Chapter 9. Other analysis techniques

This chapter will cover a few other analysis techniques, including future worth analysis, benefit-cost analysis, present worth index analysis, payback period analysis, and sensitivity analysis. You should be able to choose an appropriate approach depending on different situation. The benefit cost analysis is heavily used by public sector.

1. Future worth analysis

- Future worth analysis is like the present worth analysis, dealing with *then* (future) rather than with *now* (present) situations.

- RRSP (Registered Retirement Savings Plan) in Canada
  - Introduced in 1957, it is a retirement savings plan for employees and self-employees.
  - There is a maximum contribution amount per year, depending on an individual’s income level.
  - Tax exemption: The amount of RRSP contributions are tax deductible, and people use it to reduce tax.
  - However, an individual have to pay tax when he receives payments from the plan after retirement.

Example 1-1. RRSP

- Sally is considering investing in a RRSP after starting her job at the age of 25. What is the future worth of her RRSP at age 65 if she makes an annual deposits of $4,000 beginning her 26th birthday? Assume the fund earns an annual return of 6%.

- If she lives for the next 20 years after the retirement at 65, what is her annual retirement payment given the same interest rate?

Example 1-2. Quitting smoking

- Smoking is bad for many reasons, including its financial implications. How much could one accumulate by age 65 if $40 (the cost of packs of cigarettes) is saved *each week* from age 20? The saving account would earn 6% interest, compounded *semiannually*.

Example 1-3. Choosing a job (1)

- You are considering taking one of two job offers.
  - *Generous Electric Company* offers you a 5-year contract with a salary of $75,000 paid at the end of each year, plus 1,000 shares of GE stock at the end of the 5 years.
  - *MacroSoft Company* offers you a 5-year contract with an annual salary of $80,000 paid at the end of each year. In addition you will get 200 shares of MS stock each year, starting from now. MS stock is currently $40 per share and pays annual dividend of $2 per share.
  - Stock dividends begin one year after the stock is received. You can sell the stock at the end of 5 year. You believe the value of stock and dividend will remain constant.
- Given a 10% MARR, what must the GE stock be worth per share to make you accept the GE offer? Use the *future worth analysis*.

EXAMPLE 1-3. CHOOSING A JOB (2)

- MS offer

- GE offer

2. Benefit-cost ratio analysis

- At a given minimum attractive rate of return (MARR), an alternative is acceptable, provided

  PW (benefits) – PW (costs) $\geq$ 0 or

  EUAB – EUAC $\geq$ 0

- These could also be stated as a ratio of benefits to costs.

  Benefit-cost ratio (B/C) = PW (benefits)/PW (costs)

  = EUAB/EUAC

  - B/C should be at least larger than 1 to accept any project.
  - The idea of benefit-cost ratio is the same as PW or EUAW approach.
  - For mutually exclusive project, however, we should use the incremental approach like the case of the IRR approach.
  - The benefit-cost approach is commonly used by the *public sector*.

EXAMPLE 2-1. BENEFIT-COST RATIO (1)

- A firm is trying to decide which of two devices to install to reduce costs. Both devices have useful lives of 5 years and no salvage value.
  - Device A costs $1,000 and can be expected to result in $300 savings annually.
  - Device B costs $1,350 and will provide cost savings of $300 the first year, with an annual increase of $50 from the second year.
- With interest at 7%, which device should the firm purchase? Use the *benefit-cost ratio approach*.
  - Note that choosing the device with the largest benefit-cost ratio is wrong.
  - Incremental approach should be used.

Example 2-1. Benefit-cost ratio (2)

Example 2-2. Benefit-cost ratio (1)

- Consider the six mutually exclusive alternatives. They have 20-year useful lives and no salvage value. If MARR is 6%, which alternative should be selected?

