

a large number of NPV estimates that we summarize by calculating the average value and some measure of how spread out the different possibilities are. For example, it would be of some interest to know what percentage of the possible scenarios result in negative estimated NPVs.

Because simulation analysis (or simulation) is an extended form of scenario analysis, it has the same problems. Once we have the results, there is no simple decision rule that tells us what to do. Also, we have described a relatively simple form of simulation. To really do it right, we would have to consider the interrelationships between the different cash flow components. Furthermore, we assumed that the possible values were equally likely to occur. It is probably more realistic to assume that values near the base case are more likely than extreme values, but coming up with the probabilities is difficult, to say the least.

For these reasons, the use of simulation is somewhat limited in practice. However, recent advances in computer software and hardware (and user sophistication) lead us to believe it may become more common in the future, particularly for large-scale projects.

CONCEPT QUESTIONS

11.2a What are scenario, sensitivity, and simulation analysis?

11.2b What are the drawbacks to the various types of what-if analysis?

11.3

BREAK-EVEN ANALYSIS

It will frequently turn out that the crucial variable for a project is sales volume. If we are thinking of a new product or entering a new market, for example, the hardest thing to forecast accurately is how much we can sell. For this reason, sales volume is usually analyzed more closely than other variables.

Break-even analysis is a popular and commonly used tool for analyzing the relationship between sales volume and profitability. There are a variety of different break-even measures, and we have already seen several types. For example, we discussed (in Chapter 9) how the payback period can be interpreted as the length of time until a project breaks even, ignoring time value.

All break-even measures have a similar goal. Loosely speaking, we will always be asking: “How bad do sales have to get before we actually begin to lose money?” Implicitly, we will also be asking: “Is it likely that things will get that bad?” To get started on this subject, we first discuss fixed and variable costs.

Fixed and Variable Costs

In discussing break-even, the difference between fixed and variable costs becomes very important. As a result, we need to be a little more explicit about the difference than we have been so far.

variable costs

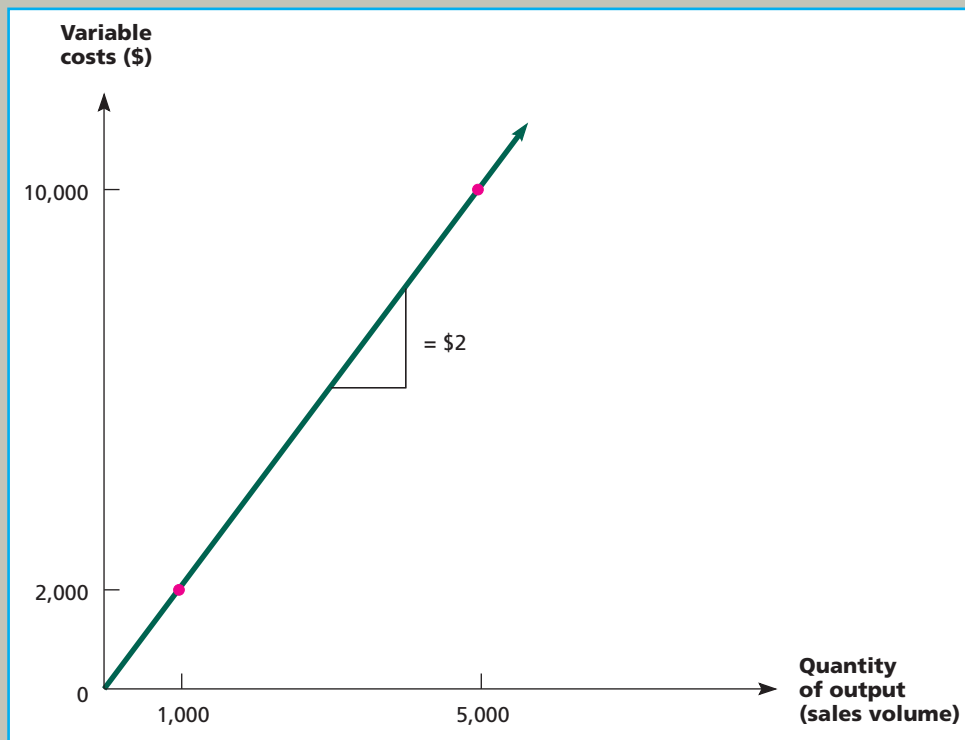
Costs that change when the quantity of output changes.

