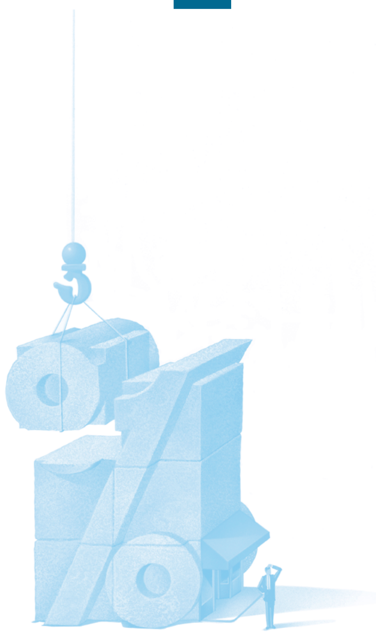
PART 4

Handling Risk and Uncertainty



CHAPTER ELEVEN

Inflation and Its Impact on Project Cash Flows

How Much Will It Cost to Send Your Child to College in the Year 2015? You may have heard your parents fondly remember the "good old days" of penny candy or 35-cents-per-gallon gasoline. But even a college student in his or her early twenties can relate to the phenomenon of escalating costs. Do you remember when a postage stamp cost a dime? When the price of a first-run movie was under $2? The accompanying table[1] demonstrates price differences between 2003 and 2005 for some commonly bought items. For example, unleaded gasoline cost $1.61 a gallon in 2003, whereas it cost $2.32 in 2005. Thus, in 2005, the same $1.61 bought only 0.69 gallon of the gasoline it would have bought in 2003. From 2003 to 2005, the $1.61 sum had lost 31% of its purchasing power!

On a brighter note, we open this chapter with some statistics about engineers' pay rates. The average starting salary of a first-year engineer was $7,500 in 1967. According to a recent survey by the National Society of Professional Engineers,[2] the average starting salary of a first-year engineer in 2005 was $51,509, which is equivalent to an annual increase of 5.20% over 38 years. During the same period, the general inflation rate remained at 4.73%, indicating that engineers' pay rates at least have kept up with the rate of inflation.

[1] *Source*: *The Wall Street Journal*, Tuesday, January 3, 2006 (Section R12, "Year-End Review of Markets and Finance, Consumer Purchases").
[2] *Source*: 2000 Income and Salary Survey by National Society of Professional Engineers.

Consumer Purchases	2003	2004	2005
Single-Family Home Median resale price	$170,000	$184,100	$215,900
Toyota Camry Sticker price, plus destination charge, for LE 5-speed	$19,560	$19,835	$20,125
Unleaded Gasoline Average national price per gallon for all grades combined, including all taxes, self-service	$1.61	$1.90	$2.32
Pair of Jeans Gap's Easy Fit, stonewashed, national price	$39.50	$39.50	$39.50
Internet Service Average monthly subscription for use of cable service from Comcast, standard tier	$42.95	$42.95	$42.95
Tax Preparation Average cost of federal, state, and local tax-return preparation by H&R Block	$130	$140	$151
McDonald's Big Mac Average recommended price	$2.22	$2.29	$2.39
Clearing Clogged Sink Roto-Rooter sewer and drain service, residential (nat'l avg.)	$189	$201	$212
Movie Ticket Adult ticket; first-run theater; evening, national average	$8.08	$8.39	$8.52
Airline Ticket Domestic roundtrip, based on a 2,000-mile trip, excluding aviation taxes	$246	$241	$235
Vacation One week for an adult at Club Med's Punta Cana resort, including airfare from New York	$1,162	$1,375	$1,315
Hospital Stay Average cost of one day in a semiprivate room, including ancillary services except private physician's fee (Cleveland)	$3,889	$4,416	$4,848
Birth Average hospital cost for mother and child, excluding private physician's fee (Cleveland)	$6,696	$7,187	$7,907
A Year in College In-state, including room and board and fees, undergraduate student at Penn State	$15,441	$16,862	$17,799
Funeral National average, excluding cemetery costs	$6,366	$6,530	$6,725

Up to this point, we have demonstrated how to develop cash flows in a variety of ways and how to compare them under constant conditions in the general economy. In other words, we have assumed that prices remain relatively unchanged over long periods. As you know from personal experience, that is not a realistic assumption. In this chapter, we define and quantify **inflation** and then go on to apply it in several economic analyses. We will demonstrate inflation's effect on depreciation, borrowed funds, the rate of return of a project, and working capital within the bigger picture of developing projects.

CHAPTER LEARNING OBJECTIVES

After completing this chapter, you should understand the following concepts:

- How to measure inflation.
- Conversion from actual dollars to constant dollars or from constant to actual dollars.
- How to compare the amount of dollars received at different points in time.
- Which inflation rate to use in economic analysis.
- Which interest rate to use in economic analysis (market interest rate versus inflation-free interest rate).
- How to handle multiple inflation rates in project analysis.
- The cost of borrowing and changes in working-capital requirements under inflation.
- How to conduct rate-of-return analysis under inflation.

11.1 Meaning and Measure of Inflation

Inflation is the rate at which the general level of prices and goods and services is rising, and, subsequently, purchasing power is falling.

Historically, the general economy has usually fluctuated in such a way as to exhibit **inflation**, a loss in the purchasing power of money over time. Inflation means that the cost of an item tends to increase over time, or, to put it another way, the same dollar amount buys less of an item over time. **Deflation** is the opposite of inflation, in that prices usually decrease over time; hence, a specified dollar amount gains in purchasing power. Inflation is far more common than deflation in the real world, so our consideration in this chapter will be restricted to accounting for inflation in economic analyses.

11.1.1 Measuring Inflation

CPI is an inflationary indicator that measures the change in the cost of a fixed basket of products and services.

Before we can introduce inflation into an engineering economic problem, we need a means of isolating and measuring its effect. Consumers usually have a relative, if not a precise, sense of how their purchasing power is declining. This sense is based on their experience of shopping for food, clothing, transportation, and housing over the years. Economists have developed a measure called the **Consumer Price Index** (**CPI**), which is based on a typical **market basket** of goods and services required by the average consumer. This market basket normally consists of items from eight major groups: (1) food and alcoholic beverages, (2) housing, (3) apparel, (4) transportation, (5) medical care, (6) entertainment, (7) personal care, and (8) other goods and services.

The CPI compares the cost of the typical market basket of goods and services in a current month with its cost 1 month ago, 1 year ago, or 10 years ago. The point in the past with which current prices are compared is called the **base period**. The index value for the base period is set at $100. The original base period used by the Bureau of Labor Statistics (BLS), of the U.S. Department of Labor, for the CPI index was 1967. For example, let us say that, in 1967, the prescribed market basket could have been purchased for $100. Now suppose the same combination of goods and services costs $578 in 2005. We can then compute the CPI for 2005 by multiplying the ratio of the current price to the base-period price by 100. In our example, the price index is $(\$578/\$100)100 = 578$, which means that the 2005 price of the contents of the market basket is 578% of its base-period price.

The revised CPI introduced by BLS in 1987 includes indexes for two populations: urban wage earners and clerical workers (CPI-W), and all urban consumers (CPI-U). As a result of the revision, both the CPI-W and the CPI-U utilize updated expenditure weights based upon data tabulated from the years 1982, 1983, and 1984 of the Consumer Expenditure Survey and incorporate a number of technical improvements. This method of assessing inflation does not imply, however, that consumers actually purchase the same goods and services year after year. Consumers tend to adjust their shopping practices to changes in relative prices, and they tend to substitute other items for those whose prices have increased greatly in relative terms. We must understand that the CPI does not take into account this sort of consumer behavior, because it is predicated on the purchase of a fixed market basket of the same goods and services, in the same proportions, month after month. For this reason, the CPI is called a **price index** rather than a **cost-of-living index**, although the general public often refers to it as a cost-of-living index.

PPI An inflationary indicator published by the U.S. Bureau of Labor Statistics to evaluate wholesale price levels in the economy.

The consumer price index is a good measure of the general increase in prices of consumer products. However, it is not a good measure of industrial price increases. In performing engineering economic analysis, the appropriate price indexes must be selected to estimate the price increases of raw materials, finished products, and operating costs. The ***Survey of Current Business***, a monthly publication prepared by the BLS, provides the **Producer Price Index** (PPI) for various industrial goods.[3]

Table 11.1 lists the overall CPI, together with several price indexes for certain commodities over a number of years. From the table, we can easily calculate the inflation rate of gasoline from 2004 to 2005 as follows:

$$\frac{162.5 - 126.1}{126.1} = 0.2887 = 28.87\%.$$

Since the inflation rate calculated is positive, the price of gasoline increased at a rate of 28.87% over the year 2004, one of the largest jumps in the price of gasoline in recent years.

Average Inflation Rate (f)

To account for the effect of varying yearly inflation rates over a period of several years, we can compute a single rate that represents an **average inflation rate**. Since each individual year's inflation rate is based on the previous year's rate, all these rates have a compounding

[3] Both CPI and PPI data are available on the Internet at the BLS home page on the Web: http://stats.bls.gov.

TABLE 11.1 Selected Price Indexes (Index for Base Year = 100, Calendar Month = April)

Year	New CPI, 1982–84	Old CPI, 1967	Gasoline, 1982	Semiconductor, 1982	Passenger Car, 1982
1995	152.2	455.0	67.7	133.1	133.7
1996	156.6	468.2	76.4	123.5	134.9
1997	160.2	479.7	72.7	114.0	134.8
1998	162.5	487.1	54.0	102.9	131.8
1999	166.2	497.8	64.4	98.5	130.9
2000	171.2	512.9	92.6	92.0	132.8
2001	176.9	529.9	104.8	87.7	133.2
2002	179.8	538.6	89.0	84.1	129.8
2003	183.8	550.5	100.1	79.4	129.0
2004	188.0	563.2	126.1	71.8	131.1
2005	194.6	582.9	162.5	70.0	133.2

Note: Years listed are base periods.

effect. As an example, suppose we want to calculate the average inflation rate for a two-year period: The first year's inflation rate is 4%, and the second year's rate is 8%, on a base price of \$100.