	A	B	C	D	E	F
Cost	\$4,000	\$2,000	\$6,000	\$1,000	\$9,000	\$10,000
PW(benefit)	7,330	4,700	8,730	1,340	9,000	9,500
B/C	1.83	2.35	1.46	1.34	1.00	0.95

- Again, we should use the incremental analysis to solve this problem.
- Since B/C of option F is less than 1, we discard F.
- Then, we reorder the options according to the cost: D, B, A, C and E.

Example 2-2. Benefit-cost ratio (2)

- **B – D**

  $\Delta B/\Delta C = (4{,}700 - 1{,}340)/(2{,}000 - 1{,}000) = 3.36$

  Option B is the current best.
- **A – B**

  $\Delta B/\Delta C = (7{,}330 - 4{,}700)/(4{,}000 - 2{,}000) = 1.32$

  Option A is the current best.
- **C – A**

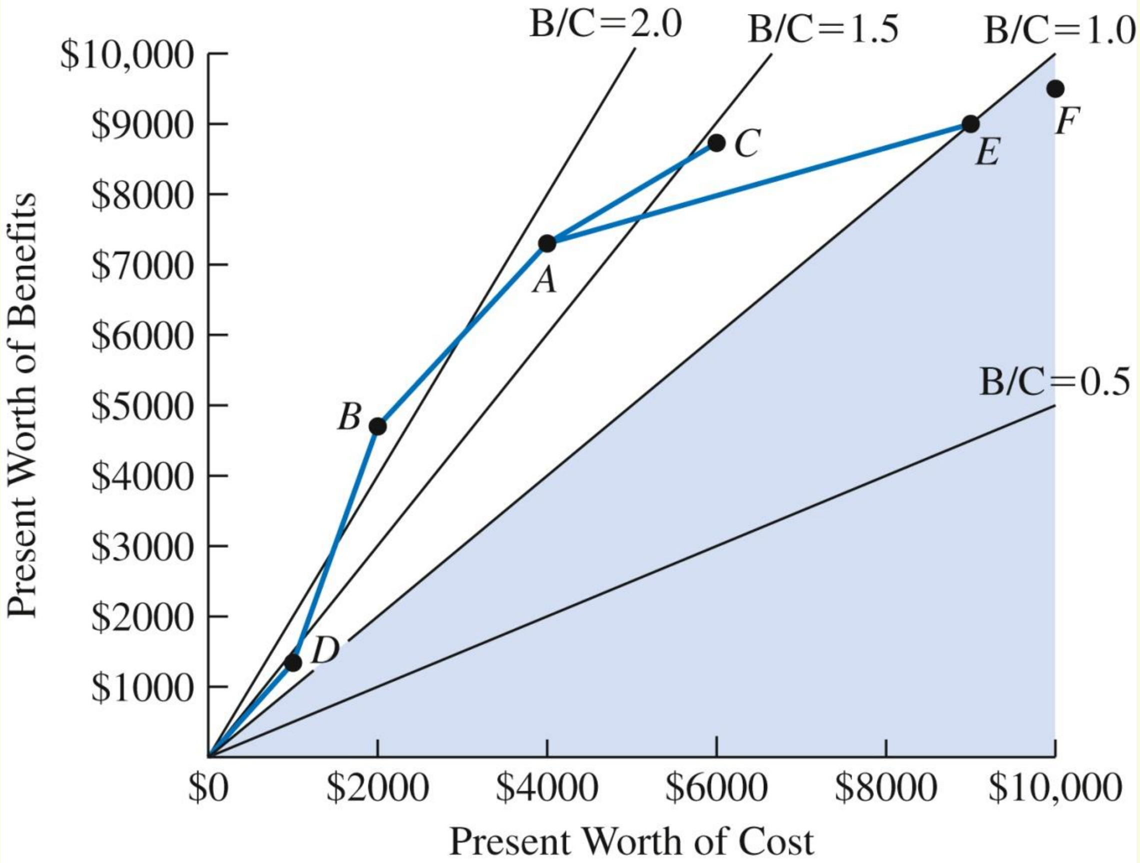
  $\Delta B/\Delta C = (8{,}730 - 7{,}330)/(6{,}000 - 4{,}000) = 0.70$

  Option A is still the current best.
- **E – A**

  $\Delta B/\Delta C = (9{,}000 - 7{,}330)/(9{,}000 - 4{,}000) = 0.33$
- Thus, **option A** should be chosen.
- Note that option A does not have the highest B/C ratio.

