Contemporary Engineering Economics, 4th edition
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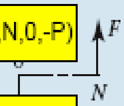
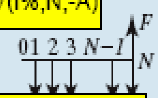
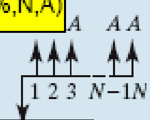
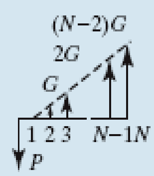
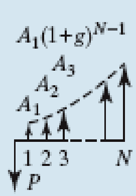
Typo Errors Found in the First Printing as of June 10, 2007.
These errors have been corrected in the subsequent printings.

Inside Front Cover (Table 3.4)

TABLE 3.4 Summary of Discrete Compounding Formulas with Discrete Payments

Flow Type	Factor Notation	Formula	Excel Command	Cash Flow Diagram
SINGLE	Compound amount $(F/P, i, N)$	$F = P(1+i)^N$	~~=FV(i, N, P,, 0)~~ =FV(i%,N,0,-P)	
SINGLE	Present worth $(P/F, i, N)$	$P = F(1+i)^{-N}$	~~=PV(i, N, F,, 0)~~ =PV(i%,N,0,F)	
EQUAL PAYMENT SERIES	Compound amount $(F/A, i, N)$	$F = A\left[\frac{(1+i)^N - 1}{i}\right]$	~~=PV(i, N, A,, 0)~~ =FV(i%,N,-A)	
EQUAL PAYMENT SERIES	Sinking fund $(A/F, i, N)$	$A = F\left[\frac{i}{(1+i)^N - 1}\right]$	~~=PMT(i, N, P, F, 0)~~ =PMT(i%,N,0,F)	
EQUAL PAYMENT SERIES	Present worth $(P/A, i, N)$	$P = A\left[\frac{(1+i)^N - 1}{i(1+i)^N}\right]$	~~=PV(i, N, A,, 0)~~ =PV(i%,N,A)	
EQUAL PAYMENT SERIES	Capital recovery $(A/P, i, N)$	$A = P\left[\frac{i(1+i)^N}{(1+i)^N - 1}\right]$	~~=PMT(i, N,, P)~~ =PMT(i%,N,-P)	
GRADIENT SERIES	Linear gradient Present worth $(P/G, i, N)$	$P = G\left[\frac{(1+i)^N - iN - 1}{i^2(1+i)^N}\right]$		
GRADIENT SERIES	Conversion factor $(A/G, i, N)$	$A = G\left[\frac{(1+i)^N - iN - 1}{i[(1+i)^N - 1]}\right]$		
GRADIENT SERIES	Geometric gradient Present worth $(P/A_1, g, i, N)$	$P = \begin{cases} A_1\left[\frac{1-(1+g)^N(1+i)^{-N}}{i-g}\right] \\ A_1\left(\frac{N}{1+i}\right) (\text{if } i = g) \end{cases}$		

Chapter 2:

TABLE P2.2 Financial Information for First Project Year

Sales		$1,500,000
Manufacturing costs		
Direct materials	$ 150,000	
Direct labor	200,000	
Overhead	100,000	
Depreciation	200,000	
Operating expenses		150,000
Equipment purchase		400,000
Borrowing to finance equipment		200,000
Increase in inventories		100,000
Decrease in accounts receivable		20,000
Increase in wages payable		30,000
Decrease in notes payable		40,000
Income taxes		272,000
Interest payment on financing		20,000

Financial Ratio Analysis

2.3 Table P2.3 shows financial statements for Nano Networks, Inc. The closing stock price for Nano Network was $56.67 (split adjusted) on December 31, 2005. On the basis of the financial data presented, compute the various financial ratios and make an informed analysis of Nano's financial health.

TABLE P2.3 Balance Sheet for Nano Networks, Inc.

Note: Both balance sheet and income statement entries are not complete. Only major entries are listed, so do not attempt to add individual entries to confirm either current assets or current liabilities.

		Dec. 2004 U.S. $ (000) (Year)
Balance Sheet Summary		
Cash	158,043	20,098
Securities	285,116	0
Receivables	24,582	8,056
Allowances	632	0
Inventory	0	0
Current assets	377,833	28,834
Property and equipment, net	20,588	10,569

(Continued)

	Dec. 2005 U.S. $ (000) (Year)	Dec. 2004 U.S. $ (000) (Year)
Depreciation	8,172	2,867
Total assets	513,378	36,671
Current liabilities	55,663	14,402
Bonds	0	0
~~Preferred mandatory~~	~~0~~	~~0~~ d
Preferred stock	0	0
Common stock	2	1
Other stockholders' equity	457,713	17,064
Total liabilities and equity	513,378	36,671
Income Statement Summary		
Total revenues	102,606	3,807
Cost of sales	45,272	4,416
Other expenses	71,954	31,661
~~Loss provision~~	~~0~~	~~0~~ e
Interest income	8,011	1,301
Income pretax	−6,609	−69
Income tax	2,425	2
Income continuing	−9,034	−30,971
Net income	**−9,034**	**−30,971**
EPS primary	**−$0.1**	**−$0.80**
EPS diluted	−$0.10	−$0.80
	−$0.05	−$0.40
	(split adjusted)	(split adjusted)

(a) Debt ratio
(b) Times-interest-earned ratio
(c) Current ratio
(d) Quick (acid-test) ratio
(e) Inventory turnover ratio
(f) Day's sales outstanding
(g) Total assets turnover
(h) Profit margin on sales
(i) Return on total assets

(j) Return on common equity
(k) Price-to-earnings ratio
(l) Book value per share

2.4 The balance sheet that follows summarizes the financial conditions for Flex, Inc., an electronic outsourcing contractor, for fiscal-year 2005. Unlike Nano Network Corporation in Problem 2.3, Flex has reported a profit for several years running. Compute the various financial ratios and interpret the firm's financial health during fiscal-year 2005.

Note: Both balance sheet and income statement entries are not complete. Only major entires are listed, so do not attempt to add individual entries to confirm the current assets or current liabilities.

	ug. 2005 S. $ (000) 12 mos.)	Aug. 2004 U.S. $ (000) (Year)
Balance Sheet Summary		
Cash	1,325,637	225,228
Securities	362,769	83,576
Receivables	1,123,901	674,193
Allowances	-5,580	−3,999
Inventory	1,080,083	788,519
Current assets	3,994,084	1,887,558
Property and equipment, net	1,186,885	859,831
Depreciation	533,311	−411,792
Total assets	4,834,696	2,410,568
Current liabilities	1,113,186	840,834
Bonds	922,653	385,519
~~Preferred mandatory~~	~~0~~	~~0~~
Preferred stock	0	0
Common stock	271	117
Other stockholders' equity	2,792,820	1,181,209
Total liabilities and equity	4,834,696	2,410,568
Income Statement Summary		
Total revenues	8,391,409	5,288,294
Cost of sales	7,614,589	4,749,988
Other expenses	335,808	237,063
Loss provision	2,143	2,254
Interest expense	36,479	24,759

insert "-" sign

(*Continued*)

	Aug. 2005 U.S. $ (000) (12 mos.)	Aug. 2004 U.S. $ (000) (Year)
Income pretax	432,342	298,983
Income tax	138,407	100,159
Income continuing	293,935	198,159
~~Discontinued~~	~~0~~	~~0~~
~~Extraordinary~~	~~0~~	~~0~~
~~Changes~~	~~0~~	~~0~~
Net income	**293,935**	**198,159**
EPS primary	**$1.19**	**$1.72**
EPS diluted	$1.13	$1.65

(a) Debt ratio
(b) Times-interest-earned ratio
(c) Current ratio
(d) Quick (acid-test) ratio
(e) Inventory turnover ratio
(f) Day's sales outstanding
(g) Total assets turnover
(h) Profit margin on sales
(i) Return on total assets
(j) Return on common equity
(k) Price-to-earnings ratio
(l) Book value per share

2.5 J. C. Olson & Co. had earnings per share of $8 in year 2006, and it paid a $4 dividend. Book value per share at year's end was $80. During the same period, the total retained earnings increased by $24 million. Olson has no preferred stock, and no new common stock was issued during the year. If Olson's year-end debt (which equals its total liabilities) was $240 million, what was the company's year-end debt-to-asset ratio?