Step 1. To find the price at the end of the second year, we use the process of compounding:

$$\underbrace{\overbrace{\$100(1 + 0.04)}^{\text{First year}}(1 + 0.08)}_{\text{Second year}} = \$112.32.$$

Step 2. To find the average inflation rate *f*, we establish the following equivalence equation:

$$\$100(1 + f)^2 = \$112.32 \text{ or } \$100(F/P, f, 2) = \$112.32.$$

Solving for *f* yields

$$f = 5.98\%.$$

We can say that the price increases in the last two years are equivalent to an average annual percentage rate of 5.98% per year. Note that the average is a geometric, not an arithmetic, average over a several-year period. Our computations are simplified by using a single average rate such as this, rather than a different rate for each year's cash flows.

EXAMPLE 11.1 Average Inflation Rate

Consider again the price increases for the 15 items listed in the table at the beginning of this chapter. Determine the average inflation rate for each item over the two-year period shown.

SOLUTION

Let's take the first item, the single-family home, for a sample calculation. Since we know the prices for 2003 and 2005, we can use the appropriate equivalence formula (single-payment compound amount factor, or growth formula). We state the problem as follows:

Given: $P = \$170{,}000$, $F = \$215{,}900$, and $N = 2005 - 2003 = 2$.

Find: f.

The equation we desire is $F = P(1 + f)^N$, so we have

$$\begin{aligned} \$215{,}900 &= \$170{,}000(1 + f)^2, \\ f &= \sqrt{1.27} - 1 \\ &= 12.69\%. \end{aligned}$$

In a similar fashion, we can obtain the average inflation rates for the remaining items. The answers are as follows:

Item	2005 Price ($)	2003 Price ($)	Average Inflation Rate
Consumer Price Index (CPI)	194.60	183.80	2.90%
Single-family home	215,900.00	170,000.00	12.69%
Toyota Camry	20,125.00	19,560.00	1.43%
Unleaded gasoline	2.32	1.61	20.04%
Pair of jeans	39.50	39.50	0.00%
Internet service	42.95	42.95	0.00%
Tax preparation	151.00	130.00	7.77%
McDonald's Big Mac	2.39	2.22	3.76%
Clearing clogged sink	212.00	189.00	5.91%
Movie ticket	8.52	8.08	2.69%
Airline ticket	235.00	246.00	−2.26%
Vacation	1,315.00	1,162.00	6.38%
Hospital stay	4,848.00	3,889.00	11.65%
Birth	7,907.00	6,696.00	8.67%
A year in college	17,798.00	15,441.00	7.36%
Funeral	6,725.00	6,366.00	2.78%

The cost of unleaded gasoline increased most among the items listed in the table, whereas the price of an airline ticket exhibited "deflation" during the same period.

General Inflation Rate $\bar{f}$ Versus Specific Inflation Rate f_j

When we use the CPI as a base to determine the average inflation rate, we obtain the **general inflation rate**. We need to distinguish carefully between the general inflation rate and the average inflation rate for specific goods:

- **General inflation rate $\bar{f}$.** This average inflation rate is calculated on the basis of the CPI for all items in the market basket. The market interest rate is expected to respond to this general inflation rate.
- **Specific inflation rate f_j.** This rate is based on an index (or the CPI) specific to segment j of the economy. For example, we must often estimate the future cost of a particular item (e.g., labor, material, housing, or gasoline). When we refer to the average inflation rate for just one item, we will drop the subscript j for simplicity.

In terms of the CPI, we define the general inflation rate as

$$\text{CPI}_n = \text{CPI}_0 (1 + \bar{f})^n, \tag{11.1}$$

or

$$\bar{f} = \left[\frac{\text{CPI}_n}{\text{CPI}_0}\right]^{1/n} - 1, \tag{11.2}$$

where $\bar{f}$ = The general inflation rate,

CPI_n = The consumer price index at the end period n, and

CPI_0 = The consumer price index for the base period.

Knowing the CPI values for two consecutive years, we can calculate the annual general inflation rate as

$$\bar{f}_n = \frac{\text{CPI}_n - \text{CPI}_{n-1}}{\text{CPI}_{n-1}}, \tag{11.3}$$

where $\bar{f}_n$ = the general inflation rate for period n.

As an example, let us calculate the general inflation rate for the year 2005, where $\text{CPI}_{2004} = 188.0$ and $\text{CPI}_{2005} = 194.6$:

$$\frac{194.6 - 188.0}{188.0} = 0.0351 = 3.51\%.$$

This was an unusually good rate for the U.S. economy, compared with the average general inflation rate of 4.78%[4] over the last 38 years.

[4] To calculate the average general inflation rate from the base period (1967) to 2005, we evaluate

$$\bar{f} = \left[\frac{582.9}{100}\right]^{1/38} - 1 = 4.78\%.$$

EXAMPLE 11.2 Yearly and Average Inflation Rates

The following table shows a utility company's cost to supply a fixed amount of power to a new housing development:

Year	Cost
0	\$504,000
1	538,400
2	577,000
3	629,500

The indices are specific to the utilities industry. Assume that year 0 is the base period, and determine the inflation rate for each period. Then calculate the average inflation rate over the three years listed in the table.

SOLUTION

Given: Annual cost to supply a fixed amount of power.
Find: Annual inflation rate (f_n) and average inflation rate $(\bar{f})$.

The inflation rate during year 1 (f_1) is

$$\frac{(\$538{,}400 - \$504{,}000)}{\$504{,}000} = 6.83\%.$$

The inflation rate during year 2 (f_2) is

$$\frac{(\$577{,}000 - \$538{,}400)}{\$538{,}400} = 7.17\%.$$

The inflation rate during year 3 (f_3) is

$$\frac{(\$629{,}500 - \$577{,}000)}{\$577{,}000} = 9.10\%.$$

The average inflation rate over the three years is

$$f = \left(\frac{\$629{,}500}{\$504{,}000}\right)^{1/3} - 1 = 0.0769 = 7.69\%.$$

Note that, although the average inflation rate[5] is 7.69% for the period taken as a whole, none of the years within the period had that particular rate.

[5] Since we obtained this average rate on the basis of costs that are specific to the utility industry, that rate is not the general inflation rate. Rather, it is a specific inflation rate for the utility in question.

11.1.2 Actual versus Constant Dollars

To introduce the effect of inflation into our economic analysis, we need to define several inflation-related terms:[6]

Actual (current) dollars: Out-of-pocket dollars paid at the time of purchasing goods and services.

Constant (nominal/real) dollars: Dollars as if in some base year, used to adjust for the effects of inflation.

- **Actual (current) dollars (A_n).** Actual dollars are estimates of future cash flows for year n that take into account any anticipated changes in amounts caused by inflationary or deflationary effects. Usually, these amounts are determined by applying an inflation rate to base-year dollar estimates.
- **Constant (real) dollars (A'_n).** Constant dollars represent constant purchasing power that is independent of the passage of time. In situations where inflationary effects were assumed when cash flows were estimated, the estimates obtained can be converted to constant dollars (base-year dollars) by adjustment with some readily accepted **general inflation rate**. We will assume that the base year is always time 0, unless we specify otherwise.

Conversion from Constant to Actual Dollars

Since constant dollars represent dollar amounts expressed in terms of the purchasing power of the base year, we may find the equivalent dollars in year n by using the general inflation rate $\bar{f}$ in the formula

$$A_n = A'_n(1 + \bar{f})^n = A'_n(F/P, \bar{f}, n), \tag{11.4}$$

where A'_n = Constant-dollar expression for the cash flow at the end of year n, and A_n = Actual-dollar expression for the cash flow at the end of year n.

If the future price of a specific cash flow element (j) is not expected to follow the general inflation rate, we will need to use the appropriate average inflation rate f_j applicable to that cash flow element, instead of $\bar{f}$. The conversion process is illustrated in Figure 11.1.

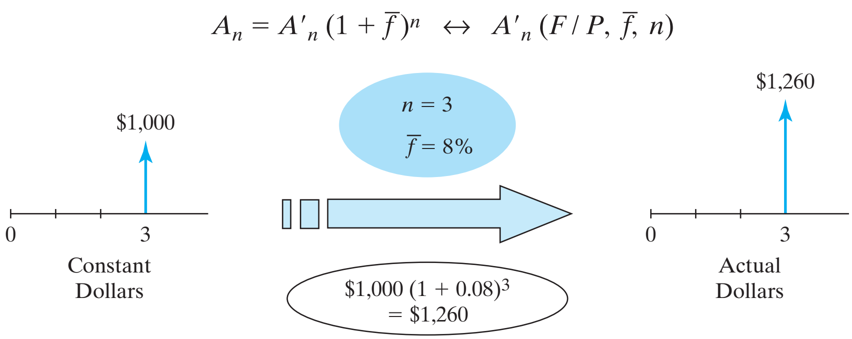


Figure 11.1 Converting a $1,000 cash flow at year 3 estimated in constant dollars to its equivalent actual dollars at the same period, assuming an 8% inflation rate.

[6] The definitions presented are based on the ANSI Z94 Standards Committee on Industrial Engineering Terminology, *The Engineering Economist*. 1988; 33(2): 145–171.

EXAMPLE 11.3 Conversion from Constant to Actual Dollars

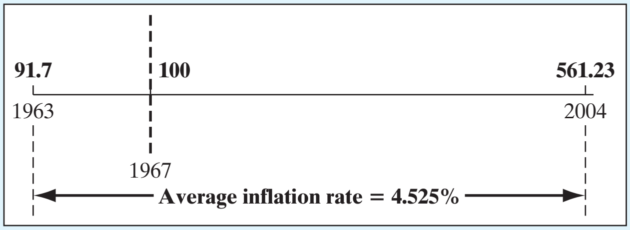
Jack Nicklaus won his first Masters Golf Championship in 1963. His prize money was $20,000. Phil Mickelson won his first Masters in 2004. The prize money was $1.17 million. It seems that Phil's prize money is much bigger. Compare these two prizes in terms of common purchasing power: Whose buying power is greater?

SOLUTION

Given: Two prize monies received in 1963 and 2004, respectively.

Find: Compare these two prizes in terms of purchasing power of 2004.

