000 investment in B determines which alternative to select (as discussed later)

Interpretation of ROR on Extra Investment

Based on concept that any *avoidable investment* that does not yield at least the MARR should not be made.

Once a lower-cost alternative *has been economically* justified, the ROR on the *extra investment* (*i.e., additional amount of money* associated with a higher first-cost alternative) must also yield a ROR ≥ MARR (because the extra investment *is avoidable* by selecting the economically-justified lower-cost alternative).

This incremental ROR is identified as Δi*

For independent projects, select all that have ROR ≥ MARR
(no incremental analysis is necessary)

ROR Evaluation for Two ME Alternatives

(1) Order alternatives by *increasing initial investment cost*

(2) *Develop incremental CF series* using LCM of years

(3) Draw incremental *cash flow diagram*, if needed

(4) Count sign changes to see if *multiple Δi^* values exist*

(5) Set up PW, AW, or FW = 0 relation and *find Δi^*_{B-A}*

Note: Incremental ROR analysis requires equal-service comparison. The LCM of lives must be used in the relation

(6) If Δi^*_{B-A} < MARR, *select A*; otherwise, select B

If multiple Δi^* values exist, ***find EROR*** using either MIRR or ROIC approach.

Example: Incremental ROR Evaluation

Either of the cost alternatives shown below can be used in a chemical refining process. If the company's MARR is 15% per year, determine which should be selected on the basis of ROR analysis?

	A	B
First cost ,$	-40,000	-60,000
Annual cost, $/year	-25,000	-19,000
Salvage value, $	8,000	10,000
Life, years	5	5

Initial observations: ME, cost alternatives with equal life estimates and no multiple ROR values indicated

Example: ROR Evaluation of Two Alternatives

Solution, using procedure:

	A	B	B - A
First cost , $	-40,000	-60,000	-20,000
Annual cost, $/year	-25,000	-19,000	+6000
Salvage value, $	8,000	10,000	+2000
Life, years	5	5	

Order by first cost **and** ***find incremental cash flow*** **B - A**

Write ROR equation **(in terms of PW, AW, or FW) on incremental CF**

$$0 = -20{,}000 + 6000(P/A,\Delta i^*,5) + 2000(P/F,\Delta i^*,5)$$

Solve **for Δi^* and** ***compare*** **to MARR**

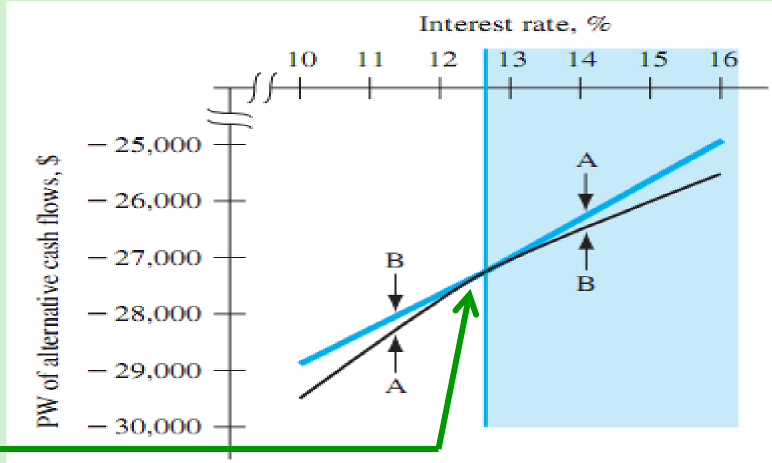
$\Delta i^*_{B\text{-}A}$ = 17.2% > MARR of 15%