Variable Costs By definition, **variable costs** change as the quantity of output changes, and they are zero when production is zero. For example, direct labor costs and raw material costs are usually considered variable. This makes sense because if we shut down operations tomorrow, there will be no future costs for labor or raw materials.

We will assume that variable costs are a constant amount per unit of output. This simply means that total variable cost is equal to the cost per unit multiplied by the number

Output Level and Variable Costs

FIGURE 11.2



of units. In other words, the relationship between total variable cost (VC), cost per unit of output (v), and total quantity of output (Q) can be written simply as:

Total variable cost = Total quantity of output \times Cost per unit of output

$$VC = Q \times v$$

For example, suppose variable costs (v) are \$2 per unit. If total output (Q) is 1,000 units, what will total variable costs (VC) be?

$$\begin{aligned} VC &= Q \times v \\ &= 1,000 \times \$2 \\ &= \$2,000 \end{aligned}$$

Similarly, if Q is 5,000 units, then VC will be $5,000 \times \$2 = \$10,000$. Figure 11.2 illustrates the relationship between output level and variable costs in this case. In Figure 11.2, notice that increasing output by one unit results in variable costs rising by \$2, so “the rise over the run” (the slope of the line) is given by $\$2/1 = \2 .

Variable Costs

The Blume Corporation is a manufacturer of pencils. It has received an order for 5,000 pencils, and the company has to decide whether or not to accept the order. From recent experience, the

EXAMPLE 11.1

company knows that each pencil requires 5 cents in raw materials and 50 cents in direct labor costs. These variable costs are expected to continue to apply in the future. What will Blume's total variable costs be if it accepts the order?

In this case, the cost per unit is 50 cents in labor plus 5 cents in material for a total of 55 cents per unit. At 5,000 units of output, we have:

$$\begin{aligned} VC &= Q \times v \\ &= 5,000 \times \$0.55 \\ &= \$2,750 \end{aligned}$$

Therefore, total variable costs will be \$2,750.

fixed costs

Costs that do not change when the quantity of output changes during a particular time period.

Fixed Costs **Fixed costs**, by definition, do not change during a specified time period. So, unlike variable costs, they do not depend on the amount of goods or services produced during a period (at least within some range of production). For example, the lease payment on a production facility and the company president's salary are fixed costs, at least over some period.

Naturally, fixed costs are not fixed forever. They are only fixed during some particular time, say, a quarter or a year. Beyond that time, leases can be terminated and executives "retired." More to the point, any fixed cost can be modified or eliminated given enough time; so, in the long run, all costs are variable.

Notice that during the time that a cost is fixed, that cost is effectively a sunk cost because we are going to have to pay it no matter what.

Total Costs Total costs (TC) for a given level of output are the sum of variable costs (VC) and fixed costs (FC):

$$\begin{aligned} TC &= VC + FC \\ &= v \times Q + FC \end{aligned}$$

So, for example, if we have variable costs of \$3 per unit and fixed costs of \$8,000 per year, our total cost is:

$$TC = \$3 \times Q + 8,000$$

If we produce 6,000 units, our total production cost will be $\$3 \times 6,000 + 8,000 = \$26,000$. At other production levels, we have:

Quantity Produced	Total Variable Costs	Fixed Costs	Total Costs
0	\$ 0	\$8,000	\$ 8,000
1,000	3,000	8,000	11,000
5,000	15,000	8,000	23,000
10,000	30,000	8,000	38,000