Both prize monies are in actual dollars at the time of winning. So, if we want to compare the prizes on the basis of the purchasing power of the year 2004, then we need to know the consumer price indexes for 1963 as well as 2004.



Using the old CPI, we find that the CPI for 1963 is 91.7 and the CPI for 2004 is 561.23. The average inflation rate between these two periods is 4.525%. To find the purchasing power of this $20,000 in 2004, we simply calculate the expression

$$20{,}000(1 + 0.04525)^{41} = \$122{,}760.$$

Given inflation and the changing value of money, $20,000 in 1963 is equivalent to $122,760 in terms of 2004 purchasing power. This is clearly much lower than Phil's actual 2004 winning prize, but Jack had 41 years to invest the amount to match Phil's winning prize.

Conversion from Actual to Constant Dollars

This conversion, shown in Figure 11.2, is the reverse process of converting from constant to actual dollars. Instead of using the compounding formula, we use a discounting formula (single-payment present-worth factor):

$$A'_n = \frac{A_n}{(1 + \overline{f})^n} = A_n(P/F, \overline{f}, n). \tag{11.5}$$

Once again, we may substitute f_j for $\overline{f}$ if future prices are not expected to follow the general inflation rate.

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

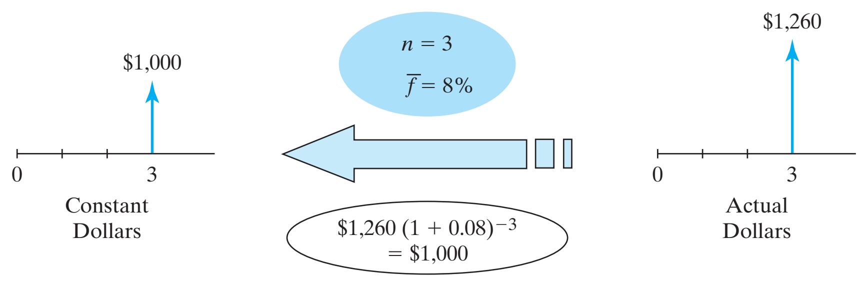


Figure 11.2 Conversion from actual to constant dollars. What it means is that $1,260 three years from now will have a purchasing power of $1,000 in terms of base dollars (year 0).

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.

11.2 Equivalence Calculations under Inflation

In previous chapters, our equivalence analyses took into consideration changes in the **earning power** of money (i.e., interest effects). To factor in changes in **purchasing power** as well—that is, inflation—we may use either (1) constant-dollar analysis or (2) actual-dollar analysis. Either method produces the same solution; however, each method requires the use of a different interest rate and procedure. Before presenting the two procedures for integrating interest and inflation, we will give a precise definition of the two interest rates.

11.2.1 Market and Inflation-Free Interest Rates

Two types of interest rates are used in equivalence calculations: the market interest rate and the inflation-free interest rate. The rate to apply depends on the assumptions used in estimating the cash flow:

- **Market interest rate (*i*).** This rate takes into account the combined effects of the earning value of capital (earning power) and any anticipated inflation or deflation (purchasing power). Virtually all interest rates stated by financial institutions for loans and savings accounts are market interest rates. Most firms use a market interest rate (also known as an **inflation-adjusted MARR**) in evaluating their investment projects.
- **Inflation-free interest rate (i').** This rate is an estimate of the true earning power of money when the inflation effects have been removed. Commonly known as the **real interest rate**, it can be computed if the market interest rate and the inflation rate are known. As you will see later in this chapter, in the absence of inflation, the market interest rate is the same as the inflation-free interest rate.

Market interest rate: The interest rate quoted by financial institutions that accounts for both earning and purchasing power.

In calculating any cash flow equivalence, we need to identify the nature of project cash flows. The three common cases are as follows:

Case 1. All cash flow elements are estimated in constant dollars.

Case 2. All cash flow elements are estimated in actual dollars.

Case 3. Some of the cash flow elements are estimated in constant dollars, and others are estimated in actual dollars.

For case 3, we simply convert all cash flow elements into one type—either constant or actual dollars. Then we proceed with either constant-dollar analysis as for case 1 or actual-dollar analysis as for case 2.

11.2.2 Constant-Dollar Analysis

Suppose that all cash flow elements are already given in constant dollars and that you want to compute the equivalent present worth of the constant dollars (A_n') occurring in year n. In the absence of an inflationary effect, we should use i' to account for only the earning power of the money. To find the present-worth equivalent of this constant-dollar amount at i', we use

$$P_n = \frac{A_n'}{(1 + i')^n}. \tag{11.6}$$

Constant-dollar analysis is common in the evaluation of many long-term public projects, because governments do not pay income taxes. Typically, income taxes are levied on the basis of taxable incomes in actual dollars.

EXAMPLE 11.5 Equivalence Calculation When Flows Are Stated in Constant Dollars

Transco Company is considering making and supplying computer-controlled traffic-signal switching boxes to be used throughout Arizona. Transco has estimated the market for its boxes by examining data on new road construction and on the deterioration and replacement of existing units. The current price per unit is \$550; the before-tax manufacturing cost is \$450. The start-up investment cost is \$250,000. The projected sales and net before-tax cash flows in constant dollars are as follows:

Period	Unit Sales	Net Cash Flow in Constant \$
0		−\$250,000
1	1,000	100,000
2	1,100	110,000
3	1,200	120,000
4	1,300	130,000
5	1,200	120,000

If Transco managers want the company to earn a 12% inflation-free rate of return (i') before tax on any investment, what would be the present worth of this project?

SOLUTION

Given: Cash flow series stated in constant dollars, $i' = 12\%$.
Find: Present worth of the cash flow series.

Since all values are in constant dollars, we can use the inflation-free interest rate. We simply discount the dollar inflows at 12% to obtain the following:

$$\begin{aligned} \text{PW}(12\%) &= -\$250{,}000 + \$100{,}000(P/A, 12\%, 5) \\ &\quad + \$10{,}000(P/G, 12\%, 4) + \$20{,}000(P/F, 12\%, 5) \\ &= \$163{,}099 \text{ (in year-0 dollars)}. \end{aligned}$$

Since the equivalent net receipts exceed the investment, the project can be justified even before considering any tax effects.

11.2.3 Actual-Dollar Analysis

Now let us assume that all cash flow elements are estimated in actual dollars. To find the equivalent present worth of the actual dollar amount (A_n) in year n, we may use either the **deflation method** or the **adjusted-discount method**.

Deflation Method

The deflation method requires two steps to convert actual dollars into equivalent present-worth dollars. First we convert actual dollars into equivalent constant dollars by discounting by the general inflation rate, a step that removes the inflationary effect. Now we can use i' to find the equivalent present worth.

EXAMPLE 11.6 Equivalence Calculation When Cash Flows Are in Actual Dollars: Deflation Method

Applied Instrumentation, a small manufacturer of custom electronics, is contemplating an investment to produce sensors and control systems that have been requested by a fruit-drying company. The work would be done under a proprietary contract that would terminate in five years. The project is expected to generate the following cash flows in actual dollars:

n	Net Cash Flow in Actual Dollars
0	−$75,000
1	32,000
2	35,700
3	32,800
4	29,000
5	58,000

(a) What are the equivalent year-0 dollars (constant dollars) if the general inflation rate $(\bar{f})$ is 5% per year?

(b) Compute the present worth of these cash flows in constant dollars at $i' = 10\%$.

SOLUTION

Given: Cash flow series stated in actual dollars, $\bar{f} = 5\%$, and $i' = 10\%$.

Find: (a) Cash flow series converted into constant dollars and (b) the present worth of the cash flow series.

The net cash flows in actual dollars can be converted to constant dollars by deflating them, again assuming a 5% yearly deflation factor. The deflated, or constant-dollar, cash flows can then be used to determine the NPW at i'.

(a) We convert the actual dollars into constant dollars as follows:

n	Cash Flows in Actual Dollars	$\times$	Deflation Factor	=	Cash Flows in Constant Dollars
0	−\$75,000		1		−\$75,000
1	32,000		$(1 + 0.05)^{-1}$		30,476
2	35,700		$(1 + 0.05)^{-2}$		32,381
3	32,800		$(1 + 0.05)^{-3}$		28,334
4	29,000		$(1 + 0.05)^{-4}$		23,858
5	58,000		$(1 + 0.05)^{-5}$		45,445

(b) We compute the equivalent present worth of the constant dollars by using $i' = 10\%$:

n	Cash Flows in Constant Dollars	$\times$	Discounting	=	Equivalent Present Worth
0	−\$75,000		1		−\$75,000
1	30,476		$(1 + 0.10)^{-1}$		27,706
2	32,381		$(1 + 0.10)^{-2}$		26,761
3	28,334		$(1 + 0.10)^{-3}$		21,288
4	23,858		$(1 + 0.10)^{-4}$		16,295
5	45,445		$(1 + 0.10)^{-5}$		28,218
					\$45,268

Adjusted-Discount Method

The two-step process shown in Example 11.6 can be greatly streamlined by the efficiency of the **adjusted-discount method,** which performs deflation and discounting in one step. Mathematically, we can combine this two-step procedure into one with the formula

$$P_n = \frac{\dfrac{A_n}{(1+\bar{f})^n}}{(1+i')^n} = \frac{A_n}{(1+\bar{f})^n(1+i')^n} = \frac{A_n}{[(1+\bar{f})(1+i')]^n}. \tag{11.7}$$

Since the market interest rate (i) reflects both the earning power and the purchasing power, we have

$$P_n = \frac{A_n}{(1+i)^n}. \tag{11.8}$$

The equivalent present-worth values in Eqs. (11.7) and (11.8) must be equal at year 0. Therefore,

$$\frac{A_n}{(1+i)^n} = \frac{A_n}{[(1+\overline{f})(1+i')]^n}.$$

This leads to the following relationship among $\overline{f}$, i', and i:

$$(1+i) = (1+\overline{f})(1+i').$$

Simplifying the terms yields

$$i = i' + \overline{f} + i'\overline{f}. \qquad (11.9)$$

Equation (11.9) implies that the market interest rate is a function of two terms: i' and $\overline{f}$. Note that without an inflationary effect, the two interest rates are the same $(\overline{f} = 0 \rightarrow i = i')$. As either i' or $\overline{f}$ increases, i also increases. For example, we can easily observe that, when prices increase due to inflation, bond rates climb, because lenders (i.e., anyone who invests in a money-market fund, a bond, or a certificate of deposit) demand higher rates to protect themselves against erosion in the value of their dollars. If inflation were to remain at 3%, you might be satisfied with an interest rate of 7% on a bond because your return would more than beat inflation. If inflation were running at 10%, however, you would not buy a 7% bond; you might insist instead on a return of at least 14%. By contrast, when prices are coming down, or at least are stable, lenders do not fear any loss of purchasing power with the loans they make, so they are satisfied to lend at lower interest rates.