Example 2-2. Benefit-cost ratio (3)

- The shaded area is where B/C < 1 (for example, option F).
- Starting with option D, the slope of each increment is considered.
- Slopes of (C – A) and (E – A) are less than 1.



2.1. Public sector and benefit-cost ratio

- Public sector heavily uses the benefit-cost ratio in its decision.
  - The goals of public investment are to promote the general welfare.
  - It should ensure that the potential benefits exceed overall costs.
- *Public sector* benefit-cost ratio
  - The public sector takes a broad viewpoint and considers who pay the costs and who receive the benefits.
  - Numerator (benefit): All consequences to the *users* or the *public* (benefit as positive and cost as negative).
  - Denominator (cost): All consequences to the *sponsor* or *government*.
  - Is "congestion in traffic" cost or benefit?
    - The public suffers from congestion, so it is a negative benefit.
  - What about "reduced maintenance cost" of a bridge?
    - It is a negative cost to the government.

Example 2-3. Government B/C ratio (1)

- Two plans are suggested to reduce traffic congestion.

	Right turn lanes	Adding left turn lanes
Initial cost	$8.9 million	$11.9 million
Uniform annual benefit (reduced congestion)	$1.6 million	$2.2 million
Annual maintenance cost	$150,000	$225,000
Added congestion during construction	$900,000	$2.1 million
Useful life, years	15	15

- Which alternative is preferred if the interest rate is 10%? Use the *Benetif-cost ratio* approach.

EXAMPLE 2-3. GOVERNMENT B/C RATIO (2)

Example 2-4. Government B/C ratio (1)

- The city of Waterloo is considering increasing its airport capacity. Option A is to build a new airport in the suburb, and option B is to upgrade the current airport. Assuming 10% MARR and a 10-year time horizon for this project, which option should be accepted? Use the *benefit-cost ratio* approach.

	A (new airport)	B (upgrading)
Improved service/year	\$55 million	\$28 million
Increased travel cost/year	\$15 million	0
Cost of highway improvements	\$50 million	\$10 million
Construction costs	\$150 million	\$115 million
Reduced value of houses	0	\$25 million

Example 2-4. Government B/C ratio (2)

3. Payback period

- Payback period: the period of time required for the project's profit or other benefits to equal the project's cost.