2.6 If Company A uses more debt than Company B and both companies have identical operations in terms of sales, operating costs, etc., which of the following statements is *true*?

(a) Company B will definitely have a higher current ratio.
(b) Company B has a higher profit margin on sales than Company A.
(c) Both companies have identical profit margins on sales.
(d) Company B's return on total assets would be higher.

Chapter 3:

SOLUTION

Given: Three different deposit scenarios with $i = 9.38\%$ and $N = 41$ years.
Find: Balance at the end of 41 years (or at the age of 65).

- Investor A:

$$F_{65} = \overbrace{\underbrace{\$2{,}000(F/A, 9.38\%, 10)(1.0938)}_{\$33{,}845}}^{\text{Balance at the end of 10 years}}(F/P, 9.38\%, 31)$$

$$= \$545{,}216.$$

- Investor B:

$$F_{65} = \underbrace{\$2{,}000(\cancel{F/P}, 9.38\%, 31)}_{\$322{,}159}(1.0938)$$

F/A

$$= \$352{,}377.$$

- Investor C:

$$F_{65} = \underbrace{\$2{,}000(\cancel{F/P}, 9.38\%, 41)}_{\$820{,}620}(1.0938)$$

$$= \$897{,}594.$$

If you know how your balance changes at the end of each year, you may want to construct a tableau such as the one shown in Table 3.3. Note that, due to rounding errors, the final balance figures are slightly off from those calculated by interest formulas.

TABLE 3.3 How Time Affects the Value of Money

		Investor A		Investor B		Investor C	
Age	Years	Contribution	Year-End Value	Contribution	Year-End Value	Contribution	Year-End Value
25	1	$2,000	$ 2,188	$0	$0	$2,000	$ 2,188
26	2	$2,000	$ 4,580	$0	$0	$2,000	$ 4,580
27	3	$2,000	$ 7,198	$0	$0	$2,000	$ 7,198
28	4	$2,000	$10,061	$0	$0	$2,000	$10,061
29	5	$2,000	$13,192	$0	$0	$2,000	$13,192
30	6	$2,000	$16,617	$0	$0	$2,000	$16,617
31	7	$2,000	$20,363	$0	$0	$2,000	$20,363
32	8	$2,000	$24,461	$0	$0	$2,000	$24,461
33	9	$2,000	$28,944	$0	$0	$2,000	$28,944
34	10	$2,000	$33,846	$0	$0	$2,000	$33,846

(Continued)

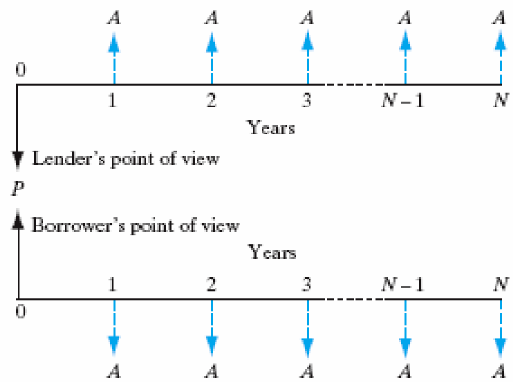


Figure 3.23 A loan cash flow diagram

Capital Recovery Factor (Annuity Factor): Find *A*, Given *P*, *i*, and *N*

We can determine the amount of a periodic payment A if we know P, i, and N. Figure 3.23 illustrates this situation. To relate P to A, recall the relationship between P and F in Eq. (3.3), $F = P(1 + i)^N$. Replacing F in Eq. (3.11) by $P(1 + i)^N$, we get

$$A = P(1 + i)^N\left[\frac{i}{(1 + i)^N - 1}\right],$$

or

$$A = P\left[\frac{i(1 + i)^N}{(1 + i)^N - 1}\right] = P(A/P, i, N). \tag{3.12}$$

Capital recovery factor: Commonly used to determine the revenue requirements needed to address the up-front capital costs for projects.

Annuity: An annuity is essentially a level stream of *cash flows* for a fixed period of time.

Now we have an equation for determining the value of the series of end-of-period payments A when the present sum P is known. The portion within the brackets is called the **equal payment series capital recovery factor**, or simply **capital recovery factor**, which is designated $(A/P, i, N)$. In finance, this A/P factor is referred to as the **annuity factor** and indicates a series of payments of a fixed, or constant, amount for a specified number of periods.

EXAMPLE 3.17 Uniform Series: Find *A*, Given *P*, *i*, and *N*

BioGen Company, a small biotechnology firm, has borrowed $250,000 to purchase laboratory equipment for gene splicing. The loan carries an interest rate of 8% per year and is to be repaid in equal installments over the next six years. Compute the amount of the annual installment (Figure 3.24).

Note: A missing figure title

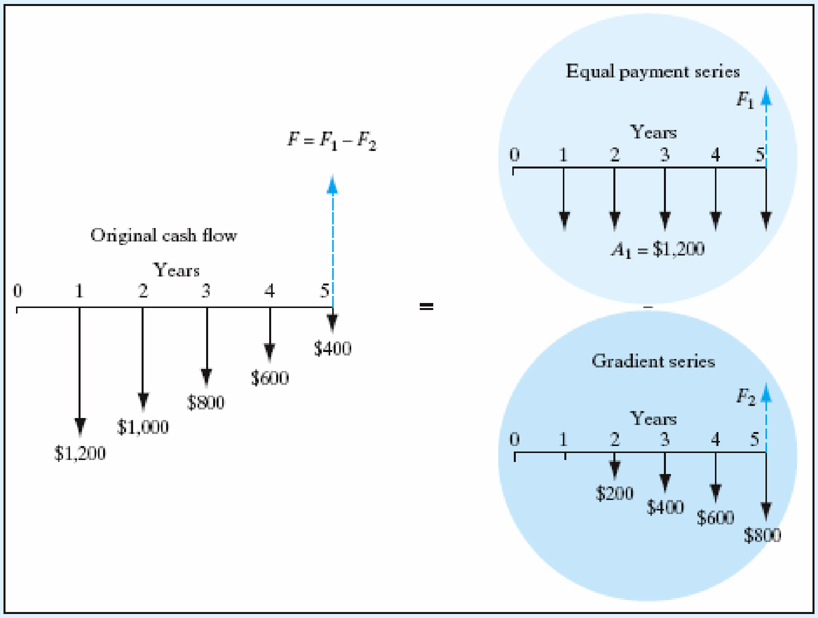


Figure 3.32 A series of decreasing gradient deposits viewed as a combination of uniform and a strict gradient series (Example 3.22)

The cash flow includes a decreasing gradient series. Recall that we derived the linear gradient factors for an increasing gradient series. For a decreasing gradient series, the solution is most easily obtained by separating the flow into two components: a uniform series and an increasing gradient that is *subtracted* from the uniform series (Figure 3.32). The future value is

$$\begin{aligned} F &= F_1 - F_2 \\ &= A_1(F/A, 10\%, 5) - \$200(P/G, 10\%, 5)(F/P, 10\%, 5) \\ &= \$1,200(6.105) - \$200(6.862)(1.611) \\ &= \$5,115. \end{aligned}$$

3.3.6 Geometric Gradient Series

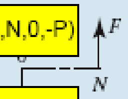
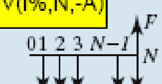
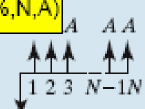
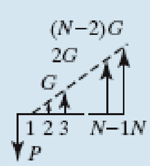
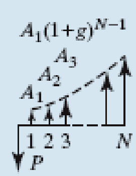
Geometric growth: The year-over-year growth rate of an investment over a specified period of time. Compound growth is an imaginary number that describes the rate at which an investment grew as though it had grown at a steady rate.

