Engineering Economy

[8]
Rate of Return Analysis
Multiple Alternatives

Example [1]

- Suppose you have $5,000 and there are two mutually exclusive alternatives, each with a 1-year service life:
- One requires an investment of $1,000 with a return of $2,000 (Plan 1)
- The other requires $5,000 with a return of $7,000 (Plan 2)
- MARR equals 10%
- Which alternative would you prefer?

Example [1]

- Before, we have chosen between the alternatives that are mutually exclusive based on the present worth or annual worth

- However, this does not work OK with the highest rate of return

- To illustrate this, just look over the solution of this example in the following table

Example [1]

MARR	10.00%			
You have	$5,000	$5,000		
Time	**1**	**2**	**Left in 1**	**Left in 2**
0	-$1,000	-$5,000	$4,000	$0
1	$2,000	$7,000	$4,400	$0

Example [1]

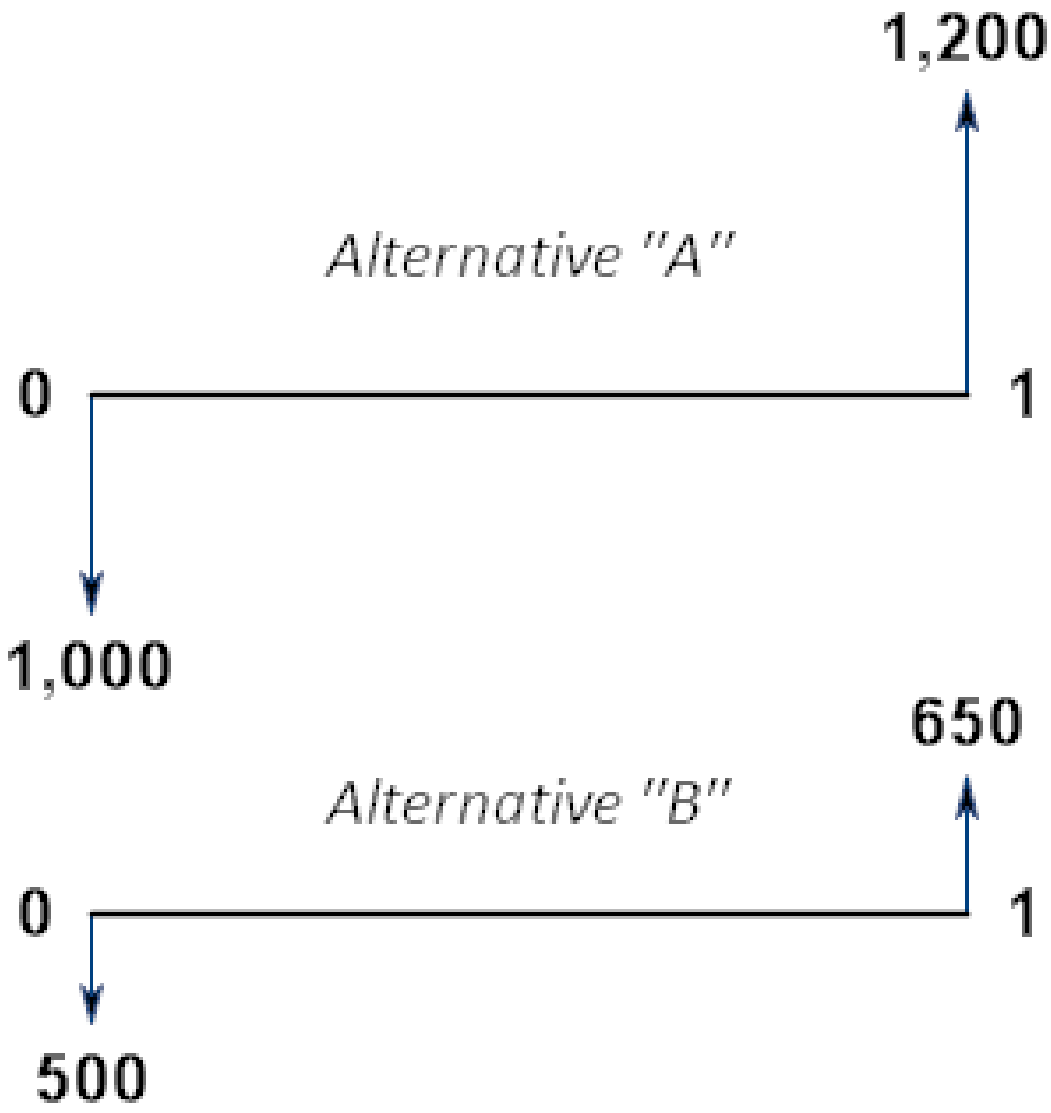
- Based on the FW analysis, one can tell that plan 2 is preferred over plan 1
- The rate of return measure gives numerically higher rating for plan 1
- The PW, FW, and AW are *absolute* measures ($)
- The rate of return is a *relative* measure (%) and *does not address the scale of the cash flows*