  Payback period = Cost/Annual benefit

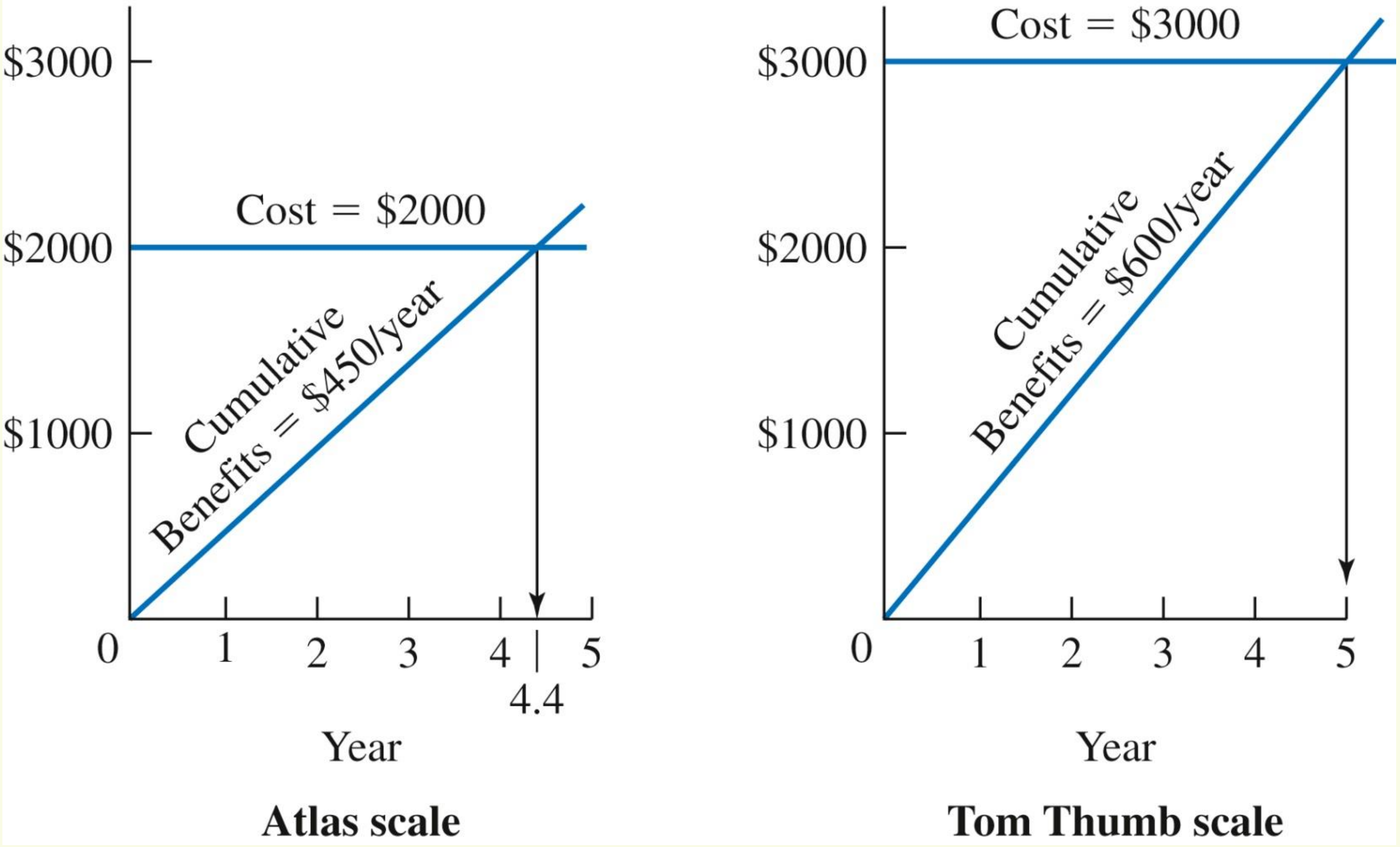
- Features of payback period method
  - Payback period can measure the *speed* of the return.
  - However, it is not a suitable or justifiable economic approach. Why?
  - The effect of timing (i.e., interest rate) is ignored.
  - It may not be consistent with other PW, EUAW or IRR methods.
- Then, why the payback period method?
  - The calculation is simple and easily understood.
  - Companies often set a "hurdle" period, and only consider projects that have payback periods less than the hurdle.

Example 3-1. Payback period (1)

- A firm is trying to decide which of two scales it should install. If both scales have a 6-year life, which one should be selected given an 8% interest rate.