Many engineering economic problems—particularly those relating to construction costs—involve cash flows that increase or decrease over time, not by a constant *amount* (as with a linear gradient), but rather by a constant percentage (a **geometric gradient**). This kind of cash flow is called **compound growth**. Price changes caused by inflation are a good example of a geometric gradient series. If we use g to designate the percentage change in a payment from one period to the next, the magnitude of the nth payment, A_n, is related to the first payment A_1 by the formula

$$A_n = A_1(1 + g)^{n-1}, n = 1, 2, \ldots, N. \tag{3.19}$$

Note: The same corrections should be made inside front back cover.

TABLE 3.4 Summary of Discrete Compounding Formulas with Discrete Payments

Flow Type	Factor Notation	Formula	Excel Command	Cash Flow Diagram
SINGLE	Compound amount $(F/P, i, N)$	$F = P(1+i)^N$	~~=FV(i, N, P,, 0)~~ =FV(i%,N,0,-P)	
	Present worth $(P/F, i, N)$	$P = F(1+i)^{-N}$	~~=PV(i, N, F,, 0)~~ =PV(i%,N,0,F)	
EQUAL PAYMENT	Compound amount $(F/A, i, N)$	$F = A\left[\dfrac{(1+i)^N - 1}{i}\right]$	~~=PV(i, N, A,, 0)~~ =FV(i%,N,-A)	
	Sinking fund $(A/F, i, N)$	$A = F\left[\dfrac{i}{(1+i)^N - 1}\right]$	~~=PMT(i, N, P, F, 0)~~ =PMT(i%,N,0,F)	
SERIES	Present worth $(P/A, i, N)$	$P = A\left[\dfrac{(1+i)^N - 1}{i(1+i)^N}\right]$	~~=PV(i, N, A,, 0)~~ =PV(i%,N,A)	
	Capital recovery $(A/P, i, N)$	$A = P\left[\dfrac{i(1+i)^N}{(1+i)^N - 1}\right]$	~~=PMT(i, N,, P)~~ =PMT(i%,N,-P)	
GRADIENT	Linear gradient Present worth $(P/G, i, N)$	$P = G\left[\dfrac{(1+i)^N - iN - 1}{i^2(1+i)^N}\right]$		
	Conversion factor $(A/G, i, N)$	$A = G\left[\dfrac{(1+i)^N - iN - 1}{i[(1+i)^N - 1]}\right]$		
SERIES	Geometric gradient Present worth $(P/A_1, g, i, N)$	$P = \begin{bmatrix} A_1\left[\dfrac{1-(1+g)^N(1+i)^{-N}}{i-g}\right] \\ A_1\left(\dfrac{N}{1+i}\right)(\text{if } i = g) \end{bmatrix}$		

Chapter 4:

SOLUTION $15,000

Given: $P = \$25{,}000$, $r = 6.25\%$ per year, $K = 12$ payments per year, $N =$ 72 months, and $M = 12$ interest periods per year.
Find: A.

In this situation, we can easily compute the monthly payment with Eq. (3.12):

$$\begin{aligned} i &= 6.25\%/12 = 0.5208\% \text{ per month}, \\ N &= (12)(6) = 72 \text{ months}, \\ A &= \$15{,}000(A/P, 0.5208\%, 72) = \$250.37. \end{aligned}$$

4.2.2 Compounding Occurs at a Different Rate than That at Which Payments Are Made

We will consider two situations: (1) compounding is more frequent than payments and (2) compounding is less frequent than payments.

Compounding Is More Frequent than Payments

The computational procedure for compounding periods and payment periods that cannot be compared is as follows:

1. Identify the number of compounding periods per year (M), the number of payment periods per year (K), and the number of interest periods per payment period (C).
2. Compute the effective interest rate per payment period:
   - For discrete compounding, compute

$$i = \left(1 + \frac{r}{M}\right) - 1.$$

   - For continuous compounding, compute

$$i = e^{r/K} - 1.$$

3. Find the total number of payment periods:

$$N = K \times (\text{number of years}).$$

4. Use i and N in the appropriate formulas in Table 3.4.

EXAMPLE 4.5 Compounding Occurs More Frequently than Payments Are Made (Discrete-Compounding Case)

Suppose you make equal quarterly deposits of $1,500 into a fund that pays interest at a rate of 6% compounded monthly, as shown in Figure 4.4. Find the balance at the end of year 2.

Chapter 8

SOLUTION

Given: Sales price, \$10 per case for generic aspirin, \$30 per case for band aspirin; fixed cost, \$5,000; variable cost, \$7 per case during weekdays, \$12 per case on Sunday operation; weekly production, 6,000 cases of generic aspirin, 1,000 cases of brand-name aspirin.
Find: (a) Optimal production mix and (b) break-even volume.

(a) Optimal production mix: The marginal costs of manufacturing brand-name aspirin are constant Monday through Saturday; they rise substantially on Sunday and are above the marginal revenue from manufacturing generic aspirin. In other words, your company should manufacture the brand-name aspirin first. Your marginal revenue is the highest the "first" day, when you manufacture the brand-name aspirin. It then falls and remains constant for the rest of the week. On the seventh day (Sunday), the marginal revenue from manufacturing the generic aspirin is still below the marginal cost. You should manufacture brand-name aspirin one day a week and generic aspirin five days a week. On Sundays, the plant should close.

- The marginal revenue from manufacturing on Sunday is \$10,000 (1,000 cases times \$10 per case).
- The marginal cost from manufacturing on Sunday is \$12,000 (1,000 cases times \$12 per case—\$10 labor + \$2 materials).
- Profits will be \$2,000 lower than revenue if the plant operates on Sunday.

(b) Break-even volume: The total revenue and cost func 10(Q - 1000) represented as follows:

$$\text{Total revenue function: } \begin{cases} 30Q & \text{for } 0 \le Q \le 1{,}000 \\ 30{,}000 + \cancel{10Q} & \text{for } 1{,}000 < Q \le \cancel{6{,}000} \end{cases} \quad 7{,}000$$

$$\text{Total cost function: } \begin{cases} 5{,}000 + 7Q & \text{for } 0 \le Q \le 6{,}000 \\ 47{,}000 + \cancel{12Q} & \text{for } 6{,}000 \le Q \le 7{,}000. \end{cases}$$

Table 8.4 shows the various factors involved in the 12(Q - 6,000) the brand-name and the generic aspirin.

- If you produce the brand-name aspirin first, the break-even volume is

$$30Q - 7Q - 5{,}000 = 0,$$
$$Q_b = 217.39.$$

- If you produce the generic aspirin first, the break-even volume is

$$10Q - 7Q - 5{,}000 = 0,$$
$$Q_b = 1{,}666.67.$$

Clearly, scheduling the production of the brand-name aspirin first is the better strategy, as you can recover the fixed cost (\$5,000) much faster by selling just 217.39 cases of brand-name aspirin. Also, Sunday operation is not economical, as the marginal cost exceeds the marginal revenue by \$2,000, as shown in Figure 8.8.

Materials Budgets

Once we know how many units we need to produce, we are ready to develop direct materials budgets. We may use the following steps:

1. From the production budget, copy the projected number of units to be produced.
2. *Multiply* by the amount of raw materials needed per unit to calculate the amount of materials needed. In our example, we will assume that each production unit consumes $4 of materials.
3. Calculate the desired ending inventory (the number of units required in the ending inventory × $4).
4. *Add* to calculate the total amount of materials needed.
5. *Subtract* the beginning inventory, which is last quarter's ending inventory, to calculate the amount of raw materials needed to be purchased.
6. Calculate the net cost of raw materials.

