horizon with project repeatability (the same costs and benefits) likely? Assume that $i = 12\%$.

5.48 Consider the two mutually exclusive investment projects in Table P5.48, which have unequal service lives.

TABLE P5.48

	Project's Cash Flow	
n	A1	A2
0	−$900	−$1,800
1	−400	−300
2	−400	−300
3	−400 + 200	−300
4	—	−300
5	—	−300
6	—	−300
7	—	−300
8	—	−300 + 500

(a) What assumption(s) do you need in order to compare a set of mutually exclusive investments with unequal service lives?

(b) With the assumption(s) defined in part (a) and using determine which project should be selected.

(c) If your analysis period (study period) is just three years, what should be the salvage value of project A2 at the end of year 3 to make the two alternatives economically indifferent?

5.49 Consider the two mutually exclusive projects in Table P5.49.

Salvage values represent the net proceeds (after tax) from disposal of the assets if they are sold at the end of each year. Both projects B1 and B2 will be available (or can be repeated) with the same costs and salvage values for an indefinite period.

(a) Assuming an infinite planning horizon, which project is a better choice at MARR = 12%?

(b) With a 10-year planning horizon, which project is a better choice at MARR = 12%?

***5.50** You need a lathe for your machine shop for 10 years. You narrowed down to two models: Kendall and Toyota. You also collected the financial data given in Table P5.50.

(*Note*: The salvage values represent the values at the end of useful life.)

If your interest rate is 12%, what should be the salvage value of the Toyota model at the end of 10 years so that you would be indifferent between the two models?

TABLE P5.49

	B1		B2	
n	Cash Flow	Salvage Value	Cash Flow	Salvage Value
0	−$20,000	—	−$17,000	—
1	−2,000	10,000	−2,500	9,000
2	−2,000	8,000	−2,500	6,000
3	−2,000	5,000	−2,500	3,000
4	−2,000	3,000	—	—
5	−2,000	2,000	—	—

TABLE P5.50

	Kendall	Toyota
First Cost	$25,000	$32,000
Annual O&M Costs	$11,000	$9,700
Useful Life	10 years	14 years
Salvage Value	$3,000	$2,000

5.51 Consider the cash flows for two types of models given in Table P5.51.

Both models will have no salvage value upon their disposal (at the end of their respective service lives). The firm's MARR is known to be 12%.

TABLE P5.51

	Project's Cash Flow	
n	Model A	Model B
0	−$8,000	−$15,000
1	3,500	10,000
2	3,500	10,000
3	3,500	—

(a) Notice that the models have different service lives. However, model A will be available in the future with the same cash flows. Model B is available at one time only. If you select model B now, you will have to replace it with model A at the end of year 2. If your firm uses the present worth as a decision criterion, which model should be selected, assuming that the firm will need either model for an indefinite period?

(b) Suppose that your firm will need either model for only two years. Determine the salvage value of model A at the end of year 2 that makes both models indifferent (equally likely).

5.52 An electric utility is taking bids on the purchase, installation, and operation of microwave towers. Table P5.52 has some details associated with the two bids that were received.

Which is the most economical bid if the interest rate is considered to be 11%? Either tower will have no salvage value after 20 years of use.

Use the NPW method to compare these two mutually exclusive plans.

5.53 Consider the following two investment alternatives given in Table P5.53.

The firm's MARR is known to be 15%.

(a) Compute PW(15%) for project A1.

(b) Compute the unknown cash flow X in years 2 and 3 for project A2.

(c) Compute the project balance (at 15%) of project A1 at the end of period 3.

(d) If these two projects are mutually exclusive alternatives, which one would you select?

TABLE P5.52

	Cost per Tower	
	Bid A	Bid B
Equipment cost	$112,000	$98,000
Installation cost	$25,000	$30,000
Annual maintenance and inspection fee	$2,000	$2,500
Annual extra income taxes	—	$800
Life	40 years	35 years
Salvage value	$0	$0

TABLE P5.53

	Project's Cash Flow	
n	A1	A2
0	−$15,000	−$25,000
1	9,500	0
2	12,500	*X*
3	7,500	*X*
PW(15%)	?	9,300

5.54 Consider each of the after-tax cash flows shown in Table P5.54.

(a) Compute the project balances for projects A and D as a function of the project year at $i = 10\%$.

(b) Compute the net future-worth values at the end of the project for projects A and D at $i = 10\%$.

(c) Suppose that projects B and C are mutually exclusive. Suppose also that the required service period is eight years and that the company is considering leasing comparable equipment with an annual lease expense of $3,000 payable at the end of each year for the remaining years of the required service period. Which project is a better choice?

5.55 A mall with two levels is under construction. The plan is to install only 9 escalators at the start, although the ultimate design calls for 16. The question arises as to whether to provide necessary facilities (stair supports, wiring conduits, motor foundations, etc.) that would permit the installation of the additional escalators at the mere cost of their purchase and installation or to defer investment in these facilities until the escalators need to be installed.