In practice, we often approximate the market interest rate (i) simply by adding the inflation rate $(\overline{f})$ to the real interest rate (i') and ignoring the product $(i'\overline{f})$. This practice is fine as long as either i' or $\overline{f}$ is relatively small. With continuous compounding, however, the relationship among i, i', and $\overline{f}$ becomes precisely

$$i' = i - \overline{f}. \qquad (11.10)$$

So, if we assume a nominal APR (market interest rate) of 6% per year compounded continuously and an inflation rate of 4% per year compounded continuously, the inflation-free interest rate is exactly 2% per year compounded continuously.

Real interest rate: The current interest rate minus the current inflation rate.

EXAMPLE 11.7 Equivalence Calculation When Flows Are in Actual Dollars: Adjusted-Discounted Method

Consider the cash flows in actual dollars in Example 11.6. Use the adjusted-discount method to compute the equivalent present worth of these cash flows.

SOLUTION

Given: Cash flow series in actual dollars, $\overline{f} = 5\%$, and $i' = 10\%$.

Find: Equivalent present worth.

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

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

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.

EXAMPLE 11.8 Effects of Inflation on Projects with Depreciable Assets

Consider again the automated machining center investment project described in Example 10.1. The summary of the financial facts in the absence of inflation is as follows:

Item	Description or Data
Project	Automated machining center
Required investment	\$125,000
Project life	5 years
Salvage value	\$50,000
Depreciation method	7-year MACRS
Annual revenues	\$100,000 per year
Annual expenses	
Labor	\$20,000 per year
Material	\$12,000 per year
Overhead	\$8,000 per year
Marginal tax rate	40%
Inflation-free interest rate (i')	15%

The after-tax cash flow for the automated machining center project was given in Table 10.2, and the net present worth of the project in the absence of inflation was calculated to be \$43,152.

What will happen to this investment project if the general inflation rate during the next five years is expected to increase by 5% annually? Sales and operating costs are assumed to increase accordingly. Depreciation will remain unchanged, but taxes, profits, and thus cash flow, will be higher. The firm's inflation-free interest rate (i') is known to be 15%.

(a) Use the deflation method to determine the NPW of the project.

(b) Compare the NPW with that in the inflation-free situation.

DISCUSSION: All cash flow elements, except depreciation expenses, are assumed to be in constant dollars. Since income taxes are levied on actual taxable income, we will use actual-dollar analysis, which requires that all cash flow elements be expressed in actual dollars.

- For the purposes of this illustration, all inflationary calculations are made as of year-end.
- Cash flow elements such as sales, labor, material, overhead, and the selling price of the asset will be inflated at the same rate as the general inflation rate.[7] For example,

[7] This is a simplistic assumption. In practice, these elements may have price indexes other than the CPI. Differential price indexes will be treated in Example 11.9.

whereas annual sales had been estimated at $100,000, under conditions of inflation they become 5% greater in year 1, or $105,000; 10.25% greater in year 2; and so forth.

The following table gives the sales conversion from constant to actual dollars for each of the five years of the project life:

Period	Sales in Constant $	Conversion $\bar{f}$	Sales in Actual $
1	$100,000	$(1 + 0.05)^1$	$105,000
2	100,000	$(1 + 0.05)^2$	110,250
3	100,000	$(1 + 0.05)^3$	115,763
4	100,000	$(1 + 0.05)^4$	121,551
5	100,000	$(1 + 0.05)^5$	127,628

Future cash flows in actual dollars for other elements can be obtained in a similar way. Note that

- No change occurs in the investment in year 0 or in depreciation expenses, since these items are unaffected by expected future inflation.
- The selling price of the asset is expected to increase at the general inflation rate. Therefore, the salvage value of the machine, in actual dollars, will be

$$\$50{,}000(1 + 0.05)^5 = \$63{,}814.$$

This increase in salvage value will also increase the taxable gains, because the book value remains unchanged. The calculations for both the book value and the gains tax are shown in Table 11.2.

SOLUTION

Given: Financial data in constant dollars, $\bar{f} = 5\%$, and $i' = 15\%$.

Find: The NPW.

Table 11.2 shows after-tax cash flows in actual dollars. Using the deflation method, we convert the cash flows to constant dollars with the same purchasing power as the dollars used to make the initial investment (year 0), assuming a general inflation rate of 5%. Then we discount these constant-dollar cash flows at i' to determine the NPW. Since NPW $= \$38{,}899 > 0$, the investment is still economically attractive.

COMMENTS: Note that the NPW in the absence of inflation was $43,152 in Example 10.1. The $4,253 decline just illustrated (known as inflation loss) in the NPW under inflation is due entirely to income tax considerations. The depreciation expense is a

TABLE 11.2 Cash Flow Statement for the Automated Machining Center Project under Inflation

	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
Taxable income			$ 45,137	$ 35,537	$ 47,595	$ 57,317	$ 70,996
Income taxes (40%)			18,055	14,215	19,038	22,927	28,398
Net income			$ 27,082	$ 21,322	$ 28,557	$ 34,390	$ 42,598
Cash flow statement:							
Operating activities							
Net income			27,082	21,322	28,557	34,390	42,598
Depreciation			17,863	30,613	21,863	15,613	5,581
Investment activities							
Investment		(125,000)					
Salvage	5%						63,814
Gains tax							(12,139)
Net cash flow (in actual dollars)		$(125,000)	$ 44,945	$ 51,935	$ 50,420	$ 50,003	$ 99,854

charge against taxable income, which reduces the amount of taxes paid and, as a result, increases the cash flow attributable to an investment by the amount of taxes saved. But the depreciation expense under existing tax laws is based on historic cost. As time goes by, the depreciation expense is charged to taxable income in dollars of declining purchasing power; as a result, the "real" cost of the asset is not totally reflected in the depreciation expense. Depreciation costs are thereby understated, and the taxable income is overstated, resulting in higher taxes. In "real" terms, the amount of this additional income tax is $4,253, which is also known as the **inflation tax**. In general, any investment that, for tax purposes, is expensed over time, rather than immediately, is subject to the inflation tax. The following table 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]

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

[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.

TABLE 11.3 Cash Flow Statement for the Automated Machining Center Project under Inflation, with Multiple Price Indexes

	Inflation Rate	0	1	2	3	4	5
Income statement:							
Revenues	6%		$106,000	$112,360	$119,102	$126,248	$133,823
Expenses							
Labor	5%		21,000	22,050	23,153	24,310	25,526
Material	4%		12,480	12,979	13,498	14,038	14,600
Overhead	5%		8,400	8,820	9,261	9,724	10,210
Depreciation			17,863	30,613	21,863	15,613	5,581
Taxable income			$ 46,257	$ 37,898	$ 51,327	$ 62,562	$ 77,906
Income taxes (40%)			18,503	15,159	20,531	25,025	31,162
Net income			$ 27,754	$ 22,739	$ 30,796	$ 37,537	$ 46,744
Cash flow statement:							
Operating activities							
Net income			27,754	22,739	30,796	37,537	46,744
Depreciation			17,863	30,613	21,863	15,613	5,581
Investment activities							
Investment		(125,000)					
Salvage	3%						57,964
Gains tax							(9,799)
Net cash flow (in actual dollars)		$(125,000)	$ 45,617	$ 53,352	$ 52,659	$ 53,150	$100,490

The equivalent present worth is obtained as follows:

$$\begin{aligned} PW(21.90\%) &= -\$125,000 + \$45,617(P/F, 21.90\%, 1) \\ &\quad + \$53,352(P/F, 21.90\%, 2) + \ldots \\ &\quad + \$100,490(P/F, 21.90\%, 5) \\ &= \$38,801. \end{aligned}$$

11.3.2 Effects of Borrowed Funds under Inflation

The repayment of a loan is based on the historical contract amount; the payment size does not change with inflation. Yet inflation greatly affects the value of these future payments, which are computed in year-0 dollars. First, we shall look at how the values of loan payments change under inflation. Interest expenses are usually already stated in the loan contract in actual dollars and need not be adjusted. Under the effect of inflation, the constant-dollar costs of both interest and principal repayments on a debt are reduced. Example 11.10 illustrates the effects of inflation on payments with project financing.

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:

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

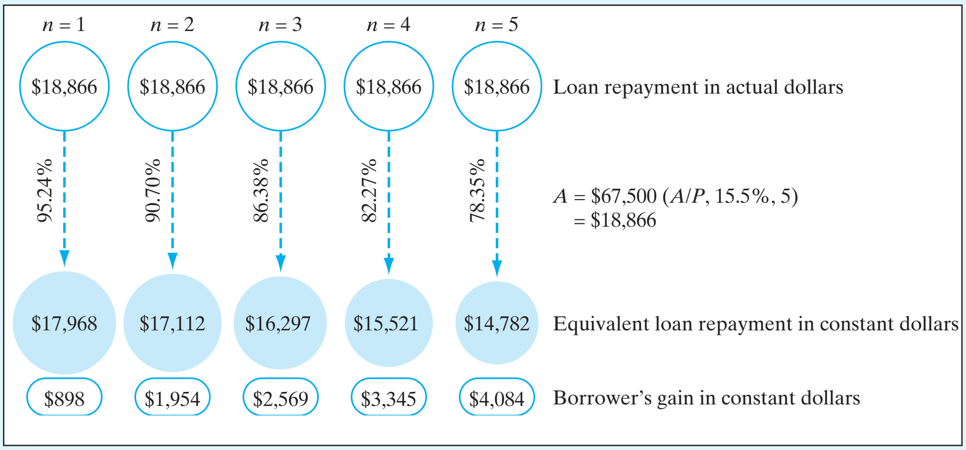


Figure 11.3 Equivalent loan repayment cash flows measured in year-0 dollars and borrower's gain over the life of the loan (Example 11.10).