Then a typical direct materials budget may look like the following:

Direct Materials Budget (Year 2006)—Product X

	1Q	2Q	3Q	4Q	Annual Total
Units to produce	1,100	1,240	1,320	1,540	5,200
Unit cost of materials	$ 4	$ 4	$ 4	$ 4	
Cost of materials for units to be produced	$ 4,400	$ 4,960	$ 5,280	$ 6,160	$ 20,800
Plus cost of materials in ending inventory	$ 800	$ 960	$ 1,040	$ 1,200	$ 4,000
Total cost of materials needed	$ 5,200	$ 5,920	$ 6,320	$ 7,360	$ 24,800
Less cost of materials in beginning inventory	$ 400	$ 800	$ 960	$ 1,040	$ 3,200
Cost of materials to purchase	$ 4,800	$ 5,120	$ 5,360	$ 6,320	$ 21,600

Direct Labor Budget for a Manufacturing Business

As with the materials budgets, once the production budget has been completed, we can easily prepare the direct labor budget. This budget allows the firm to estimate labor requirements—both labor hours and dollars—in advance. To illustrate, use the following steps:

$1.27 in 1Q, $1.30 in 2Q, $1.32 in 3Q, and $1.35 in 4Q.

1. From the production budget, copy the projected number of units to be produced.
2. *Multiply* by the direct labor cost per unit to calculate the total direct labor cost. In our example, we will assume that the direct labor cost is ~~$3 per unit.~~

unit

Then a typical direct labor budget may look like the following:

Direct Labor Budget (Year 2006)—Product X					
	1Q	2Q	3Q	4Q	Annual Total
Units to produce	1,100	1,240	,320	1,540	5,200
× Direct labor cost per unit	$ ~~3.00~~ $1.27	$ ~~3.00~~ $1.30	~~3.00~~ $1.32	$ ~~3.00~~ $1.35	
Total direct labor cost ($)	~~,300~~ $1,379	~~$ 3,720~~ $1,612	~~$ 3,960~~ $1,742	~~$ 4,620~~ $2,079	$ ~~15,600~~ $5,244

Overhead Budget for a Manufacturing Business

The overhead budget should provide a schedule of all costs of production other than direct materials and direct labor. Typically, the overhead budget is expressed in dollars, based on a predetermined overhead rate. In preparing a manufacturing overhead budget, we may take the following steps:

1. From the production budget, copy the projected number of units to be produced.
2. *Multiply* by the variable overhead rate to calculate the budgeted variable overhead. In our example, we will assume the variable overhead rate to be $1.50 per unit. There are several ways to determine this overhead rate. One common approach (known as traditional standard costing) is to divide the expected total overhead cost by the budgeted number of direct labor hours (or units). Another approach is to adopt an **activity-based costing** concept, allocating indirect costs against the activities that caused them. We will not review this accounting method here, but it can more accurately reflect indirect cost improvement than traditional standard costing can.
3. *Add* any budgeted fixed overhead to calculate the total budgeted overhead. In our example, we will assume the fixed overhead to be $230 each quarter.

Activity-based costing (ABC) identifies opportunities to improve business process effectiveness and efficiency by determining the "true" cost of a product or service.

Then a typical manufacturing overhead budget may look like the following:

Manufacturing Overhead Budget (Year 2006)—Product X					
	1Q	2Q	3Q	4Q	Annual Total
Units to produce	1,100	1,240	1,320	1,540	5,200
Variable mfg overhead rate per unit ($1.50)	$ 1,650	$ 1,860	$ 1,980	$ 2,310	$ 7,800
Fixed mfg overhead	$ 230	$ 230	$ 230	$ 230	$ 920
Total overhead	$ 1,880	$ 2,090	$ 2,210	$ 2,540	$ 8,720

8.5.4 Preparing the Cost-of-Goods-Sold Budget

The production budget developed in the previous section shows how much it would cost to produce the required production volume. Note that the number of units to be produced includes both the anticipated number of sales units and the number of units in inventory.

The cost-of-goods-sold budget is different from the production budget, because we do not count the costs incurred to carry the inventory. Therefore, we need to prepare a budget that details the costs related to the sales, not the inventory. Typical steps in preparing a cost-of-goods-sold budget are as follows:

1. From the sales budget, and not the production budget, copy the budgeted number of sales units.
2. *Multiply* by the direct material cost per unit to estimate the amount of direct materials.
3. *Multiply* by the direct labor cost per unit to estimate the direct labor.
4. *Multiply* by the manufacturing overhead per unit to estimate the overhead.

Then a typical cost-of-goods-sold budget may look like the following:

Cost of goods sold: A figure reflecting the cost of the product or good that a company sells to generate revenue.

Cost of Goods Sold (Year 2006)—Product X

	1Q	2Q	3Q	4Q	Annual Total
Budgeted sales units	1,000	1,200	1,300	1,500	5,000
Direct materials ($4/unit)	$ 4,000	$ 4,800	$ 5,200	$ 6,000	$ 20,000
Direct labor ($3/unit)	~~$ 3,000~~	~~$ 3,600~~	~~$ 3,900~~	~~$ 4,500~~	~~$ 15,000~~
Mfg overhead:	$1,270	$1,570	$1,720	$2,020	$6,580
Variable ($1.50 per unit)	$ 1,500	$ 1,800	$ 1,950	$ 2,250	$ 7,500
Fixed	$ 230	$ 230	$ 230	$ 230	$ 920
Cost of goods sold	$ 7,000	$ 8,400	$ 9,100	$ 10,500	$ 35,000

8.5.5 Preparing the Nonmanufacturing Cost Budget

To complete the entire production budget, we need to add two more items related to production: the selling expenses and the administrative expenses.

Selling Expenses Budget for a Manufacturing Business

Since we know the sales volume, we can develop a selling expenses budget by considering the budgets of various individuals involved in marketing the products. The budget includes both variable cost items (shipping, handling, and sales commission) and fixed items, such as advertising and salaries for marketing personnel. To prepare the selling expenses budget, we may take the following steps:

1. From the sales budget, copy the projected number of unit sales.
2. List the variable selling expenses, such as the sales commission. In our example, we will assume that the sales commission is calculated at 5% of unit sales.
3. List the fixed selling expenses, typically rent, depreciation expenses, advertising, and other office expenses. In our example, we will assume the following: rent, $500 per quarter; advertising, $300 per quarter; office expense, $200 per quarter.
4. *Add* to calculate the total budgeted selling expenses.

Chapter 9

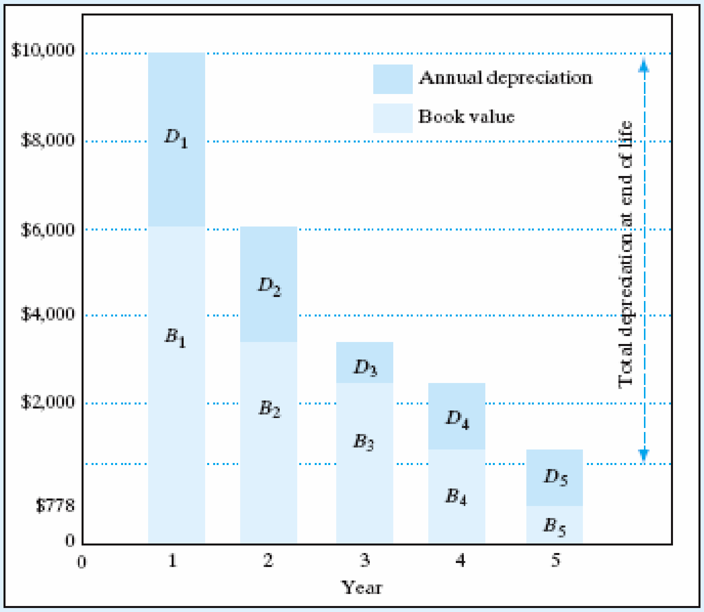


Figure 9.3 Double-declining-balance method (Example 9.4).

The book value at the beginning of the first year is $10,000, and the declining-balance rate (α) is $\left(\frac{1}{5}\right)(2) = 40\%$. Then the depreciation deduction for the first year will be $4,000 ($40\% \times \$10{,}000 = \$4{,}000$). To figure the depreciation deduction in the second year, we must first adjust the book value for the amount of depreciation we deducted in the first year. The first year's depreciation from the beginning book value is subtracted ($\$10{,}000 - \$4{,}000 = \$6{,}000$), and the resulting amount is multiplied by the rate of depreciation ($\$6{,}000 \times 40\% = \$2{,}400$). By continuing the process, we obtain the following table:

n-1

n	B_n	D_n	B_n
1	10,000	4,000	6,000
2	6,000	2,400	3,600
3	3,600	1,440	2,160
4	2,160	864	1,296
5	1,296	518	778

The declining balance is illustrated in terms of the book value of time in Figure 9.3.