ROR on $20,000 extra investment is acceptable: **Select B**

Breakeven ROR Value

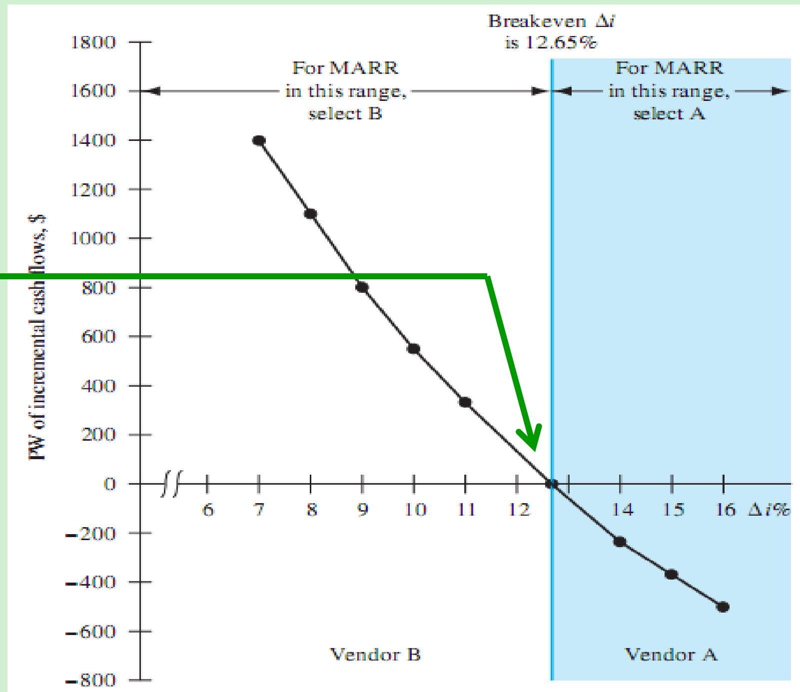
An ROR at which the PW, AW or FW values:

- Of cash flows for two alternatives are exactly equal. This is the i* value



- Of *incremental* cash flows between two alternatives are exactly equal.

  This is the Δi* value



If MARR > breakeven ROR, select lower-investment alternative

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ROR Analysis – Multiple Alternatives

Six-Step Procedure for Mutually Exclusive Alternatives

(1) Order alternatives from *smallest to largest initial investment*

(2) For revenue alts, calculate **i*** (vs. DN) and *eliminate all with i* < MARR*; remaining alternative with lowest cost is ***defender*****. F**or cost alternatives, go to step (3)

(3) Determine incremental CF between ***defender*** and ***next lowest-cost*** alternative (known as the *challenger*). Set up ROR relation

(4) Calculate **Δi*** on incremental CF between *two alternatives from step (3)*

(5) If **Δi* ≥ MARR,** *eliminate defender* and *challenger becomes new defender* against next alternative on list

(6) Repeat steps (3) through (5) *until only one alternative* remains. ***Select it***.

For Independent Projects

Compare each alternative vs. DN and select ***all with ROR ≥ MARR***

Example: ROR for Multiple Alternatives

The five mutually exclusive alternatives shown below are under consideration for improving visitor safety and access to additional areas of a national park. If all alternatives are considered to last indefinitely, determine which should be selected on the basis of a rate of return analysis using an interest rate of 10%.

	A	B	C	D	E
First cost, $ millions	-20	-40	-35	-90	-70
Annual M&O cost, $ millions	-2	-1.5	-1.9	-1.1	-1.3

Solution: **Rank on the basis of initial cost: A,C,B,E,D; calculate CC values**

C vs. A: $0 = -15 + 0.1/0.1$ **$\Delta i^* = 6.7\%$** (eliminate C)

B vs. A: $0 = -20 + 0.5/0.1$ **$\Delta i^* = 25\%$** (eliminate A)

E vs. B: $0 = -30 + 0.2/0.1$ **$\Delta i^* = 6.7\%$** (eliminate E)

D vs. B: $0 = -50 + 0.4/0.1$ **$\Delta i^* = 8\%$** (eliminate D)

Select alternative B

Summary of Important Points

- Must consider ***incremental cash flows*** for mutually exclusive alternatives

  Incremental cash flow = cash flow$_B$ – cash flow$_A$

  where alternative with ***larger*** initial investment is **Alternative B**

- Eliminate **B** if incremental ROR **Δi* < *MARR*;** *otherwise,* **eliminate A**

- ***Breakeven ROR*** is i* between ***project cash flows*** of two alternatives, or Δi* between ***incremental cash flows*** of two alternatives

- For multiple mutually exclusive alternatives, compare two at a time and eliminate alternatives until ***only one remains***

- For independent alternatives, compare each against **DN** and ***select all that have ROR ≥ MARR***