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%						63,814
Gains tax							(12,139)
Financing activities							
Borrowed funds		62,500					
Principal repayment			(9,179)	(10,601)	(12,244)	(14,142)	(16,334)
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:

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

COMMENTS: In the absence of debt financing, the project would have a net present worth of \$38,899, as shown in Example 11.8. Compared with the preceding result of \$54,159, the gain in present worth due to debt financing is \$15,260. This increase in NPW is due primarily to the debt financing. An inflationary trend decreases the purchasing power of future dollars, which helps long-term borrowers because they can repay a loan with dollars with reduced buying power. That is, the debt-financing cost is reduced in an inflationary environment. In this case, the benefits of financing under inflation have more than offset the *inflation tax* effect on depreciation and the salvage value. The amount of the gain may vary with the interest rate on the loan: The interest rate for borrowing is also generally higher during periods of inflation because it is a market-driven rate.

11.4 Rate-of-Return Analysis under Inflation

In addition to affecting individual aspects of a project's income statement, inflation can have a profound effect on the overall return—that is, the very acceptability—of an investment project. In this section, we will explore the effects of inflation on the rate of return on an investment and present several examples.

11.4.1 Effects of Inflation on Return on Investment

The effect of inflation on the rate of return on an investment depends on how future revenues respond to the inflation. Under inflation, a company is usually able to compensate for increasing material and labor prices by raising its selling prices. However, even if future revenues increase to match the inflation rate, the allowable depreciation schedule, as we have seen, does not increase. The result is increased taxable income and higher income-tax payments. This increase reduces the available constant-dollar after-tax benefits and, therefore, the inflation-free after-tax rate of return (IRR'). The next example will help us to understand this situation.

EXAMPLE 11.11 IRR Analysis with Inflation

Hartsfield Company, a manufacturer of auto parts, is considering purchasing a set of machine tools at a cost of \$30,000. The purchase is expected to generate increased sales of \$24,500 per year and increased operating costs of \$10,000 per year in each of the next four years. Additional profits will be taxed at a rate of 40%. The asset falls into the three-year MACRS property class for tax purposes. The project has a four-year life with zero salvage value. (All dollar figures represent constant dollars.)

(a) What is the expected internal rate of return?
(b) What is the expected IRR′ if the general inflation is 10% during each of the next four years? (Here also, assume that $f_j = \overline{f} = 10\%$.)
(c) If the company requires an inflation-free MARR (or MARR′) of 20%, should the company invest in the equipment?

SOLUTION

Given: Financial data in constant dollars, $t_m = 40\%$, and $N = 4$ years.

Find: (a) IRR, (b) IRR$'$ when $\bar{f} = 10\%$, and (c) whether the project can be justified at MARR $= 20\%$.

(a) Rate-of-return analysis without inflation:

We find the rate of return by first computing the after-tax cash flow by the income statement approach, as illustrated in Table 11.5. The first part of the table shows the calculation of additional sales, operating costs, depreciation, and taxes. The asset will be depreciated fully over four years, with no expected salvage value. As we emphasized in Chapter 10, depreciation is not a cash expense, although it affects taxable income, and thus cash flow, indirectly. Therefore, we must add depreciation to net income to determine the net cash flow.

Thus, if the investment is made, we expect to receive additional annual cash flows of \$12,700, \$14,033, \$10,478, and \$9,589. This is a simple investment, so we can calculate the IRR for the project as follows:

$$\begin{aligned} \text{PW}(i') &= -\$30{,}000 + \$12{,}700(P/F, i', 1) + \$14{,}033(P/F, i', 2) \\ &\quad + \$10{,}478(P/F, i', 3) + \$9{,}589(P/F, i', 4) \\ &= 0. \end{aligned}$$

Solving for i' yields

$$\text{IRR}' = i'^{*} = 21.88\%.$$

TABLE 11.5 Rate-of-Return Calculation without Inflation

	0	1	2	3	4
Income statement:					
Revenues		\$ 24,500	\$ 24,500	\$ 24,500	\$ 24,500
Expenses					
O&M		10,000	10,000	10,000	10,000
Depreciation		10,000	13,333	4,445	2,222
Taxable income		4,500	1,167	10,055	12,278
Income taxes (40%)		1,800	467	4,022	4,911
Net income		\$ 2,700	\$ 700	\$ 6,033	\$ 7,367
Cash flow statement:					
Operating activities					
Net income		2,700	700	6,033	7,367
Depreciation		10,000	13,333	4,445	2,222
Investment activities					
Machine center	\$ (30,000)				
Salvage					0
Gains tax					0
Net cash flow (in actual dollars)	\$ (30,000)	\$ 12,700	\$ 14,033	\$ 10,478	\$ 9,589

The project has an inflation-free rate of return of 21.88%; that is, the company will recover its original investment ($30,000) plus interest at 21.88% each year for each dollar still invested in the project. Since IRR′ > MARR′ (20%), the company should buy the equipment.

(b) Rate-of-return analysis under inflation:
With inflation, we assume that sales, operating costs, and the future selling price of the asset will increase. Depreciation will be unchanged, but taxes, profits, and cash flow will be higher. We might think that higher cash flows will mean an increased rate of return. Unfortunately, this is not the case. We must recognize that cash flows for each year are stated in dollars of declining purchasing power. When the net after-tax cash flows are converted to dollars with the same purchasing power as those used to make the original investment, the resulting rate of return decreases. These calculations, assuming an inflation rate of 10% in sales and operating expenses and a 10% annual decline in the purchasing power of the dollar, are shown in Table 11.6. For example, whereas additional sales

TABLE 11.6 Rate-of-Return Calculation under Inflation

	0	1	2	3	4
Income statement:					
Revenues		$26,950	$29,645	$32,610	$35,870
Expenses					
O&M		11,000	12,100	13,310	14,641
Depreciation		10,000	13,333	4,445	2,222
Taxable income		5,950	4,212	14,855	19,007
Income taxes (40%)		2,380	1,685	5,942	7,603
Net income		$ 3,570	$ 2,527	$ 8,913	$11,404
Cash flow statement:					
Operating activities					
Net income		3,570	2,527	8,913	11,404
Depreciation		10,000	13,333	4,445	2,222
Investment activities					
Machine center	$(30,000)				
Salvage					0
Gains tax					0
Net cash flow (in actual dollars)	$(30,000)	$13,570	$15,860	$13,358	$13,626
Net cash flow (in constant dollars)	$(30,000)	$12,336	$13,108	$10,036	$ 9,307

Note: PW(20%) = $(321); IRR (actual dollars) = 31.34%; IRR′ (constant dollars) = 19.40%.

had been \$24,500 yearly, under conditions of inflation they would be 10% greater in year 1, or \$26,950; 21% greater in year 2; and so forth. No change in investment or depreciation expenses will occur, since these items are unaffected by expected future inflation. We have restated the after-tax cash flows (actual dollars) in dollars of a common purchasing power (constant dollars) by deflating them, again assuming an annual deflation factor of 10%. The constant-dollar cash flows are then used to determine the real rate of return. First,

$$\begin{aligned} \mathrm{PW}(i') &= -\$30{,}000 + \$12{,}336(P/F, i', 1) + \$13{,}108(P/F, i', 2) \\ &\quad + \$10{,}036(P/F, i', 3) + \$9{,}307(P/F, i', 4) \\ &= 0. \end{aligned}$$

Then, solving for i' yields

$$i'^{*} = 19.40\%.$$

The rate of return for the project's cash flows in constant dollars (year-0 dollars) is 19.40%, which is less than the 21.88% return in the inflation-free case. Since $\mathrm{IRR}' < \mathrm{MARR}'$, the investment is no longer acceptable.

COMMENTS: We could also calculate the rate of return by setting the PW of the actual dollar cash flows to 0. This would give a value of IRR = 31.34%, but that is an inflation-adjusted IRR. We could then convert to an IRR′ by deducting the amount caused by inflation:

$$\begin{aligned} i' &= \frac{(1 + i)}{(1 + \bar{f})} - 1 \\ &= \frac{(1 + 0.3134)}{(1 + 0.10)} - 1 \\ &= 19.40\%. \end{aligned}$$

This approach gives the same final result of $\mathrm{IRR}' = 19.40\%$.

11.4.2 Effects of Inflation on Working Capital

The loss of tax savings in depreciation is not the only way that inflation may distort an investment's rate of return. Another source is working-capital drain. Projects requiring increased levels of working capital suffer from inflation because additional cash must be invested to maintain new price levels. For example, if the cost of inventory increases, additional outflows of cash are required to maintain appropriate inventory levels over time. A similar phenomenon occurs with funds committed to accounts receivable. These additional working-capital requirements can significantly reduce a project's rate of return, as the next example illustrates.

EXAMPLE 11.12 Effect of Inflation on Profits with Working Capital

Suppose that, in Example 11.11, a $1,000 investment in working capital is expected and that all the working capital will be recovered at the end of the project's four-year life. Determine the rate of return on this investment.

SOLUTION

Given: Financial data in Example 11.11 and working-capital requirement = $1,000.

Find: IRR.

Using the data in the upper part of Table 11.7, we can calculate IRR′ = IRR of 20.88% in the absence of inflation. Also, PW(20%) = $499. The lower part of the table includes the effect of inflation on the proposed investment. As illustrated in Figure 11.4, working-capital levels can be maintained only by additional infusions of cash; the working-capital drain also appears in the lower part of Table 11.7. For example,

TABLE 11.7 Effects of Inflation on Working Capital and After-Tax Rate of Return

Case 1: Without Inflation	0	1	2	3	4
Income statement:					
Revenue		$ 24,500	$ 24,500	$ 24,500	$ 24,500
Expenses					
O&M		10,000	10,000	10,000	10,000
Depreciation		10,000	13,333	4,445	2,222
Taxable income		4,500	1,167	10,055	12,278
Income taxes (40%)		1,800	467	4,022	4,911
Net income		$ 2,700	$ 700	$ 6,033	$ 7,367
Cash flow statement:					
Operating activities					
Net income		2,700	700	6,033	7,367
Depreciation		10,000	13,333	4,445	2,222
Investment activities					
Machine center	$ (30,000)				
Working capital	(1,000)				1,000
Salvage					0
Gains tax					0
Net cash flow (in actual dollars)	$ (31,000)	$ 12,700	$ 14,033	$ 10,478	$ 10,589

Note: PW(20%) = $499; IRR′ = 20.88%.