Example [1]

- Therefore, the answer is to select plan 2 with the lower rate of return but higher future worth

- As such, we need to use the incremental analysis if we would like to use the rate of return analysis

Example [2]



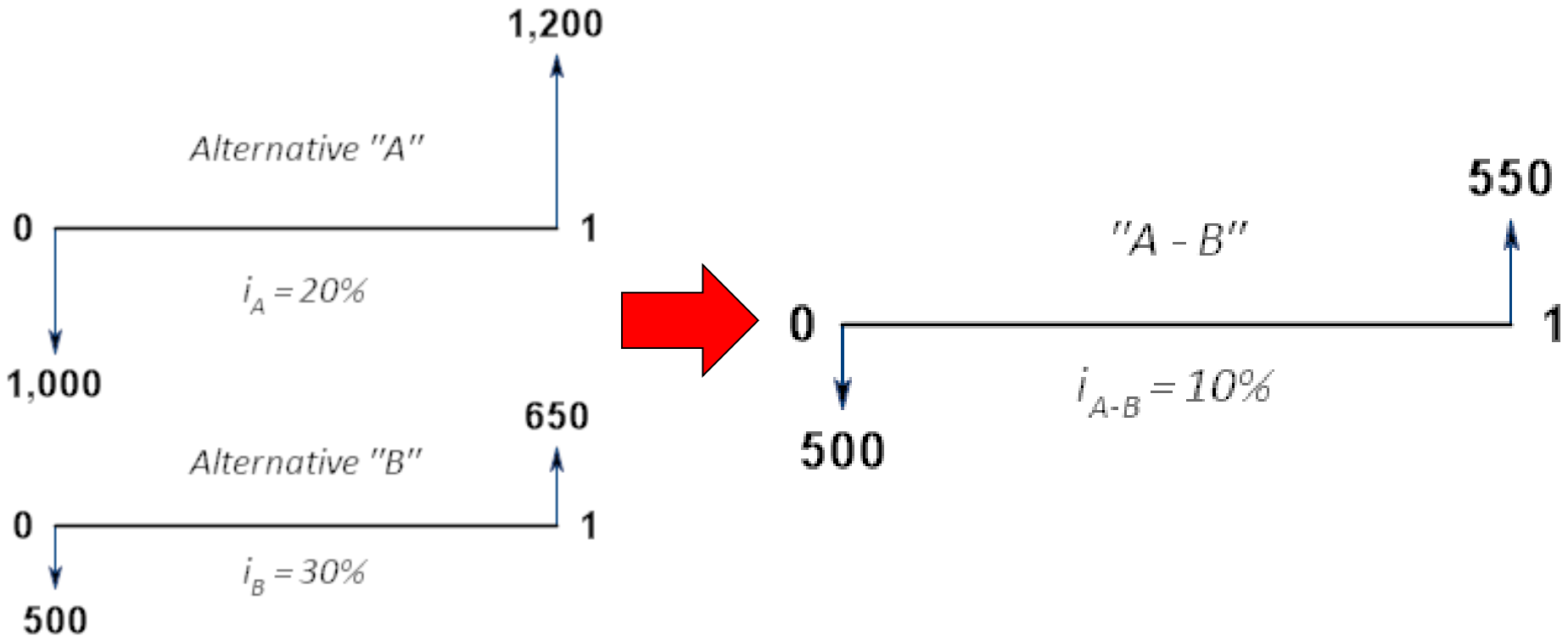
Which alternative would you choose to invest your $1,000 if:

(1) MARR = 12%?

and

(2) MARR = 8%?