The salvage value (S) of the asset must be estimated at the outset of depreciation analysis. In Example 9.4, the final book value (B_N) conveniently equals the estimated salvage value of \$778, a coincidence that is rather unusual in the real world. When $B_N \neq S$, we would want to make adjustments in our depreciation methods.

- **Case 1: $B_N > S$**

  When $B_N > S$, we are faced with a situation in which we have not depreciated the entire cost of the asset and thus have not taken full advantage of depreciation's tax-deferring benefits. If you would prefer to reduce the book value of an asset to its salvage value as quickly as possible, it can be done by switching from DB to SL whenever SL depreciation results in larger depreciation charges and therefore a more rapid reduction in the book value of the asset. The switch from DB to SL depreciation can take place in any of the n years, the objective being to identify the optimal year to switch. The switching rule is as follows: If depreciation by DB in any year is less than (or equal to) what it would be by SL, we should switch to and remain with the SL method for the duration of the project's depreciable life. The straight-line depreciation in any year n is calculated by

$$D_n = \frac{\text{Book value at beginning of year } n - \text{salvage value}}{\text{Remaining useful life at beginning of year } n} \tag{9.7}$$

EXAMPLE 9.5 Declining Balance with Conversion to Straight-Line Depreciation ($B_N > S$)

Suppose the asset given in Example 9.4 has a zero salvage value instead of \$778; that is,

$$\begin{aligned} \text{Cost basis of the asset, } I &= \$10{,}000 \\ \text{Useful life, } N &= 5 \text{ years,} \\ \text{Salvage value, } S &= \$0, \\ \alpha &= (1/5)(2) = 40\%. \end{aligned}$$

" a Greek symbol, alpha"

Determine the optimal time to switch from DB to SL depreciation and the resulting depreciation schedule.

SOLUTION

Given: $I = \$10{,}000$, $S = 0$, $N = 5$ years, and $\alpha = 40\%$.
Find: Optimal conversion time, D_n and B_n for $n = 1$ to 5.

We will first proceed by computing the DDB depreciation for each year, as before:

Year	D_n	B_n
1	\$4,000	\$6,000
2	2,400	3,600
3	1,440	2,160
4	864	1,296
5	518	778

Marginal Tax Rate

Marginal tax rate: The amount of tax paid on an additional dollar of income.

The **marginal tax rate** is defined as the rate applied to the last dollar of income earned. Income of up to \$50,000 is taxed at a 15% rate (meaning that if your taxable income is less than \$50,000, your marginal tax rate is 15%); income between \$50,000 and \$75,000 is taxed at 25%; and income over \$75,000 is taxed at a 34% rate.

An additional 5% surtax (resulting in 39%) is imposed on a corporation's taxable income in excess of \$100,000, with the maximum additional tax limited to \$11,750 ($235{,}000 \times 0.05$). This surtax provision phases out the benefit of graduated rates for corporations with taxable incomes between \$100,000 and \$335,000. Another 3% surtax is imposed on corporate taxable income in the range from \$15,000,001 to \$18,333,333.

Corporations with incomes in excess of \$18,333,333 in effect pay a flat tax of 35%. As shown in Table 9.6, the corporate tax is progressive up to \$18,333,333 in taxable income, but essentially is constant thereafter.

Effective (Average) Tax Rate

Effective (average) tax rate: The rate a taxpayer would be taxed at if taxing was done at a constant rate, instead of progressively.

Effective tax rates can be calculated from the data in Table 9.6. For example, if your corporation had a taxable income of \$16,000,000 in 2006, then the income tax owed by the corporation would be as follows:

Taxable Income	Tax Rate	Taxes	Cumulative Taxes
First \$50,000	15%	\$7,500	\$7,500
Next \$25,000	25%	6,250	13,750
Next \$25,000	34%	8,500	22,250
Next \$235,000	39%	91,650	113,900
Next \$9,665,000	34%	3,286,100	3,400,000
Next \$5,000,000	35%	1,750,000	5,150,000
Remaining \$1,000,000	38%	380,000	\$5,530,000

Alternatively, using the tax formulas in Table 9.6, we obtain

$$\$5{,}150{,}000 + 0.38(\$16{,}000{,}000 - \$15{,}000{,}000) = \$5{,}530{,}000.$$

The effective (average) tax rate would then be

$$\frac{\$5{,}530{,}000}{\$16{,}000{,}000} = 0.3456, \text{ or } 34.56\ \%$$

as opposed to the marginal rate of 38%. In other words, on the average, the company paid 34.56 cents for each taxable dollar it generated during the accounting period.

subtracting state income taxes. Taxes computed in this fashion represent total taxes. If state income taxes are considered, the combined state and federal marginal tax rate may be higher than 35%. Since state income taxes are deductible as expenses in determining federal taxes, the marginal rate for combined federal and state taxes can be calculated with the expression

$$t_m = t_f + t_s - (t_f)(t_s), \tag{9.11}$$

where

t_m = combined marginal tax rate,
t_f = federal marginal tax rate.
t_s = state marginal tax rate.

This second approach provides a more convenient and efficient way to handle taxes in an economic analysis in which the incremental tax rates are known. Therefore, incremental tax rates will be stated as combined marginal tax rates, unless indicated otherwise. (For large corporations, these would be about 40%, but they vary from state to state.)

EXAMPLE 9.17 Combined State and Federal Income Taxes

Consider a corporation whose revenues and expenses before income taxes are as follows:

Gross revenue	$1,000,000
All expenses	400,000

If the marginal federal tax rate is 35% and the marginal state rate is 7%, compute the combined state and federal taxes, using the two methods just described.

SOLUTION

Given: Gross income = $1,000,000, deductible expenses = $400,000, t_f = 35%, and t_s = 7%.

Find: Combined income taxes t_m.

(a) Explicit calculation of state income taxes:

Let's define FT as federal taxes and ST as state taxes. Then

$$\text{State taxable income} = \$1{,}000{,}000 - \$400{,}000$$

and

$$\text{ST} = (0.07)(\$600{,}000)$$
$$= \$42{,}000.$$

Also,

$$\text{Federal taxable income} = \$1{,}000{,}000 - \$400{,}000 - \text{ST}$$
$$= \boxed{(0.35)}(\$558{,}000).$$

$558,000

Chapter 10

TABLE 10.6 Cash Flow Statement for LMC's Machining Center Project with Multiple Assets (Example 10.6)

Year	0	1	2	3	4	5	6	7	8	9	10
Income Statement											
Revenues		$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000
Expenses											
Materials		22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000
Labor		32,000	32,000	32,000	32,000	32,000	32,000	32,000	32,000	32,000	32,000
Energy		3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500
Other		2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Depreciation											
Building		2,949	3,077	3,077	3,077	3,077	3,077	3,077	3,077	3,077	2,949
Machines		14,290	24,490	17,490	12,490	8,930	8,920	8,930	4,460		
Tools		4,000	5,333	1,778	889		4,000	5,333	1,778	889	
Taxable income		68,761	57,100	67,655	73,544	77,993	74,003	72,660	80,685	86,034	87,051
Income taxes		27,504	22,840	27,062	29,418	31,197	29,601	29,064	32,274	34,414	34,820
Net income		$ 41,257	$ 34,260	$ 40,593	$ 44,126	$ 46,796	$ 44,402	$ 43,596	$ 48,411	$ 51,620	$ 52,231
Cash Flow Statement											
Operating activities:											
Net income		41,257	34,260	40,593	44,126	46,796	44,402	43,596	48,411	51,620	52,231
Depreciation		21,239	32,900	22,345	16,456	12,007	15,997	17,340	9,315	3,966	2,949
Investment activities:											
Land	(40,000)										110,000
Building	(120,000)										80,000
Machines	(100,000)										10,000
Tools (first cycle)	(12,000)					1,000					
Tools (second cycle)						(12,000)					1,000
Gains tax:											
Land									(28,000)		
Building											3,794
Machines											(4,000)
Tools						(400)					(400)
Net cash flow	$ (272,000)	$ 62,496	$ 67,160	$ 62,938	$ 60,582	$ 47,403	$ 60,399	$ 60,936	$ 57,726	$ 55,586	$227,574

Note: Investment in tools (jigs and dies) will be repeated at the end of year 5, at the cost of the initial purchase.