Case 2: With Inflation (10%)	**0**	**1**	**2**	**3**	**4**
Income statement:					
Revenue		$ 26,950	$ 29,645	$ 32,610	$ 35,870
Expenses					
O&M		11,000	12,100	13,310	14,641
Depreciation		10,000	13,333	4,445	2,222
Taxable income		5,950	4,212	14,855	19,007
Income taxes (40%)		2,380	1,685	5,942	7,603
Net income		$ 3,570	$ 2,527	$ 8,913	$ 11,404
Cash flow statement:					
Operating activities					
Net income		3,570	2,527	8,913	11,404
Depreciation		10,000	13,333	4,445	2,222
Investment activities					
Machine center	$ (30,000)				
Working capital	(1,000)	(100)	(110)	(121)	$ 1,331
Salvage					0
Gains tax					0
Net cash flow (in actual dollars)	$ (31,000)	$ 13,470	$ 15,750	$ 13,237	$ 14,957
Net cash flow (in constant dollars)	$ (31,000)	$ 12,245	$ 13,017	$ 9,945	$ 10,216

Note: PW(20%) = $(1,074); IRR (actual dollars) = 29.89%; IRR′ (constant dollars) = 18.09%.

the $1,000 investment in working capital made in year 0 will be recovered at the end of the first year, assuming a one-year recovery cycle. However, because of 10% inflation, the required working capital for the second year increases to $1,100. In addition to reinvesting the $1,000 revenues, an additional investment of $100 must be made. This $1,100 will be recovered at the end of the second year. However, the project will need a 10% increase, or $1,210, for the third year, and so forth.

As Table 11.7 illustrates, the combined effect of depreciation and working capital is significant. Given an inflationary economy and investment in working capital, the project's IRR′ drops to 18.09%, or PW(20%) = −$1,074. By using either IRR analysis or NPW analysis, we end up with the same result (as we must): Alternatives that are attractive when inflation does not exist may not be acceptable when inflation does exist.

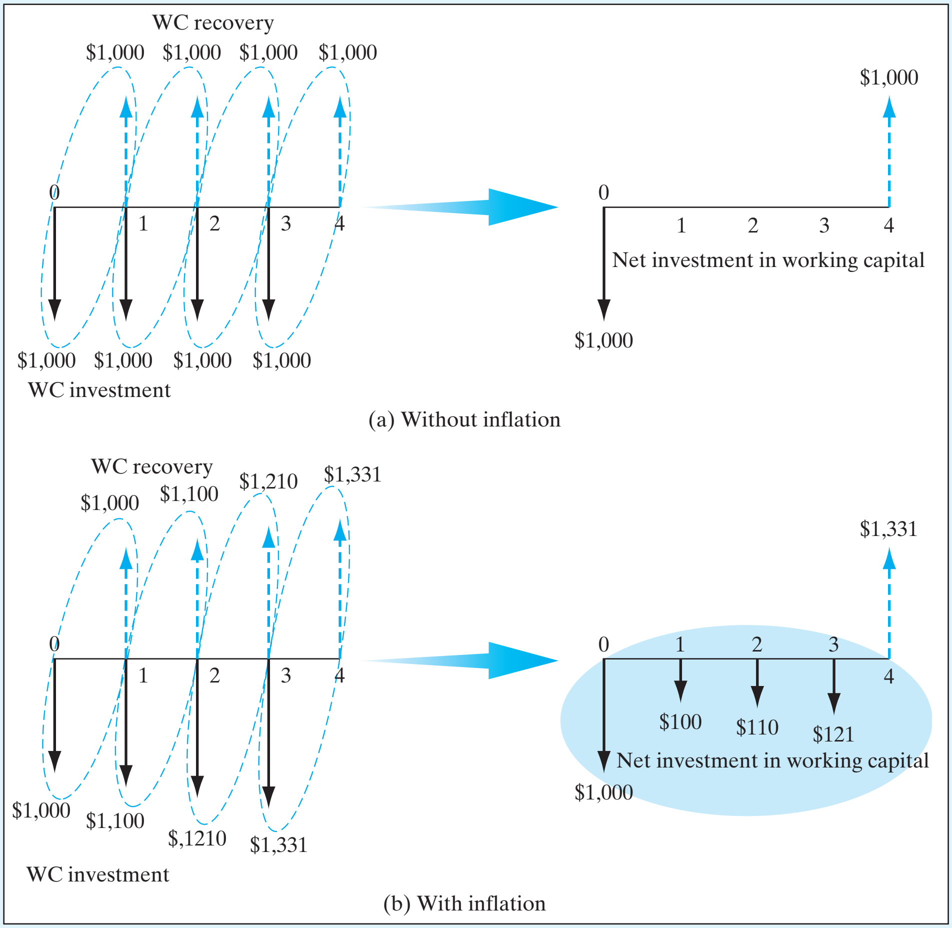


Figure 11.4 Working-capital requirements under inflation: (a) Requirements without inflation and (b) requirements with inflation, assuming a one-year recovery cycle.

SUMMARY

- The **Consumer Price Index (CPI)** is a statistical measure of change, over time, of the prices of goods and services in major expenditure groups—such as food, housing, apparel, transportation, and medical care—typically purchased by urban consumers. Essentially, the CPI compares the cost of a sample "market basket" of goods and services in a specific period with the cost of the same "market basket" in an earlier reference period, designated the **base period**.
- **Inflation** is the term used to describe a **decline in purchasing power** evidenced in an economic environment of rising prices.
- **Deflation** is the opposite: an increase in purchasing power evidenced by falling prices.
- The **general inflation rate** $\bar{f}$ is an average inflation rate based on the CPI. An annual general inflation rate $\bar{f}_j$ can be calculated with the following equation:

$$\bar{f}_n = \frac{\text{CPI}_n - \text{CPI}_{n-1}}{\text{CPI}_{n-1}}.$$

- Specific, individual commodities do not always reflect the general inflation rate in their price changes. We can calculate an **average inflation rate** $\bar{f}_j$ for a specific commodity (j) if we have an index (i.e., a record of historical costs) for that commodity.
- Project cash flows may be stated in one of two forms:

  Actual dollars (A_n): Dollars that reflect the inflation or deflation rate.

  Constant dollars (A'_n): Year-0 dollars.
- Interest rates used in evaluating a project may be stated in one of two forms:

  Market interest rate (i): A rate that combines the effects of interest and inflation; used with **actual-dollar** analysis.

  Inflation-free interest rate (i'): A rate from which the effects of inflation have been removed; this rate is used with constant-dollar analysis.
- To calculate the present worth of actual dollars, we can use a two-step or a one-step process:

  Deflation method—two steps:

  1. Convert actual dollars by deflating with the general inflation rate $\bar{f}$.

  2. Calculate the PW of constant dollars by discounting at i'.

  Adjusted-discount method—one step (use the market interest rate):

$$P_n = \frac{A_n}{((1 + \bar{f})(1 + i'))^n} = \frac{A_n}{(1 + i)^n}.$$

- A number of individual elements of project evaluations can be distorted by inflation. These elements are summarized in Table 11.8.

TABLE 11.8 **Effects of Inflation on Project Cash Flows and Return**

Item	Effects of Inflation
Depreciation expense	Depreciation expense is charged to taxable income in dollars of declining values; taxable income is overstated, resulting in higher taxes.
Salvage values	Inflated salvage values combined with book values based on historical costs result in higher taxable gains.
Loan repayments	Borrowers repay historical loan amounts with dollars of decreased purchasing power, reducing the cost of financing debt.
Working capital requirement	Known as a *working capital drain*, the cost of working capital increases in an inflationary economy.
Rate of return and NPW	Unless revenues are sufficiently increased to keep pace with inflation, tax effects and a working-capital drain result in a lower rate of return or a lower NPW.

PROBLEMS

Note: *In the problems that follow, the term "market interest rate" represents the "inflation-adjusted MARR" for project evaluation or the "interest rate" quoted by a financial institution for commercial loans.*

Measure of Inflation

11.1 The following data indicate the median price of unleaded gasoline during the last 10 years for California residents:

Period	Price ($)
1996	$1.10
2005	$2.62

Assuming that the base period (price index = 100) is 1996, compute the average price index for the unleaded gasoline price for the year 2005.

11.2 The following data indicate the price indexes of lumber (base period 1982 = 100) during the last five years:

Period	Price (cents)
1996	150.6
1997	155.1
1998	158.3
1999	161.8
2000	165.8
2005	?

(a) Assuming that the base period (price index = 100) is reset to the year 1996, compute the average price index for lumber between 1996 and 2000.

(b) If the past trend is expected to continue, how would you estimate the lumber product in 2005?

11.3 For prices that are increasing at an annual rate of 5% the first year and 8% the second year, determine the average inflation rate ($\bar{f}$) over the two years.

11.4 Because of general price inflation in our economy, the purchasing power of the dollar shrinks with the passage of time. If the average general inflation rate is expected to be 7% per year for the foreseeable future, how many years will it take for the dollar's purchasing power to be one-half of what it is now?

Actual versus Constant Dollars

11.5 An annuity provides for 10 consecutive end-of-year payments of $4,500. The average general inflation rate is estimated to be 5% annually, and the market interest rate is 12% annually. What is the annuity worth in terms of a single equivalent amount of today's dollars?