Example [2]


1,200
Alternative "A"
0
1
$i_A = 20\%$
1,000
650
Alternative "B"
0
1
$i_B = 30\%$
500
550
"A - B"
0
1
$i_{A-B} = 10\%$
500

Example [2]

- First of all, the two alternatives are eligible since i_A>MARR and i_B>MARR
- Find the incremental cash flows which equal A – B
- This implies the ***additional*** investment in alternative "A" on top of alternative "B" that produces a benefit of $550
- That is, the reference alternative would be alternative "B" and if "A-B" has an i value (i_{A-B}) larger than MARR then choose alternative "A" since it equals alternative B + "A-B" otherwise choose alternative "B"

Incremental Analysis

- For two mutually exclusive projects, rate-of-return analysis is done by *computing the rate of return on the incremental investment between the projects*

- Thus, compute the cash flow for the difference between the projects by subtracting the cash flow for the lower investment-cost project (1) from that of the higher investment-cost project (2)

Incremental Analysis

The decision rule is:

- If $RoR_{2-1} > MARR$, select project 2
- If $RoR_{2-1} = MARR$, select any project
- If $RoR_{2-1} < MARR$, select 1

- Note: 2 higher cost, 1 lower cost

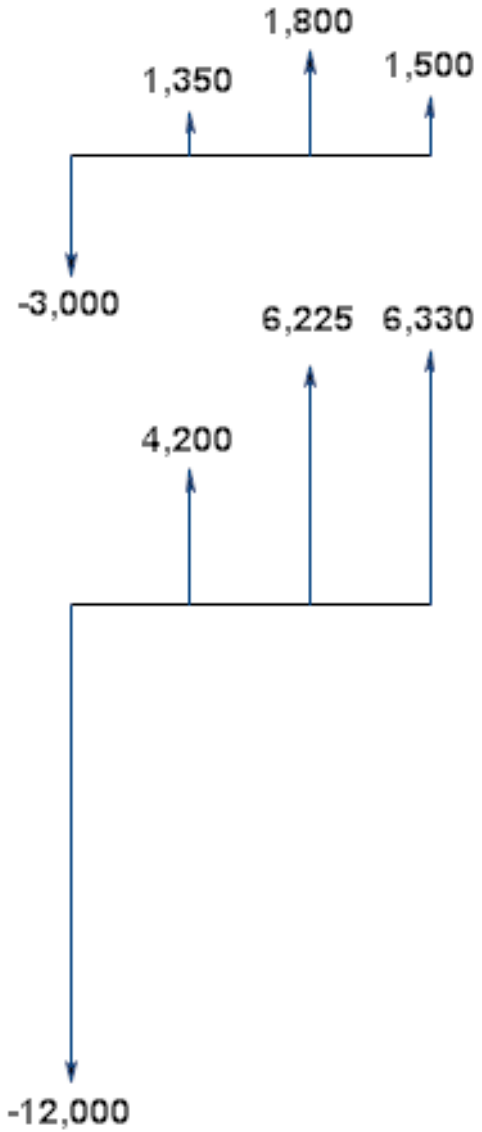
Example [3]

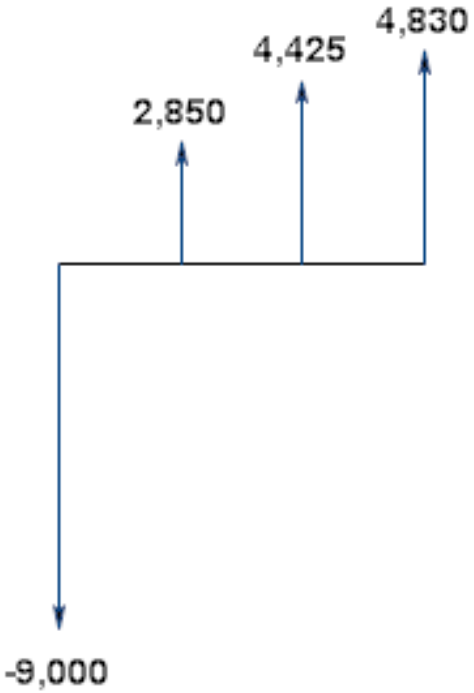
- The cash flows for two mutually exclusive alternatives are as in the table below