$18,500

10.7 A firm has been paying a print shop ~~$18,000~~ annually to print the company's monthly newsletter. The agreement with this print shop has now expired, but it could be renewed for a further five years. The new subcontracting charges are expected to be 12% higher than they were under the previous contract. The company is also considering the purchase of a desktop publishing system with a high-quality laser printer driven by a microcomputer. With appropriate text and graphics software, the newsletter can be composed and printed in near-typeset quality. A special device is also required to print photos in the newsletter. The following estimates have been quoted by a computer vendor:

Personal computer	$4,500
Color laser printer	6,500
Photo device/scanner	5,000
Software	2,500
Total cost basis	$18,500
Annual O&M costs	10,000

The salvage value of each piece of equipment at the end of five years is expected to be only 10% of the original cost. The company's marginal tax rate is 40%, and the desktop publishing system will be depreciated by MACRS under its five-year property class.

(a) Determine the projected net after-tax cash flows for the investment.

(b) Compute the IRR for this project.

(c) Is the project justifiable at MARR = 12%?

10.8 An asset in the five-year MACRS property class costs $120,000 and has a zero estimated salvage value after six years of use. The asset will generate annual revenues of $300,000 and will require $80,000 in annual labor and $50,000 in annual material expenses. There are no other revenues and expenses. Assume a tax rate of 40%.

(a) Compute the after-tax cash flows over the project life.

(b) Compute the NPW at MARR = 12%. Is the investment acceptable?

10.9 An automaker is considering installing a three-dimensional (3-D) computerized car-styling system at a cost of $200,000 (including hardware and software). With the 3-D computer modeling system, designers will have the ability to view their design from many angles and to fully account for the space required for the engine and passengers. The digital information used to create the computer model can be revised in consultation with engineers, and the data can be used to run milling machines that make physical models quickly and precisely. The automaker expects to decrease the turnaround time for designing a new automobile model (from configuration to final design) by 22%. The expected savings in dollars is $250,000 per year. The training and operating maintenance cost for the new system is expected to be $50,000 per year. The system has a five-year useful life and can be depreciated

Chapter 11

$$A'_n = A_n(1 + \bar{f})^{-n} \quad \leftrightarrow \quad A'_n(P/F, \bar{f}, n)$$

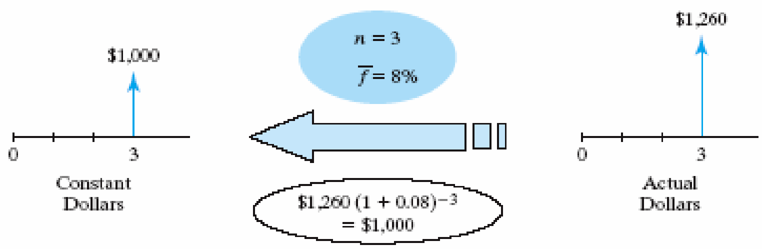


Figure 4.4 Conversion from actual to constant dollars. What it means is that $1,260 three years from now will have a purchasing power of $1,000 in terms of base dollars (year 0).

EXAMPLE 11.4 Conversion from Actual to Constant Dollars

Jagura Creek Fish Company, an aquacultural production firm, has negotiated a five-year lease on 20 acres of land, which will be used for fishponds. The annual cost stated in the lease is $20,000, to be paid at the beginning of each of the five years. The general inflation rate $\bar{f} = 5\%$. Find the equivalent cost in constant dollars during each period.

DISCUSSION: Although the $20,000 annual payments are *uniform*, they are not expressed in constant dollars. Unless an inflation clause is built into a contract, any stated amounts refer to *actual dollars*.

SOLUTION

Given: Actual dollars, $\bar{f} = 5\%$.
Find: Constant dollars during each period.

Using Eq. (11.5), we can determine the equivalent lease payments in constant dollars as follows:

End of Period	Cash Flow in Actual $	Conversion at f	Cash Flow in Constant $	Loss of Purchasing Power
0	$20,000	$(1 + 0.05)^0$	$20,000	0%
1	20,000	$(1 + 0.05)^{-1}$	19,048	4.76
2	20,000	$(1 + 0.05)^{-2}$	18,141	9.30
3	20,000	$(1 + 0.05)^{-3}$	17,277	13.62
4	20,000	$(1 + 0.05)^{-4}$	16,454	17.73

Note that, under the inflationary environment, the lender's receipt of the lease payment in year 5 is worth only 82.27% of the first lease payment.

First, we need to determine the market interest rate i. With $\bar{f} = 5\%$ and $i' = 10\%$, we obtain

$$
\begin{aligned}
i &= i' + \bar{f} + i'\bar{f} \\
&= 0.10 + \cancel{0.5} + (0.10)(0.05) \qquad \boxed{0.05} \\
&= 15.5\%.
\end{aligned}
$$

Note that the equivalent present worth that we obtain with the adjusted-discount method ($i = 15.5\%$) is exactly the same as the result we obtained in Example 11.6:

n	Cash Flows in Actual Dollars	Multiplied by	=	Equivalent Present Worth
0	−\$75,000	1		−\$75,000
1	32,000	$(1 + 0.155)^{-1}$		27,706
2	35,700	$(1 + 0.155)^{-2}$		26,761
3	32,800	$(1 + 0.155)^{-3}$		21,288
4	29,000	$(1 + 0.155)^{-4}$		16,296
5	58,000	$(1 + 0.155)^{-5}$		28,217
				\$45,268

11.2.4 Mixed-Dollar Analysis

Let us consider another situation in which some cash flow elements are expressed in constant (or today's) dollars and the other elements in actual dollars. In this situation, we can convert all cash flow elements into the same dollar units (either constant or actual). If the cash flow is converted into actual dollars, the market interest rate (i) should be used in calculating the equivalence value. If the cash flow is converted into constant dollars, the inflation-free interest rate (i') should be used.

11.3 Effects of Inflation on Project Cash Flows

We now introduce inflation into some investment projects. We are especially interested in two elements of project cash flows: depreciation expenses and interest expenses. These two elements are essentially immune to the effects of inflation, as they are always given in actual dollars. We will also consider the complication of how to proceed when multiple price indexes have been used to generate various project cash flows.

Because depreciation expenses are calculated on some base-year purchase amount, they do not increase over time to keep pace with inflation. Thus, they lose some of their value to defer taxes, because inflation drives up the general price level and hence taxable income. Similarly, the selling prices of depreciable assets can increase with the general inflation rate, and because any gains on salvage values are taxable, they can result in increased taxes. Example 11.8 illustrates how a project's profitability changes under an inflationary economy.

gives the net cash flow conversion from actual to constant dollars for each of the five years of the project's life:

Year	Net Cash Flow in Actual \$	Conversion $\bar{f}$	Net Cash Flow in Constant \$	NPW at 15%
0	−\$125,000	$(1 + 0.05)^{0}$	−\$125,000	−\$125,000
1	44,945	$(1 + 0.05)^{-1}$	42,805	37,222
2	51,935	$(1 + 0.05)^{-2}$	47,107	35,620
3	50,420	$(1 + 0.05)^{-3}$	43,555	28,638
4	50,003	$(1 + 0.05)^{-4}$	41,138	23,521
5	99,854	$(1 + 0.05)^{-5}$	78,238	38,898
				\$38,899

11.3.1 Multiple Inflation Rates

As we noted previously, the inflation rate f_j represents a rate applicable to a specific segment j of the economy. For example, if we were estimating the future cost of a piece of machinery, we should use the inflation rate appropriate for that item. Furthermore, we may need to use several rates to accommodate the different costs and revenues in our analysis. The next example introduces the complexity of multiple inflation rates.