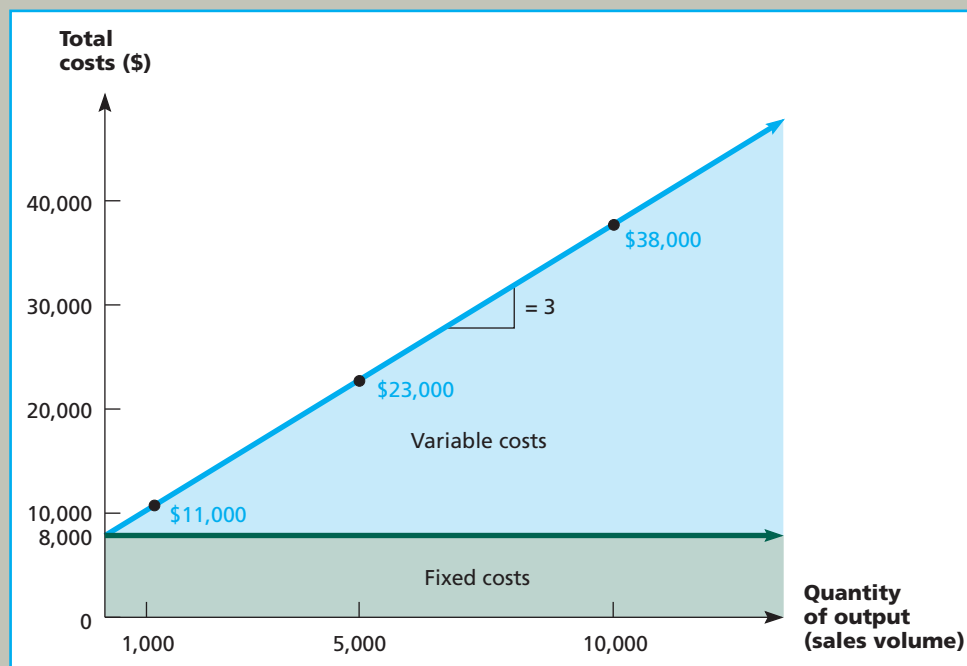
marginal, or incremental, cost

The change in costs that occurs when there is a small change in output.

By plotting these points in Figure 11.3, we see that the relationship between quantity produced and total costs is given by a straight line. In Figure 11.3, notice that total costs are equal to fixed costs when sales are zero. Beyond that point, every one-unit increase in production leads to a \$3 increase in total costs, so the slope of the line is 3. In other words, the **marginal**, or **incremental, cost** of producing one more unit is \$3.

Output Level and Total Costs

FIGURE 11.3



Average Cost versus Marginal Cost

Suppose the Blume Corporation has a variable cost per pencil of 55 cents. The lease payment on the production facility runs \$5,000 per month. If Blume produces 100,000 pencils per year, what are the total costs of production? What is the average cost per pencil?

The fixed costs are \$5,000 per month, or \$60,000 per year. The variable cost is \$.55 per pencil. So the total cost for the year, assuming that Blume produces 100,000 pencils, is:

$$\begin{aligned}
 \text{Total cost} &= v \times Q + FC \\
 &= \$0.55 \times 100,000 + 60,000 \\
 &= \$115,000
 \end{aligned}$$

The average cost per pencil is $\$115,000 / 100,000 = \1.15 .

Now suppose that Blume has received a special, one-shot order for 5,000 pencils. Blume has sufficient capacity to manufacture the 5,000 pencils on top of the 100,000 already produced, so no additional fixed costs will be incurred. Also, there will be no effect on existing orders. If Blume can get 75 cents per pencil for this order, should the order be accepted?

What this boils down to is a very simple proposition. It costs 55 cents to make another pencil. Anything Blume can get for this pencil in excess of the 55-cent incremental cost contributes in a positive way towards covering fixed costs. The 75-cent **marginal, or incremental, revenue** exceeds the 55-cent marginal cost, so Blume should take the order.