Alternative	Cost	Annual benefit	Salvage value
Atlas scale	\$2,000	\$450	\$100
Tom Thumb scale	\$3,000	\$600	\$700

EXAMPLE 3-1. PAYBACK PERIOD (2)



EXAMPLE 3-2. PAYBACK PERIOD (1)

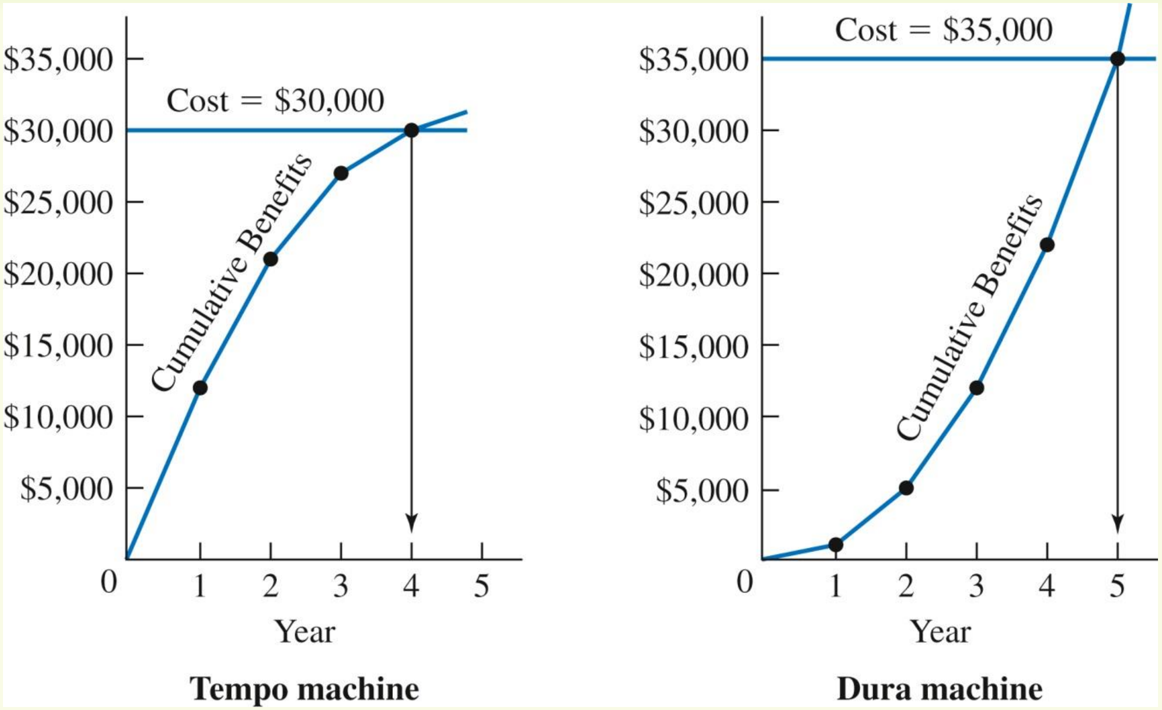
- A firm is buying production equipment for a new plant. Two alternative machines are being considered. Neither machine has any salvage value. Which one to choose?

	Tempo machine	Dura machine
Initial cost	$30,000	$35,000
Annual benefit	$12,000 the first year, declining $3,000 per year	$1,000 the first year, increasing $3,000 per year
Useful life, years	4	8

Payback period method

- Because the annual benefit is not uniform, we should use the graphical approach.

Example 3-2. Payback period (2)



- Tempo machine has a declining annual benefit, while the Dura has an increasing annual benefit.
- Tempo has a shorter payback period (4 years), and should be chosen. Right?

Example 3-2. Payback period (3)

IRR method

4. Sensitivity and breakeven analysis

- Many decisions include projections of future consequence, and there may be considerable uncertainty regarding the accuracy.
- To what extent do variations in the data affect my decision?
- Sensitivity analysis
  - How much a particular estimate would need to change in order to change a particular decision?
  - The decision is more sensitive to some estimates than others.
- Breakeven analysis
  - It is a form of sensitivity analysis.
  - In what conditions, two alternatives are viewed as "indifferent" (or same)?
  - One application of this analysis is staged construction.
- What-if analysis: It examines the change in many variables.