- Which project would you select at MARR = 10%?

n	B1	B2	B2-B1
0	-$3,000	-$12,000	-$9,000
1	$1,350	$4,200	$2,850
2	$1,800	$6,225	$4,425
3	$1,500	$6,330	$4,830
RoR	25.00%	17.43%	15.00%

Example [3]





Example [3]

- To choose the best project, we compute the incremental cash flow B2 – B1

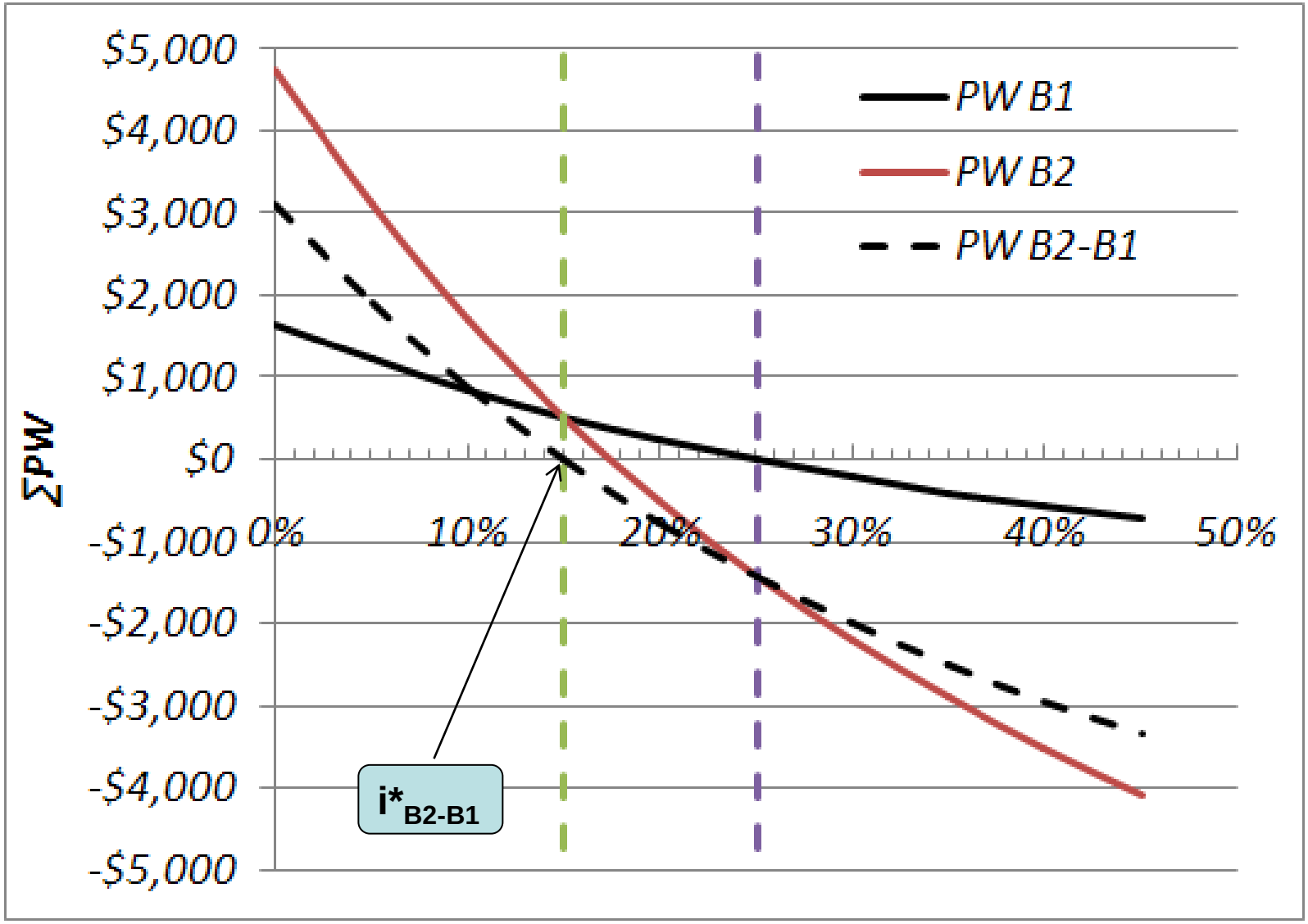
- Then we compute the rate of return on this increment of investment by solving the equation:

$$-9{,}000 + 2{,}850(P/F,i^*,1) + 4{,}425(P/F,i^*,2) + 4{,}830(P/F,i^*,3) = 0$$

- We obtain $i^*_{B2\text{-}B1} = 15\%$

- Since $i^*_{B2\text{-}B1} > MARR$, we select B2

Example [3]