The fixed cost of \$60,000 is not relevant to this decision because it is effectively sunk, at least for the current period. In the same way, the fact that the average cost is \$1.15 is irrelevant

EXAMPLE 11.2

marginal, or incremental, revenue

The change in revenue that occurs when there is a small change in output.

because this average reflects the fixed cost. As long as producing the extra 5,000 pencils truly does not cost anything beyond the 55 cents per pencil, then Blume should accept anything over that 55 cents.

Accounting Break-Even

accounting break-even

The sales level that results in zero project net income.

The most widely used measure of break-even is **accounting break-even**. The accounting break-even point is simply the sales level that results in a zero project net income.

To determine a project's accounting break-even, we start off with some common sense. Suppose we retail one-terabyte computer diskettes for \$5 apiece. We can buy diskettes from a wholesale supplier for \$3 apiece. We have accounting expenses of \$600 in fixed costs and \$300 in depreciation. How many diskettes do we have to sell to break even, that is, for net income to be zero?

For every diskette we sell, we pick up $\$5 - \$3 = \$2$ towards covering our other expenses (this \$2 difference between the selling price and the variable cost is often called the *contribution margin per unit*). We have to cover a total of $\$600 + \$300 = \$900$ in accounting expenses, so we obviously need to sell $\$900 / \$2 = 450$ diskettes. We can check this by noting that, at a sales level of 450 units, our revenues are $\$5 \times 450 = \$2,250$ and our variable costs are $\$3 \times 450 = \$1,350$. The income statement is thus:

Sales	\$2,250
Variable costs	1,350
Fixed costs	600
Depreciation	300
EBIT	\$ 0
Taxes (34%)	0
Net income	\$ 0

Remember, because we are discussing a proposed new project, we do not consider any interest expense in calculating net income or cash flow from the project. Also, notice that we include depreciation in calculating expenses here, even though depreciation is not a cash outflow. That is why we call it an accounting break-even. Finally, notice that when net income is zero, so are pretax income and, of course, taxes. In accounting terms, our revenues are equal to our costs, so there is no profit to tax.

Figure 11.4 presents another way to see what is happening. This figure looks a lot like Figure 11.3 except that we add a line for revenues. As indicated, total revenues are zero when output is zero. Beyond that, each unit sold brings in another \$5, so the slope of the revenue line is 5.

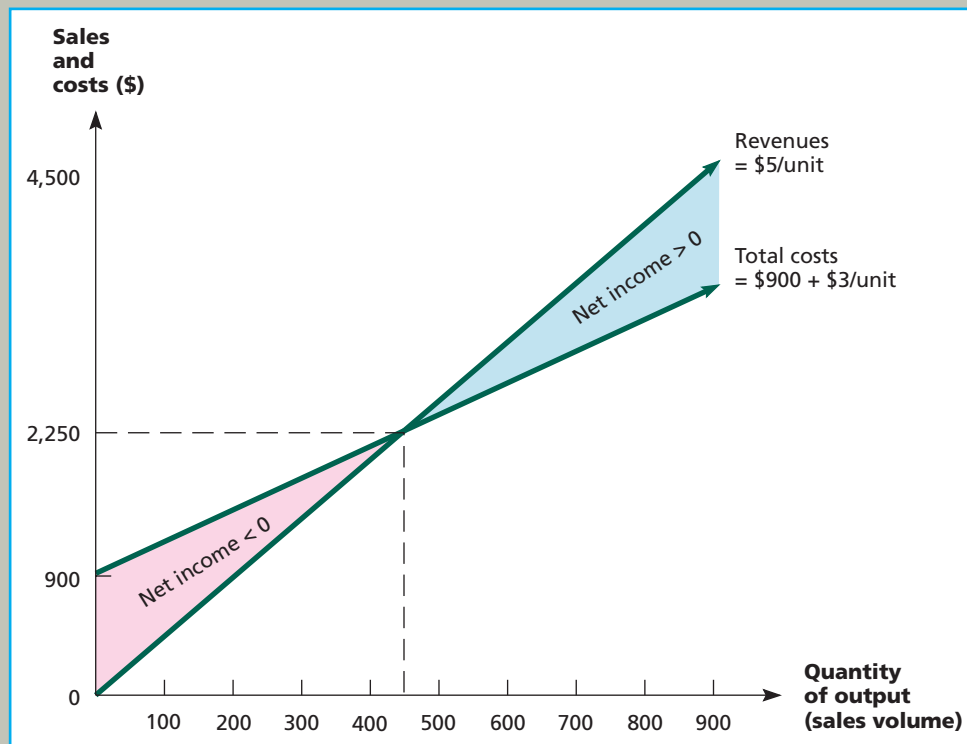
From our preceding discussion, we know that we break even when revenues are equal to total costs. The line for revenues and the line for total costs cross right where output is at 450 units. As illustrated, at any level of output below 450, our accounting profit is negative, and, at any level above 450, we have a positive net income.