Example 4-1. Stage construction (1)

- Consider a project that may be constructed to full capacity now with a cost of \$140,000, or may be constructed in two stages (with \$100,000 now and \$120,000 *n* years from now).
  - All facilities will last for 40 years with zero salvage value.
  - The annual operation and maintenance cost is the same.
  - Assume an 8% interest rate.
- Mark the breakeven point on the sensitivity graph.
  - Construction of full capacity now: PW (cost) = 140,000
  - Two-stage construction

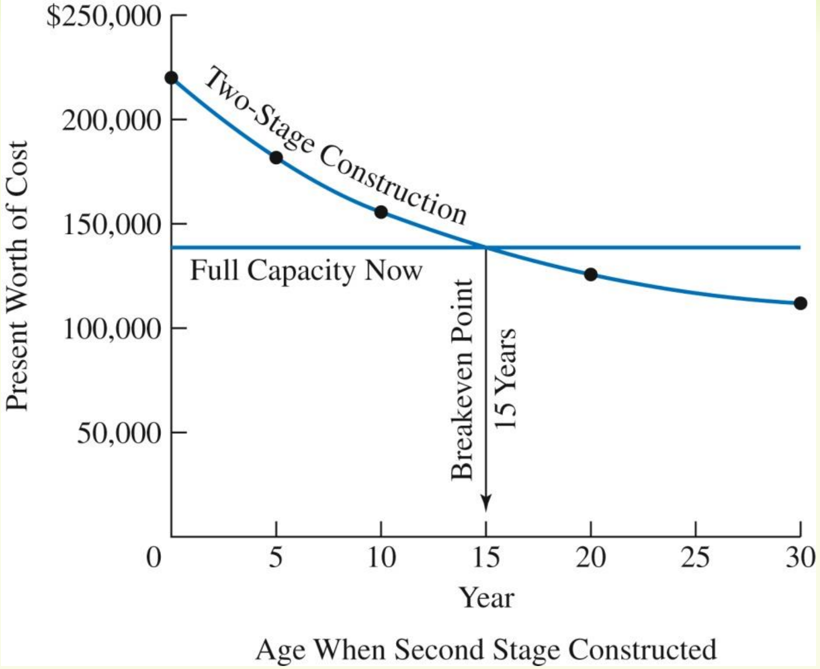
    PW (cost) = 100,000 + 120,000(P/F, 8%, n)

    n = 5 PW = 100,000 + 120,000(0.6806) = \$181,700

    n = 10 PW = 100,000 + 120,000(0.4632) = \$155,600

    n = 20 PW = 100,000 + 120,000(0.2145) = \$125,700

Example 4-1. Stage construction (2)



- The PW of cost of two-stage construction decreases as the second stage is delayed.
- The breakeven year is 15 years.
- If the second-stage were to be needed prior to 15 years, the full capacity construction is preferred.

Example 4-2. Life of project (1)