EXAMPLE 11.9 Applying Specific Inflation Rates

Let us rework Example 11.8, using different annual indexes (differential inflation rates) in the prices of cash flow components. Suppose that we expect the general rate of inflation, $\bar{f}$, to average 6% per year during the next five years. We also expect that the selling price of the equipment will increase 3% per year, that wages (labor) and overhead will increase 5% per year, and that the cost of materials will increase 4% per year. We expect sales revenue to climb at the general inflation rate. Table 11.3 shows the relevant calculations based on the income statement format. For simplicity, all cash flows and inflation effects are assumed to occur at year's end. Determine the net present worth of this investment, using the adjusted-discount method.

SOLUTION

Given: Financial data given in Example 11.8, multiple inflation rates.

Find: The NPW, using the adjusted-discount method.

Table 11.3 summarizes the after-tax cash flows in actual dollars. To evaluate the present worth using actual dollars, we must adjust the original discount rate of 15%, which is an inflation-free interest rate i'. The appropriate interest rate to use is the market interest rate:[8]

i'

$$\begin{aligned} i &= \boxed{i} + \bar{f} + i'\bar{f} \\ &= 0.15 + 0.06 + (0.15)(0.06) \\ &= 21.90\%. \end{aligned}$$

[8] In practice, the market interest rate is usually given and the inflation-free interest rate can be calculated when the general inflation rate is known for years in the past or is estimated for time in the future. In our example, we are considering the opposite situation.

EXAMPLE 11.10 Effects of Inflation on Payments with Financing (Borrowing)

Let us rework Example 11.8 with a debt-to-equity ratio of 0.50, where the debt portion of the initial investment is borrowed at 15.5% annual interest. Assume, for simplicity, that the general inflation rate $\bar{f}$ of 5% during the project period will affect all revenues and expenses (except depreciation and loan payments) and the salvage value of the asset. Determine the NPW of this investment. (Note that the borrowing rate of 15.5% reflects the higher cost of debt financing under an inflationary environment.)

SOLUTION

Given: Cash flow data in Example 11.8, debt-to-equity ratio = 0.50, borrowing interest rate = 15.5%, $\bar{f}$ = 5%, and i' = 15%.

Find: The NPW.

For equal future payments, the actual-dollar cash flows for the financing activity are represented by the circles in Figure 11.3. If inflation were to occur, the cash flow, measured in year-0 dollars, would be represented by the shaded circles in the figure. Table 11.4 summarizes the after-tax cash flows in this situation. For simplicity, assume that all cash flows and inflation effects occur at year's end. To evaluate the present worth with the use of actual dollars, we must adjust the original discount rate (MARR) of 15%, which is an inflation-free interest rate i'. The appropriate interest rate to use is thus the market interest rate:

$$\begin{aligned} i &= i' + \bar{f} + i'\bar{f} \\ &= 0.15 + 0.05 + (0.15)(0.05) \\ &= 20.75\%. \end{aligned}$$

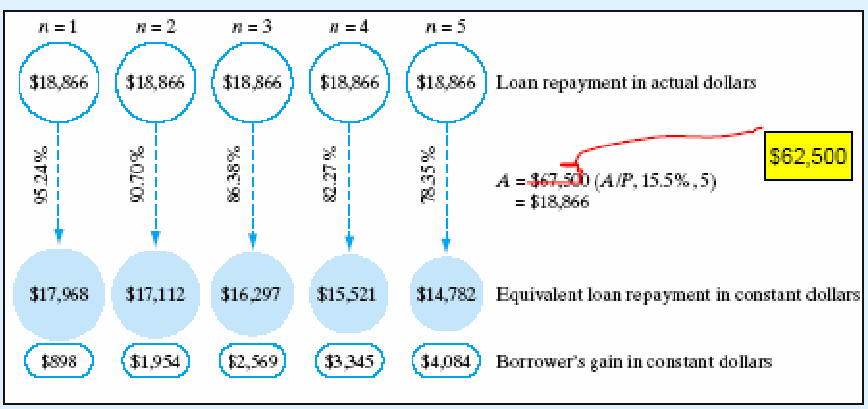


Figure 11.3 Equivalent loan repayment cash flows measured in year-0 dollars and borrower's gain over the life of the loan (Example 11.10).

TABLE 11.4 Cash Flow Statement for the Automated Machining Center Project under Inflation, with Borrowed Funds

	Inflation Rate	0	1	2	3	4	5
Income statement:							
Revenues	5%		$105,000	$110,250	$115,763	$121,551	$127,628
Expenses							
Labor	5%		21,000	22,050	23,153	24,310	25,526
Material	5%		12,600	13,230	13,892	14,586	15,315
Overhead	5%		8,400	8,820	9,261	9,724	10,210
Depreciation			17,863	30,613	21,863	15,613	5,581
Debt interest			9,688	8,265	6,622	4,724	2,532
Taxable income			$ 35,449	$ 27,272	$ 40,973	$ 52,593	$ 68,464
Income taxes (40%)			14,180	10,909	16,389	21,037	27,386
Net income			$ 21,269	$ 16,363	$ 24,584	$ 31,556	$ 41,078
Cash flow statement:							
Operating activities							
Net income			21,269	16,363	24,584	31,556	41,078
Depreciation			17,863	30,613	21,863	15,613	5,581
Investment activities							
Investment		$ (125,000)					
Salvage	5%					$\boxed{63{,}814}$	
Gains tax							(12,139)
Financing activities							
Borrowed funds		62,500					
Principal repayment			(9,179)	(10,601)	(12,244)	(14,14	should appear in the year 5 column
Net cash flow (in actual dollars)		$ (62,500)	$ 29,953	$ 36,375	$ 34,203	$ 33,027	$ 82,000
Net cash flow (in constant dollars)	5%	$ (62,500)	$ 28,527	$ 32,993	$ 29,545	$ 27,171	$ 64,249
Equivalent present worth	15%	$ (62,500)	$ 24,806	$ 24,948	$ 19,427	$ 15,535	$ 31,943
Net present worth	$54,159						

Then, from Table 11.4, we compute the equivalent present worth of the after-tax cash flow as follows:

$$\begin{aligned}\mathrm{PW}(20.75\%) &= -\$62{,}500 + \$29{,}953(P/F, 20.75\%, 1) + \cdots \\ &\quad + \$82{,}000(P/F, 20.75\%, 5) \\ &= \$54{,}159.\end{aligned}$$

Chapter 12

- Then the conditional net present value of this stock transaction is

  $$PW(5\%) = -\$50{,}100 + \$69{,}940(P/F, 5\%, 1) = \$16{,}510.$$

  This amount of \$16,510 is entered at the tip of the corresponding branch. This procedure is repeated for each possible branch, and the resulting amounts are shown in Figure 12.17(b).

2. With a 9% return, we have
   - Period 0: −\$50,100
   - Period 1: \$53,540
   - $PW(5\%) = -50{,}100 + 53{,}540(P/F, 5\%, 1) = \$890$

3. With a 30% loss, we have
   - Period 0: −\$50,100
   - Period 1: \$37,940
   - $PW(5\%) = -\$50{,}100 + \$37{,}940(P/F, 5\%, 1) = -\$13{,}967$

- **Option 2.** Since the interest income on the U.S. government bond will not be taxed, there will be no capital-gains tax. Considering only the brokerage commission, we find that the relevant cash flows would be as follows:
  - Period 0: $(-\$50{,}000 - \$150) = \$50{,}150$
  - Period 1: $(+\$53{,}750 - \$150) = \$53{,}600$
  - $PW(5\%) = -\$50{,}150 + \$53{,}600(P/F, 5\%, 1) = \$$

"-"
insert minus sign

Figure 12.17(b) shows the complete decision tree for Bill's investment problem. Now Bill can calculate the expected monetary value (EMV) at each chance node. The EMV of Option 1 represents the sum of the products of the probabilities of high, medium, and low returns and the respective conditional profits (or losses):

$$EMV = \$16{,}510(0.25) + \$890(0.40) - \$13{,}967(0.35) = -\$405.$$

For Option 2, the EMV is simply

$$EMV = \$898.$$

In Figure 12.17, the expected monetary values are shown in the event nodes. Bill must choose which action to take, and this would be the one with the highest EMV, namely, Option 2, with EMV = \$898. This expected value is indicated in the tree by putting \$898 in the decision node at the beginning of the tree. Note that the decision tree uses the idea of maximizing expected monetary value developed in the previous section. In addition, the mark || is drawn across the nonoptimal decision branch (Option 1), indicating that it is not to be followed. In this simple example, the benefit of using a decision tree may not be evident. However, as the decision problem becomes more complex, the decision tree becomes more useful in organizing the information flow needed to make the decision. This is true in particular if Bill must make a sequence of decisions, rather than a single decision, as we next illustrate.