Accounting Break-Even: A Closer Look

In our numerical example, notice that the break-even level is equal to the sum of fixed costs and depreciation, divided by price per unit less variable costs per unit. This is always true. To see why, we recall all of the following variables:

Accounting Break-Even

FIGURE 11.4



P = Selling price per unit

v = Variable cost per unit

Q = Total units sold

S = Total sales = $P \times Q$

VC = Total variable costs = $v \times Q$

FC = Fixed costs

D = Depreciation

T = Tax rate

Project net income is given by:

$$\begin{aligned}\text{Net income} &= (\text{Sales} - \text{Variable costs} - \text{Fixed costs} - \text{Depreciation}) \times (1 - T) \\ &= (S - VC - FC - D) \times (1 - T)\end{aligned}$$

From here, it is not difficult to calculate the break-even point. If we set this net income equal to zero, we get:

$$\text{Net income} \stackrel{\text{set}}{=} 0 = (S - VC - FC - D) \times (1 - T)$$

Divide both sides by $(1 - T)$ to get:

$$S - VC - FC - D = 0$$

As we have seen, this says that when net income is zero, so is pretax income. If we recall that $S = P \times Q$ and $VC = v \times Q$, then we can rearrange the equation to solve for the break-even level:

$$\begin{aligned} S - VC &= FC + D \\ P \times Q - v \times Q &= FC + D \\ (P - v) \times Q &= FC + D \\ Q &= (FC + D)/(P - v) \end{aligned} \quad [11.1]$$

This is the same result we described earlier.

Uses for the Accounting Break-Even

Why would anyone be interested in knowing the accounting break-even point? To illustrate how it can be useful, suppose we are a small specialty ice cream manufacturer with a strictly local distribution. We are thinking about expanding into new markets. Based on the estimated cash flows, we find that the expansion has a positive NPV.

Going back to our discussion of forecasting risk, we know that it is likely that what will make or break our expansion is sales volume. The reason is that, in this case at least, we probably have a fairly good idea of what we can charge for the ice cream. Further, we know relevant production and distribution costs with a fair degree of accuracy because we are already in the business. What we do not know with any real precision is how much ice cream we can sell.

Given the costs and selling price, however, we can immediately calculate the break-even point. Once we have done so, we might find that we need to get 30 percent of the market just to break even. If we think that this is unlikely to occur, because, for example, we have only 10 percent of our current market, then we know our forecast is questionable and there is a real possibility that the true NPV is negative. On the other hand, we might find that we already have firm commitments from buyers for about the break-even amount, so we are almost certain we can sell more. In this case, the forecasting risk is much lower, and we have greater confidence in our estimates.

There are several other reasons why knowing the accounting break-even can be useful. First, as we will discuss in more detail later, accounting break-even and payback period are very similar measures. Like payback period, accounting break-even is relatively easy to calculate and explain.

Second, managers are often concerned with the contribution a project will make to the firm's total accounting earnings. A project that does not break even in an accounting sense actually reduces total earnings.

Third, a project that just breaks even on an accounting basis loses money in a financial or opportunity cost sense. This is true because we could have earned more by investing elsewhere. Such a project does not lose money in an out-of-pocket sense. As described in the following pages, we get back exactly what we put in. For noneconomic reasons, opportunity losses may be easier to live with than out-of-pocket losses.