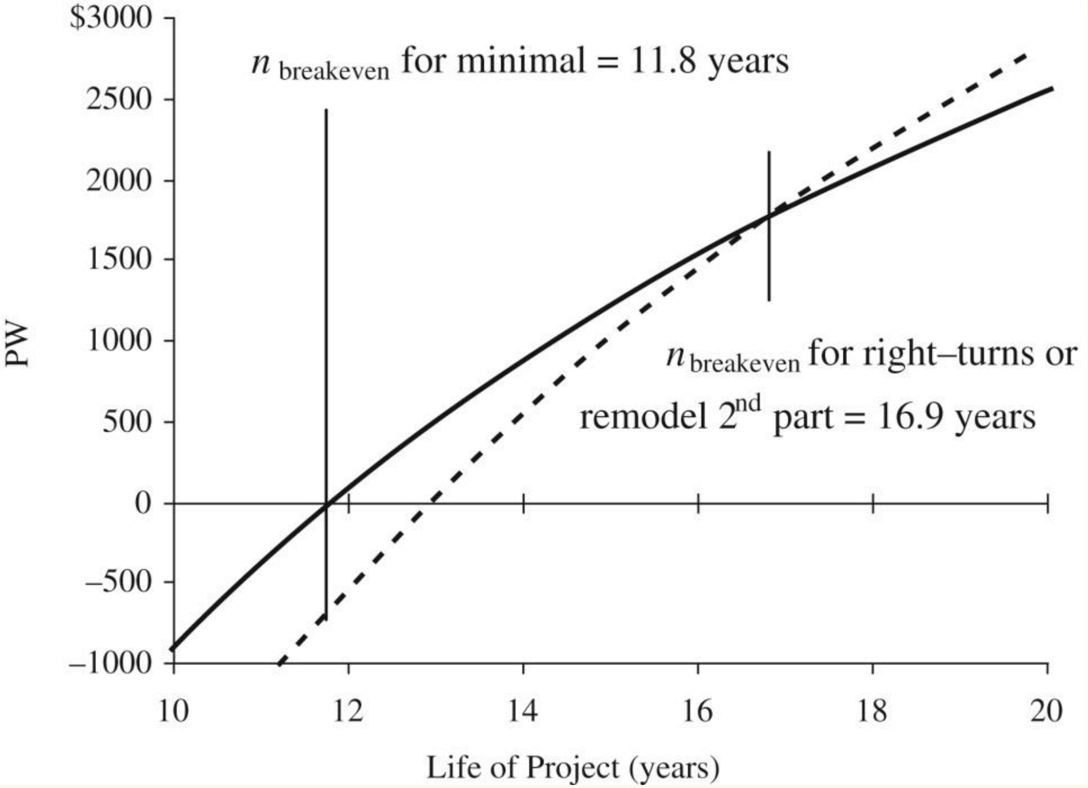
- In example 2-3, the life of 15 years is subject to uncertainty. Analyze the sensitivity of the decision to the project life, using the present worth measure.

$$\begin{aligned}\text{PW (right turn)} &= -900{,}000 - 8{,}900{,}000 \\ &\quad + (1{,}600{,}000 - 150{,}000)(P/A, 10\%, n) \\ &= -9{,}800{,}000 + 1{,}450{,}000(P/A, 10\%, n)\end{aligned}$$

$$\begin{aligned}\text{PW (left turn)} &= -2{,}100{,}000 - 8{,}900{,}000 - 3{,}000{,}000 \\ &\quad + (2{,}200{,}000 - 225{,}000)(P/A, 10\%, n) \\ &= -14{,}000{,}000 + 1{,}975{,}000(P/A, 10\%, n)\end{aligned}$$

- This question could be analyzed for breakeven value of n.
- Here, we use the graph technique to solve this problem.

Example 4-2. Life of project (2)



- The right turn option is the best one for lives of 12 to 16 years (In the previous question, the life was 15 years.)
- Adding left turn option is best for lives of more than 17 years.

Example 4-3. Airline seats

- WestJet flies non-stop between Toronto and Winnipeg with a 120-passager plane. Considering all the costs of owning the plane, landing fees, etc., the *fixed cost* for a single flight is $12,000. The cost associated with each passenger (*variable cost*) is $50 per passenger. If the average ticket price is $200, what percentage of seats must be filled for the flight to break even?

Example 4-4. Breakeven analysis (1)

- Victoria is choosing between a regular Camry and a hybrid Camry. How many miles must Victoria drive in a year to make hybrid more cost efficient, if interest rate is 10%?

	Regular Camry	**Hybrid Camry**
Purchase price	\$23,700	\$27,700
Litres/100 km	7	4.7
Gas price/litre	\$1.30	\$1.30
Driving km per year	*X*	*X*
Useful life, years	8	8

Example 4-4. Breakeven analysis (2)

- Let X be the number of km of driving at the breakeven point.

SUMMARY OF CHAPTER 9

- Future worth
- Benefit cost ratio
- Payback period
- Sensitivity and breakeven analysis

- Selective end of chapter problems
  - 9, 19, 27, 34, 49, 72 (assume n = 20)