- **Option 1.** Provide these facilities now for all 7 future escalators at $300,000.
- **Option 2.** Defer the investment in the facility as needed. Install 2 more escalators in two years, 3 more in five years, and the last 2 in eight years. The installation of these facilities at the time they are required is estimated to cost $140,000 in year 2, $160,000 in year 5, and $180,000 in year 8.

Additional annual expenses are estimated at $7,000 for each escalator facility installed. Assume that these costs begin one year subsequent to the actual addition. At an interest rate of 12%, compare the net present worth of each option over eight years.

***5.56** An electrical utility is experiencing a sharp power demand that continues to grow at a high rate in a certain local area.

Two alternatives are under consideration. Each is designed to provide enough capacity during the next 25 years, and both will consume the same amount of fuel, so fuel cost is not considered in the analysis.

- **Alternative A.** Increase the generating capacity now so that the ultimate demand can be met without additional expenditures later. An initial investment of $30 million would be required, and it is estimated that this plant facility would be in service for 25 years and have a salvage value of $0.85 million. The annual operating and maintenance costs (including income taxes) would be $0.4 million.
- **Alternative B.** Spend $10 million now and follow this expenditure with future additions during the 10th year and the 15th year. These additions would cost $18 million and $12 million, respectively. The facility would be sold 25 years from now with a salvage value of $1.5 million. The annual

TABLE P5.54 After-Tax Cash Flows

	Project's Cash Flow			
n	A	B	C	D
0	−$2,500	−$7,000	−$5,000	−$5,000
1	650	−2,500	−2,000	−500
2	650	−2,000	−2,000	−500
3	650	−1,500	−2,000	4,000
4	600	−1,500	−2,000	3,000
5	600	−1,500	−2,000	3,000
6	600	−1,500	−2,000	2,000
7	300	—	−2,000	3,000
8	300	—	—	—

operating and maintenance costs (including income taxes) initially will be $250,000 and will increase to $0.35 million after the second addition (from the 11th year to the 15th year) and to $0.45 million during the final 10 years. (Assume that these costs begin one year subsequent to the actual addition.)

On the basis of the present-worth criterion, if the firm uses 15% as a MARR, which alternative should be undertaken?

5.57 A large refinery–petrochemical complex is to manufacture caustic soda, which will use feedwater of 10,000 gallons per day. Two types of feedwater storage installation are being considered over the 40 years of their useful life.

- **Option 1.** Build a 20,000-gallon tank on a tower. The cost of installing the tank and tower is estimated to be $164,000. The salvage value is estimated to be negligible.
- **Option 2.** Place a tank of 20,000-gallon capacity on a hill, which is 150 yards away from the refinery. The cost of installing the tank on the hill, including the extra length of service lines, is estimated to be $120,000 with negligible salvage value. Because of the tank's location on the hill, an additional investment of $12,000 in pumping equipment is required. The pumping equipment is expected to have a service life of 20 years with a salvage value of $1,000 at the end of that time. The annual operating and maintenance cost (including any income tax effects) for the pumping operation is estimated at $1,000.

If the firm's MARR is known to be 12%, which option is better on the basis of the present-worth criterion?

Short Case Studies

ST5.1 Apex Corporation requires a chemical finishing process for a product under contract for a period of six years. Three options are available. Neither option 1 nor option 2 can be repeated after its process life. However, option 3 will always be available from H&H Chemical Corporation at the same cost during the period that the contract is operative. Here are the options:

- **Option 1:** Process device A, which costs $100,000, has annual operating and labor costs of $60,000 and a useful service life of four years with an estimated salvage value of $10,000.
- **Option 2:** Process device B, which costs $150,000, has annual operating and labor costs of $50,000 and a useful service life of six years with an estimated salvage value of $30,000.
- **Option 3:** Subcontract out the process at a cost of $100,000 per year.

According to the present-worth criterion, which option would you recommend at $i = 12\%$?

ST5.2 A utility company is in the process of considering two alternative methods of providing transformer capacity.

- **Option 1:** Purchase a 16 MVA transformer now and add a similar-sized unit at a later date when load growth is warranted. The price of a 16 MVA unit is $680,000.
- **Option 2:** Purchase a 25 MVA transformer at the outset which will meet the future load growth for at least the next 10 years. The price of a 25 MVA unit is $920,000.

Technical specs for the transformers are as given in Table ST5.2.

TABLE ST5.2

Descriptions	Option 1	Option 2
No-load losses	16.1 kW	21.8 kW
Full-load losses	88 kW	121 kW
Cost of the no-load losses	$680/kW	$680/kW
Cost of the full-load series losses	$280/kW	$280/kW

Suppose the expected load growth over the next 20 years is 11 MVA during the first year and 1 MVA each following year over the previous year. Each transformer has a useful life of 20 years. Which transformer unit would be selected using an interest rate of 8% with the study period of 10 years? How about with 20 years? Assume the future replacement cost would be the same as the intial purchase price.