$5,000
$4,000
$3,000
$2,000
$1,000
$0
-$1,000
-$2,000
-$3,000
-$4,000
-$5,000
ΣPW
0%
10%
20%
30%
40%
50%
PW B1
PW B2
PW B2-B1
i*B2-B1

Example [4]

- Sandersen Meat Processors has asked its lead process engineer to evaluate two different types of conveyors for the bacon curing line

- Type A has an initial cost of $70,000 and a life of 8 years. Type B has an initial cost of $95,000 and a life expectancy of 12 years. The annual operating cost for type A is expected to be $9,000, while the AOC for type B is expected to be $7,000. The salvage values are $5,000 and $10,000 for type A and type B, respectively

- *Tabulate the incremental cash flows*

Example [4]

	Type A	Type B
Initial cost, $	**-70,000**	**-95,000**
Annual operating cost, $/year	**-9,000**	**-7,000**
Salvage value, $	**5,000**	**10,000**
Life, year	**8**	**12**

Year	A	B	B-A
0	-$70,000	-$95,000	-$25,000
1	-$9,000	-$7,000	$2,000
2	-$9,000	-$7,000	$2,000
3	-$9,000	-$7,000	$2,000
4	-$9,000	-$7,000	$2,000
5	-$9,000	-$7,000	$2,000
6	-$9,000	-$7,000	$2,000
7	-$9,000	-$7,000	$2,000
8	-$74,000	-$7,000	$67,000
9	-$9,000	-$7,000	$2,000
10	-$9,000	-$7,000	$2,000
11	-$9,000	-$7,000	$2,000
12	-$9,000	-$92,000	-$83,000
13	-$9,000	-$7,000	$2,000
14	-$9,000	-$7,000	$2,000
15	-$9,000	-$7,000	$2,000
16	-$74,000	-$7,000	$67,000
17	-$9,000	-$7,000	$2,000
18	-$9,000	-$7,000	$2,000
19	-$9,000	-$7,000	$2,000
20	-$9,000	-$7,000	$2,000
21	-$9,000	-$7,000	$2,000
22	-$9,000	-$7,000	$2,000
23	-$9,000	-$7,000	$2,000
24	-$4,000	$3,000	$7,000

Example [4]

Example [5]

- In 2000, Bell Atlantic and GTE merged to form a giant telecommunications corporation named Verizon Communications

- As expected, some equipment incompatibilities had to be rectified, especially for long distance and international wireless and video services. One item had two suppliers—a U.S. firm (A) and an Asian firm (B). Approximately 3,000 units of this equipment were needed. Estimates for vendors A and B are given for each unit

- *Determine which vendor should be selected if the MARR is 15% per year*

Example [5]

	A	B
Initial cost, $	-8,000	-13,000
Annual cost, $	-3,500	-1,600
Salvage value, $	0	2,000
Life, years	10	5