Chapter 13

Add a "dotted" line

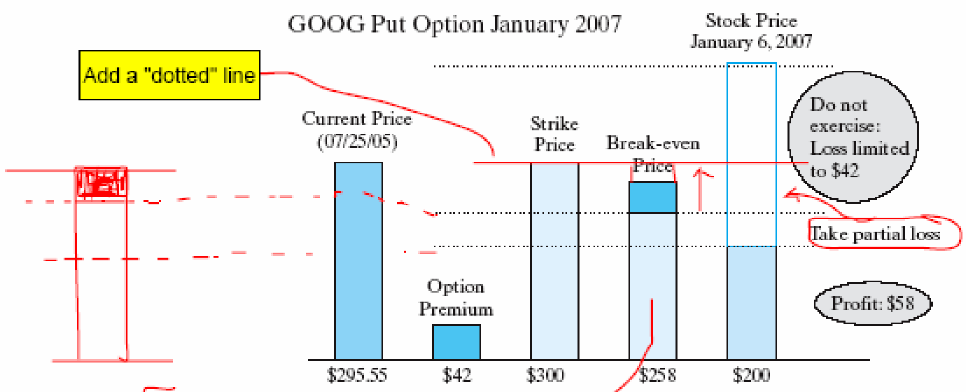


Figure 13.4 Buying a put option on Google stock. If the stock price de-
~~eases to $200,~~ the investor will earn a $58 profit; otherwise the investor
ll lose money from holding the put option.

Redraw this bar:

1. Extend the bar to touch the new dotted line.
2. The size of the solid shaded box should be the same size as "option premium" box

e cost of the premium. Figure 13.4 illustrates how an investor might profit a put option on Google stock. Once again, with a strike price of $300 and an ium of $42, you would exercise your put only when the share price of the below $300. At $258, you will break even; between $258 and $300, you will l loss by recovering some of your premium. Once again, the reason you are option with a strike price of $300 is that the current price of the stock is too in that value in the future.

13.2 Option Strategies

Now that we have described how the basic financial options work, we will review two basic strategies on how to hedge the financial risk when we use these options. The first strategy is to reduce the capital that is at risk by buying call options, and the second strategy is to buy a put option to hedge the market risk.

13.2.1 Buying Calls to Reduce Capital That Is at Risk

Once again, buying a call gives the owner a right, but not an obligation. The risk for the call buyer is limited to the premium paid for the call (the price of the call), plus commissions. The value of the call tends to increase as the price of the underlying stock rises. This gain will increasingly reflect a rise in the value of the underlying stock when the market price moves above the option's strike price. As an investor, you could buy the underlying security, or you could buy call options on the underlying security. As a call buyer, you have three options: (1) Hold the option to maturity and trade at the strike price, (2) trade for profit before the option expires (known as exercising your option), and (3) let the option expire if doing so is advantageous to you. Example 13.1 illustrates how you might buy a call to participate in the upward movement of a stock while limiting your downside risk.

movement (d). Since the time unit is one year, $\Delta t = 1$; and since $\sigma = 0.1823$, we compute u and d as follows:

$$u = e^{\sigma\sqrt{\Delta t}} = e^{0.1823\sqrt{1}} = 1.2,$$

$$d = \frac{1}{u} = 0.833.$$

The lattice evolution of the underlying project value will look like the event tree shown in Figure 13.17.

SOLUTION

(a) Traditional NPW calculation:
Using a traditional discounted cash flow model, we may calculate the present value of the expected future cash flows, discounted at 10.83%, as follows:

$$\begin{aligned} PW(10.83\%)_{\text{Investment}} &= 60 + \frac{400}{1.1083} + \frac{800}{1.1083^3} \\ &= 1{,}008.56 \text{ million}, \\ PW(10.83\%)_{\text{Value of investment}} &= \$1{,}000 \text{ million}, \\ NPW &= \$1{,}000 - \$1{,}008.56 \\ &= -\$8.56 < 0 \text{ (Reject)}. \end{aligned}$$

Since the NPW is negative, the project would be a no-go one. Note that we used a cost of capital (k) of 10.83% in discounting the expected cash flows. This cost of capital represents a market risk-adjusted discount rate.

(b) Real-options analysis:
Using a process known as backward induction, we may proceed to create the option valuation lattice in two steps: the valuation of the terminal nodes and the valuation of the intermediate nodes. In our example, we start with the nodes at year 3.

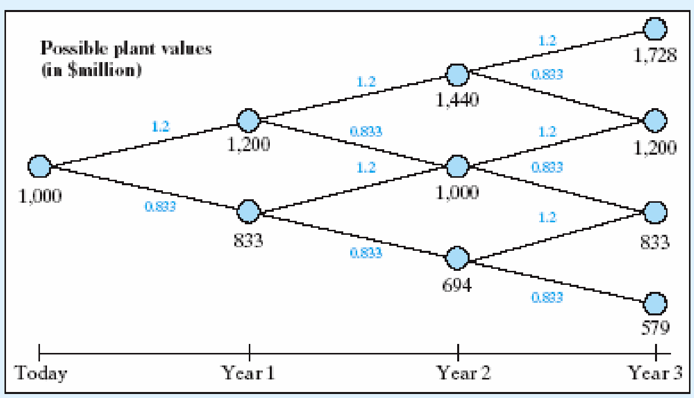


Figure 13.17 The event tree that illustrates how the project's value changes over time.

time steps gets larger, the value calculated with the binomial lattice model approaches the closed-form solution to the Black–Scholes model.

- Real-options analysis is the process of valuing managerial strategic and operating flexibilities. Real options exist when managers can influence the size and risk of a project's cash flows by taking different actions during the project's life in response to changing market dynamics.
- The single most important characteristic of an option is that it does not obligate its owner to take any action. It merely gives the owner the right to buy or sell an asset.
- Financial options have an underlying asset that is traded—usually a security such as a stock.
- Real options have an underlying asset that is not a security—for example, a project or a growth opportunity—and it is not traded.
- The payoffs for financial options are specified in the contract, whereas real options are found or created inside of projects. Their payoffs vary.
- Among the different types of real-option models are the option to defer investment, an abandonment option, follow-on (compound) options, and the option to adjust production.
- One of the most critical parameters in valuing real options is the volatility of the return on the project.
- The fundamental difference between the traditional NPW approach and real-options analysis is in how they treat managing the project risk: The traditional NPW approach is to avoid risk whenever possible, whereas the real-options approach is to manage the risk.

PROBLEMS

Financial Options

13.1 Use a binomial lattice with the following attributes to value a European call option:
   (a) Current underlying asset value of 60.
   (b) Exercise price of 60.
   (c) Volatility of 30%.
   (d) Risk-free rate of 5%.
   (e) Time to expiration equal to 18 months.
   (f) A two-period lattice.

13.2 Use a binomial lattice with the following attributes to value an American put option:
   (a) Current underlying asset value of 40.
   (b) Exercise price of 45.
   (c) Volatility of 40%.
   (d) Risk-free rate of 5%.
   ~~(e) Dividend yield of 3%.~~
   e (f) Time to expiration equal to three years.
   f (g) A three-period lattice.