11.6 A company is considering buying workstation computers to support its engineering staff. In today's dollars, it is estimated that the maintenance costs for the computers (paid at the end of each year) will be $25,000, $30,000, $32,000, $35,000, and $40,000 for years 1 to 5, respectively. The general inflation rate $(\bar{f})$ is estimated to be 8% per year, and the company will receive 15% per year on its invested funds during the inflationary period. The company wants to pay for maintenance expenses in equivalent equal payments (in actual dollars) at the end of each of the five years. Find the amount of the company's payments.

11.7 The following cash flows are in actual dollars:

n	Cash Flow (in actual $)
0	$1,500
4	2,500
5	3,500
7	4,500

Convert to an equivalent cash flow in constant dollars if the base year is time 0. Keep cash flows at the same point in time—that is, years 0, 4, 5, and 7. Assume that the market interest rate is 16% and that the general inflation rate $(\bar{f})$ is 4% per year.

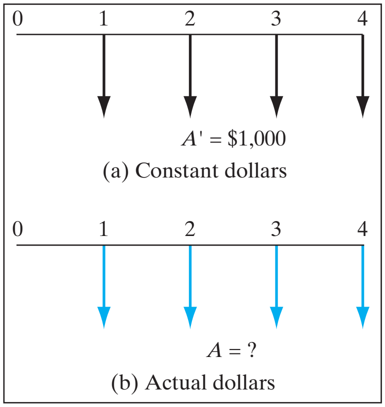
11.8 The purchase of a car requires a $25,000 loan to be repaid in monthly installments for four years at 12% interest compounded monthly. If the general inflation rate is 6% compounded monthly, find the actual- and constant-dollar value of the 20th payment.

11.9 A series of four annual constant-dollar payments beginning with $7,000 at the end of the first year is growing at the rate of 8% per year. (Assume that the base year is the current year $(n = 0)$.) If the market interest rate is 13% per year and the general inflation rate $(\bar{f})$ is 7% per year, find the present worth of this series of payments, based on

(a) constant-dollar analysis.

(b) actual-dollar analysis.

11.10 Consider the accompanying cash flow diagrams, where the equal payment cash flow in constant dollars (a) is converted from the equal payment cash flow in actual dollars (b) at an annual general inflation rate of $\bar{f} = 3.8\%$ and $i = 9\%$. What is the amount A in actual dollars equivalent to $A' = \$1{,}000$ in constant dollars?



11.11 A 10-year $1,000 bond pays a nominal rate of 9% compounded semiannually. If the market interest rate is 12% compounded annually and the general inflation rate is 6% per year, find the actual- and constant-dollar amount (in time-0 dollars) of the 16th interest payment on the bond.

Equivalence Calculation under Inflation

11.12 Suppose that you borrow $20,000 at 12% compounded monthly over five years. Knowing that the 12% represents the market interest rate, you realize that the monthly payment in actual dollars will be $444.90. If the average monthly general inflation rate is expected to be 0.5%, determine the equivalent equal monthly payment series in constant dollars.

11.13 The annual fuel costs required to operate a small solid-waste treatment plant are projected to be $1.5 million, without considering any future inflation. The best estimates indicate that the annual inflation-free interest rate (i') will be 6% and the general inflation rate $(\bar{f})$ will be 5%. If the plant has a remaining useful life of five years, what is the present equivalent of its fuel costs? Use actual-dollar analysis.

11.14 Suppose that you just purchased a used car worth $6,000 in today's dollars. Suppose also that you borrowed $5,000 from a local bank at 9% compounded monthly over two years. The bank calculated your monthly payment at $228. Assuming that average general inflation will run at 0.5% per month over the next two years,

(a) Determine the annual inflation-free interest rate (i') for the bank.

(b) What equal monthly payments, in terms of constant dollars over the next two years, are equivalent to the series of actual payments to be made over the life of the loan?

11.15 A man is planning to retire in 20 years. Money can be deposited at 6% compounded monthly, and it is also estimated that the future general inflation $(\bar{f})$ rate will be 5% compounded annually. What monthly deposit must be made each month until the man retires so that he can make annual withdrawals of $40,000 in terms of today's dollars over the 15 years following his retirement? (Assume that his first withdrawal occurs at the end of the first six months after his retirement.)

11.16 On her 23rd birthday, a young woman engineer decides to start saving toward building up a retirement fund that pays 8% interest compounded quarterly (the market interest rate). She feels that \$600,000 worth of purchasing power in today's dollars will be adequate to see her through her sunset years after her 63rd birthday. Assume a general inflation rate of 6% per year.

(a) If she plans to save by making 160 equal quarterly deposits, what should be the amount of her quarterly deposit in actual dollars?

(b) If she plans to save by making end-of-the-year deposits, increasing by \$1,000 over each subsequent year, how much would her first deposit be in actual dollars?

11.17 A father wants to save for his 8-year-old son's college expenses. The son will enter college 10 years from now. An annual amount of \$40,000 in constant dollars will be required to support the son's college expenses for 4 years. Assume that these college payments will be made at the beginning of the school year. The future general inflation rate is estimated to be 6% per year, and the market interest rate on the savings account will average 8% compounded annually. Given this information,

(a) What is the amount of the son's freshman-year expense in terms of actual dollars?

(b) What is the equivalent single-sum amount at the present time for these college expenses?

(c) What is the equal amount, in actual dollars, the father must save each year until his son goes to college?

Effects of Inflation on Project Cash Flows

11.18 Consider the following project's after-tax cash flow and the expected annual general inflation rate during the project period:

	Expected	
End of Year	Cash Flow (in actual \$)	General Inflation Rate
0	−\$45,000	
1	26,000	6.5%
2	26,000	7.7
3	26,000	8.1

(a) Determine the average annual general inflation rate over the project period.

(b) Convert the cash flows in actual dollars into equivalent constant dollars with the base year 0.

(c) If the annual inflation-free interest rate is 5%, what is the present worth of the cash flow? Is this project acceptable?

11.19 Gentry Machines, Inc., has just received a special job order from one of its clients. The following financial data have been collected:

- This two-year project requires the purchase of special-purpose equipment for \$55,000. The equipment falls into the MACRS five-year class.
- The machine will be sold for \$27,000 (today's dollars) at the end of two years.

- The project will bring in additional annual revenue of $114,000 (actual dollars), but it is expected to incur an additional annual operating cost of $53,800 (today's dollars).
- The project requires an investment in working capital in the amount of $12,000 at $n = 0$. In each subsequent year, additional working capital needs to be provided at the general inflation rate. Any investment in working capital will be recovered after the project is terminated.
- To purchase the equipment, the firm expects to borrow $50,000 at 10% over a two-year period. The remaining $5,000 will be taken from the firm's retained earnings. The firm will make equal annual payments of $28,810 (actual dollars) to pay off the loan.
- The firm expects a general inflation of 5% per year during the project period. The firm's marginal tax rate is 40%, and its market interest rate is 18%.

(a) Compute the after-tax cash flows in actual dollars.

(b) What is the equivalent present value of this amount at time 0?

11.20 Hugh Health Product Corporation is considering purchasing a computer to control plant packaging for a spectrum of health products. The following data have been collected:

- First cost = $120,000, to be borrowed at 9% interest, with only interest paid each year and the principal due in a lump sum at end of year 2.
- Economic service life (project life) = 6 years.
- Estimated selling price in year-0 dollars = $15,000.
- Depreciation = Five-year MACRS property.
- Marginal income tax rate = 40% (remains constant).
- Annual revenue = $145,000 (today's dollars).
- Annual expense (not including depreciation and interest) = $82,000 (today's dollars).
- Market interest rate = 18%.

(a) With an average general inflation rate of 5% expected during the project period (which will affect all revenues, expenses, and the salvage value of the computer), determine the cash flows in actual dollars.

(b) Compute the net present value of the project under inflation.

(c) Compute the net present-value loss (gain) due to inflation.

(d) In (c), how much is the present-value loss (or gain) due to borrowing?

11.21 Norcross Textile Company is considering automating its piece-goods screen printing system at a cost of $20,000. The firm expects to phase out the new printing system at the end of five years due to changes in style. At that time, the firm could scrap the system for $2,000 in today's dollars. The expected net savings due to automation also are in today's dollars (constant dollars) as follows:

End of Year	Cash Flow (in constant $)
1	$15,000
2	17,000
3–5	14,000

The system qualifies as a five-year MACRS property and will be depreciated accordingly. The expected average general inflation rate over the next five years is approximately 5% per year. The firm will finance the entire project by borrowing at 10%. The scheduled repayment of the loan will be as follows:

End of Year	Principal Payment	Interest Payment
1	$6,042	$2,000
2	6,647	3,396
3	7,311	731

The firm's market interest rate for project evaluation during this inflation-ridden time is 20%. Assume that the net savings and the selling price will be responsive to this average inflation rate. The firm's marginal tax rate is known to be 40%.

(a) Determine the after-tax cash flows of this project, in actual dollars.

(b) Determine the net present-value reduction (or gains) in profitability due to inflation.

11.22 The J. F. Manning Metal Co. is considering the purchase of a new milling machine during year 0. The machine's base price is $135,000, and it will cost another $15,000 to modify it for special use. This results in a $150,000 cost base for depreciation. The machine falls into the MACRS seven-year property class. The machine will be sold after three years for $80,000 (actual dollars). Use of the machine will require an increase in net working capital (inventory) of $10,000 at the beginning of the project year. The machine will have no effect on revenues, but it is expected to save the firm $80,000 (today's dollars) per year in before-tax operating costs, mainly for labor. The firm's marginal tax rate is 40%, and this rate is expected to remain unchanged over the duration of the project. However, the company expects that the labor cost will increase at an annual rate of 5%, but that the working-capital requirement will grow at an annual rate of 8%, caused by inflation. The selling price of the milling machine is not affected by inflation. The general inflation rate is estimated to be 6% per year over the project period. The firm's market interest rate is 20%.

(a) Determine the project cash flows in actual dollars.

(b) Determine the project cash flows in constant (time-0) dollars.

(c) Is this project acceptable?

Rate of Return Analysis under Inflation

11.23 Fuller Ford Company is considering purchasing a vertical drill machine. The machine will cost $50,000 and will have an eight-year service life. The selling price of the machine at the end of eight years is expected to be $5,000 in today's dollars. The machine will generate annual revenues of $20,000 (today's dollars), but the company expects to have an annual expense (excluding depreciation) of $8,000 (today's dollars). The asset is classified as a seven-year MACRS property. The project requires a working-capital investment of $10,000 at year 0. The marginal income tax rate for the firm is averaging 35%. The firm's market interest rate is 18%.