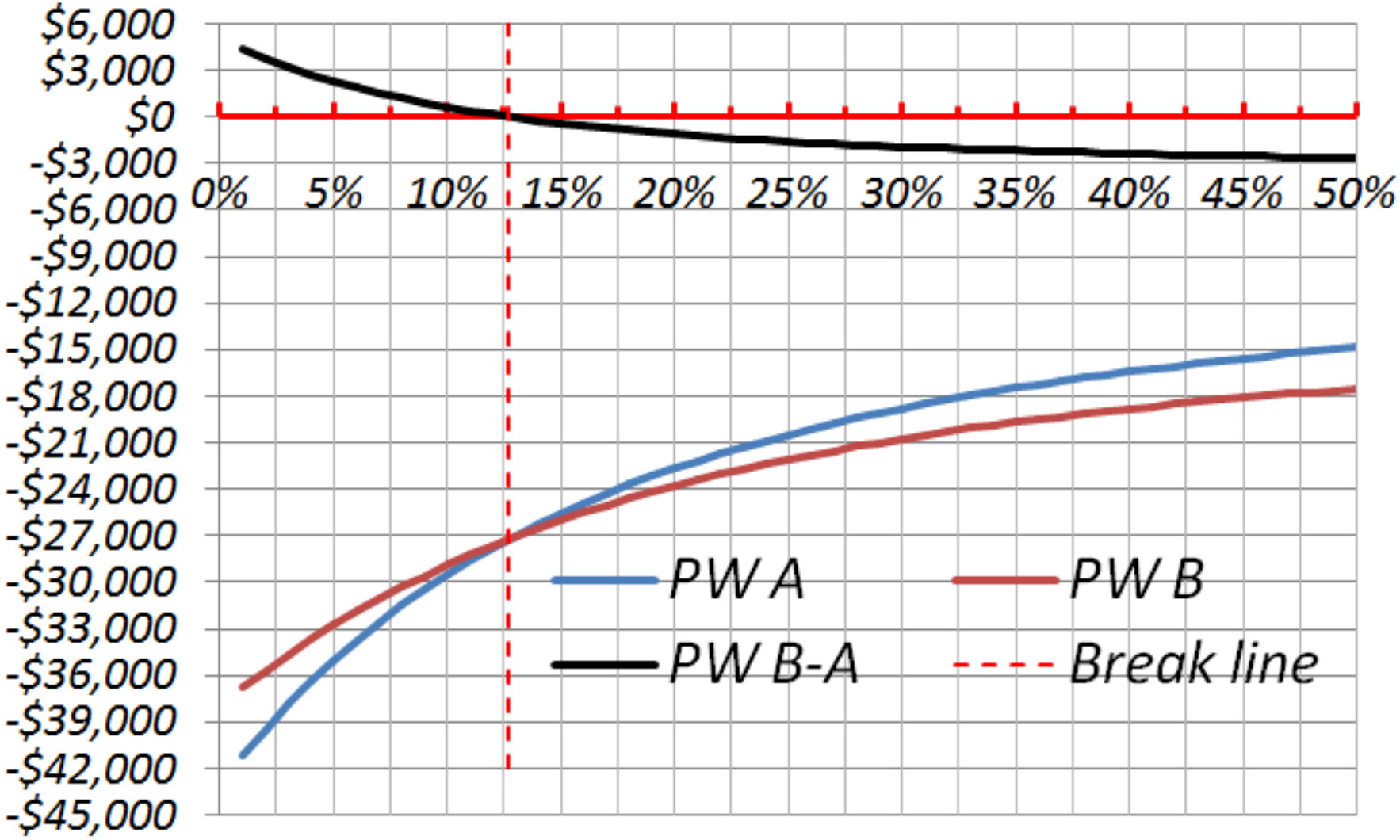
Example [5]

- Tabulate the incremental cash flows. There are three sign changes in the incremental cash flow series indicating three roots and at least one positive root
- Based on the PW of the incremental cash flow, we have:
- $0 = -5{,}000 + 1{,}900(P/A,i,10) - 11{,}000(P/F,i,5) + 2{,}000(P/F,i,10)$
- This yields $i^*_{B-A} = 12.649\%$
- Since $i^*_{B-A} < MARR$, alternative A is selected

Example [5]

Year	A	B	B-A
0	-$8,000	-$13,000	-$5,000
1	-$3,500	-$1,600	$1,900
2	-$3,500	-$1,600	$1,900
3	-$3,500	-$1,600	$1,900
4	-$3,500	-$1,600	$1,900
5	-$3,500	-$12,600	-$9,100
6	-$3,500	-$1,600	$1,900
7	-$3,500	-$1,600	$1,900
8	-$3,500	-$1,600	$1,900
9	-$3,500	-$1,600	$1,900
10	-$3,500	$400	$3,900
Total	**-$43,000**	**-$38,000**	**$5,000**

Example [5]


$6,000
$3,000
$0
-$3,000
-$6,000
-$9,000
-$12,000
-$15,000
-$18,000
-$21,000
-$24,000
-$27,000
-$30,000
-$33,000
-$36,000
-$39,000
-$42,000
-$45,000
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
PW A
PW B
PW B-A
Break line