(a) Determine the internal rate of return of this investment.

(b) Assume that the firm expects a general inflation rate of 5%, but that it also expects an 8% annual increase in revenue and working capital and a 6% annual increase in expense caused by inflation. Compute the real (inflation-free) internal rate of return. Is this project acceptable?

11.24 Sonja Jensen is considering the purchase of a fast-food franchise. Sonja will be operating on a lot that is to be converted into a parking lot in six years, but that may be rented in the interim for $800 per month. The franchise and necessary equipment will have a total initial cost of $55,000 and a salvage value of $10,000 (in today's dollars) after six years. Sonja is told that the future annual general inflation rate will be 5%. The projected operating revenues and expenses, in actual dollars, other than rent and depreciation for the business, are as follows:

End of Year	Revenue	Expenses
1	$30,000	$15,000
2	35,000	21,000
3	55,000	25,000
4	70,000	30,000
5	70,000	30,000
6	60,000	30,000

Assume that the initial investment will be depreciated under the five-year MACRS and that Sonja's tax rate will be 30%. Sonja can invest her money at a rate of least 10% in other investment activities during this inflation-ridden period.

(a) Determine the cash flows associated with the investment over its life.

(b) Compute the projected after-tax rate of return (real) for this investment opportunity.

11.25 Suppose you have $10,000 cash that you want to invest. Normally, you would deposit the money in a savings account that pays an annual interest rate of 6%. However, you are now considering the possibility of investing in a bond. Your alternatives are either a nontaxable municipal bond paying 9% or a taxable corporate bond paying 12%. Your marginal tax rate is 30% for both ordinary income and capital gains. You expect the general inflation to be 3% during the investment period. You can buy a high-grade municipal bond costing $10,000 and that pays interest of 9% ($900) per year. This interest is not taxable. A comparable high-grade corporate bond is also available that is just as safe as the municipal bond, but that pays an interest rate of 12% ($1,200) per year. This interest is taxable as ordinary income. Both bonds mature at the end of year 5.

(a) Determine the real (inflation-free) rate of return for each bond.

(b) Without knowing your MARR, can you make a choice between these two bonds?

11.26 Air Florida is considering two types of engines for use in its planes. Each engine has the same life, the same maintenance, and the same repair record.

- Engine A costs $100,000 and uses 50,000 gallons of fuel per 1,000 hours of operation at the average service load encountered in passenger service.
- Engine B costs $200,000 and uses 32,000 gallons of fuel per 1,000 hours of operation at the same service load.

Both engines are estimated to have 10,000 service hours before any major overhaul of the engines is required. If fuel currently costs $1.25 per gallon, and its price is expected to increase at the rate of 8% because of inflation, which engine should the firm install for an expected 2,000 hours of operation per year? The firm's marginal income tax rate is 40%, and the engine will be depreciated on the basis of the unit-of-production method. Assume that the firm's market interest rate is 20%. It is estimated that both engines will retain a market value of 40% of their initial cost (actual dollars) if they are sold on the market after 10,000 hours of operation.

(a) Using the present-worth criterion, which project would you select?
(b) Using the annual-equivalent criterion, which project would you select?
(c) Using the future-worth criterion, which project would you select?

11.27 Johnson Chemical Company has just received a special subcontracting job from one of its clients. The two-year project requires the purchase of a special-purpose painting sprayer of $60,000. This equipment falls into the MACRS five-year class. After the subcontracting work is completed, the painting sprayer will be sold at the end of two years for $40,000 (actual dollars). The painting system will require an increase of $5,000 in net working capital (for spare-parts inventory, such as spray nozzles). This investment in working capital will be fully recovered after the project is terminated. The project will bring in an additional annual revenue of $120,000 (today's dollars), but it is expected to incur an additional annual operating cost of $60,000 (today's dollars). It is projected that, due to inflation, sales prices will increase at an annual rate of 5%. (This implies that annual revenues will increase at an annual rate of 5%.) An annual increase of 4% for expenses and working-capital requirement is expected. The company has a marginal tax rate of 30%, and it uses a market interest rate of 15% for project evaluation during the inflationary period. If the firm expects a general inflation of 8% during the project period,

(a) Compute the after-tax cash flows in actual dollars.
(b) What is the rate of return on this investment (real earnings)?
(c) Is the special subcontracting project profitable?

11.28 Land Development Corporation is considering purchasing a bulldozer. The bulldozer will cost $100,000 and will have an estimated salvage value of $30,000 at the end of six years. The asset will generate annual before-tax revenues of $80,000 over the next six years. The asset is classified as a five-year MACRS property. The marginal tax rate is 40%, and the firm's market interest rate is known to be 18%. All dollar figures represent constant dollars at time 0 and are responsive to the general inflation rate $\bar{f}$.

(a) With $\bar{f} = 6\%$, compute the after-tax cash flows in actual dollars.
(b) Determine the real rate of return of this project on an after-tax basis.
(c) Suppose that the initial cost of the project will be financed through a local bank at an interest rate of 12%, with an annual payment of $24,323 over six years. With this additional condition, answer part (a) again.

(d) In part (a), determine the present-value loss due to inflation.

(e) In part (c), determine how much the project has to generate in additional before-tax annual revenue in actual dollars (equal amount) to make up the loss due to inflation.

Short Case Studies

ST11.1 Wilson Machine Tools, Inc., a manufacturer of fabricated metal products, is considering purchasing a high-tech computer-controlled milling machine at a cost of \$95,000. The cost of installing the machine, preparing the site, wiring, and rearranging other equipment is expected to be \$15,000. This installation cost will be added to the cost of the machine to determine the total cost basis for depreciation. Special jigs and tool dies for the particular product will also be required at a cost of \$10,000. The milling machine is expected to last 10 years, the jigs and dies only 5 years. Therefore, another set of jigs and dies has to be purchased at the end of 5 years. The milling machine will have a \$10,000 salvage value at the end of its life, and the special jigs and dies are worth only \$300 as scrap metal at any time in their lives. The machine is classified as a 7-year MACRS property, and the special jigs and dies are classified as a 3-year MACRS property. With the new milling machine, Wilson expects an additional annual revenue of \$80,000 due to increased production. The additional annual production costs are estimated as follows: materials, \$9,000; labor, \$15,000; energy, \$4,500; and miscellaneous O&M costs, \$3,000. Wilson's marginal income tax rate is expected to remain at 35% over the project life of 10 years. All dollar figures represent today's dollars. The firm's market interest rate is 18%, and the expected general inflation rate during the project period is estimated at 6%.

(a) Determine the project cash flows in the absence of inflation.

(b) Determine the internal rate of return for the project in (a).

(c) Suppose that Wilson expects price increases during the project period: material at 4% per year, labor at 5% per year, and energy and other O&M costs at 3% per year. To compensate for these increases in prices, Wilson is planning to increase annual revenue at the rate of 7% per year by charging its customers a higher price. No changes in salvage value are expected for the machine or the jigs and dies. Determine the project cash flows in actual dollars.

(d) In (c), determine the real (inflation-free) rate of return of the project.

(e) Determine the economic loss (or gain) in present worth caused by inflation.

ST11.2 Recent biotechnological research has made possible the development of a sensing device that implants living cells on a silicon chip. The chip is capable of detecting physical and chemical changes in cell processes. Proposed uses of the device include researching the mechanisms of disease on a cellular level, developing new therapeutic drugs, and substituting for animals in cosmetic and drug testing. Biotech Device Corporation (BDC) has just perfected a process for mass-producing the chip. The following information has been compiled for the board of directors:

- BDC's marketing department plans to target sales of the device to the larger chemical and drug manufacturers. BDC estimates that annual sales would be 2,000 units if the device were priced at \$95,000 per unit (in dollars of the first operating year).

- To support this level of sales volume, BDC would need a new manufacturing plant. Once the "go" decision is made, this plant could be built and made ready for production within 1 year. BDC would need a 30-acre tract of land that would cost \$1.5 million. If the decision were to be made, the land could be purchased on December 31, 2006. The building would cost \$5 million and would be depreciated according to the MACRS 39-year class. The first payment of \$1 million would be due to the contractor on December 31, 2007, and the remaining \$4 million on December 31, 2008.
- The required manufacturing equipment would be installed late in 2008 and would be paid for on December 31, 2008. BDC would have to purchase the equipment at an estimated cost of \$8 million, including transportation, plus a further \$500,000 for installation. The equipment would fall into the MACRS 7-year class.
- The project would require an initial investment of \$1 million in working capital. This investment would be made on December 31, 2008. Then, on December 31 of each subsequent year, net working capital would be increased by an amount equal to 15% of any sales increase expected during the coming year. The investments in working capital would be fully recovered at the end of the project year.
- The project's estimated economic life is 6 years (excluding the 2-year construction period). At that time, the land is expected to have a market value of \$2 million, the building a value of \$3 million, and the equipment a value of \$1.5 million. The estimated variable manufacturing costs would total 60% of the dollar sales. Fixed costs, excluding depreciation, would be \$5 million for the first year of operations. Since the plant would begin operations on January 1, 2009, the first operating cash flows would occur on December 31, 2009.
- Sales prices and fixed overhead costs, other than depreciation, are projected to increase with general inflation, which is expected to average 5 percent per year over the 6-year life of the project.
- To date, BDC has spent \$5.5 million on research and development (R&D) associated with cell implantation. The company has already expensed \$4 million R&D costs. The remaining \$1.5 million will be amortized over 6 years (i.e., the annual amortization expense will be \$250,000). If BDC decides not to proceed with the project, the \$1.5 million R&D cost could be written off on December 31, 2006.
- BDC's marginal tax rate is 40%, and its market interest rate is 20%. Any capital gains will also be taxed at 40%.

  (a) Determine the after-tax cash flows of the project, in actual dollars.

  (b) Determine the inflation-free (real) IRR of the investment.

  (c) Would you recommend that the firm accept the project?