CONCEPT QUESTIONS

11.3a How are fixed costs similar to sunk costs?

11.3b What is net income at the accounting break-even point? What about taxes?

11.3c Why might a financial manager be interested in the accounting break-even point?

OPERATING CASH FLOW, SALES VOLUME, AND BREAK-EVEN

11.4

Accounting break-even is one tool that is useful for project analysis. Ultimately, however, we are more interested in cash flow than accounting income. So, for example, if sales volume is the critical variable, then we need to know more about the relationship between sales volume and cash flow than just the accounting break-even.

Our goal in this section is to illustrate the relationship between operating cash flow and sales volume. We also discuss some other break-even measures. To simplify matters somewhat, we will ignore the effect of taxes. We start off by looking at the relationship between accounting break-even and cash flow.

Accounting Break-Even and Cash Flow

Now that we know how to find the accounting break-even, it is natural to wonder what happens with cash flow. To illustrate, suppose the Wettway Sailboat Corporation is considering whether or not to launch its new Margo-class sailboat. The selling price will be \$40,000 per boat. The variable costs will be about half that, or \$20,000 per boat, and fixed costs will be \$500,000 per year.

The Base Case The total investment needed to undertake the project is \$3,500,000. This amount will be depreciated straight-line to zero over the five-year life of the equipment. The salvage value is zero, and there are no working capital consequences. Wettway has a 20 percent required return on new projects.

Based on market surveys and historical experience, Wettway projects total sales for the five years at 425 boats, or about 85 boats per year. Ignoring taxes, should this project be launched?

To begin, ignoring taxes, the operating cash flow at 85 boats per year is:

$$\begin{aligned}\text{Operating cash flow} &= \text{EBIT} + \text{Depreciation} - \text{Taxes} \\ &= (S - VC - FC - D) + D - 0 \\ &= 85 \times (\$40,000 - 20,000) - 500,000 \\ &= \$1,200,000 \text{ per year}\end{aligned}$$

At 20 percent, the five-year annuity factor is 2.9906, so the NPV is:

$$\begin{aligned}\text{NPV} &= -\$3,500,000 + 1,200,000 \times 2.9906 \\ &= -\$3,500,000 + 3,588,720 \\ &= \$88,720\end{aligned}$$

In the absence of additional information, the project should be launched.

Calculating the Break-Even Level To begin looking a little closer at this project, you might ask a series of questions. For example, how many new boats does Wettway need to sell for the project to break even on an accounting basis? If Wettway does break even, what will be the annual cash flow from the project? What will be the return on the investment in this case?

Before fixed costs and depreciation are considered, Wettway generates $\$40,000 - 20,000 = \$20,000$ per boat (this is revenue less variable cost). Depreciation is $\$3,500,000/5 = \$700,000$ per year. Fixed costs and depreciation together total \$1.2 million, so Wettway needs to sell $(FC + D)/(P - v) = \$1.2 \text{ million}/20,000 = 60$ boats

per year to break even on an accounting basis. This is 25 boats less than projected sales; so, assuming that Wettway is confident its projection is accurate to within, say, 15 boats, it appears unlikely that the new investment will fail to at least break even on an accounting basis.

To calculate Wettway's cash flow in this case, we note that if 60 boats are sold, net income will be exactly zero. Recalling from the previous chapter that operating cash flow for a project can be written as net income plus depreciation (the bottom-up definition), we can see that the operating cash flow is equal to the depreciation, or \$700,000 in this case. The internal rate of return is exactly zero (why?).

Payback and Break-Even As our example illustrates, whenever a project breaks even on an accounting basis, the cash flow for that period will be equal to the depreciation. This result makes perfect accounting sense. For example, suppose we invest \$100,000 in a five-year project. The depreciation is straight-line to a zero salvage, or \$20,000 per year. If the project exactly breaks even every period, then the cash flow will be \$20,000 per period.

The sum of the cash flows for the life of this project is $5 \times \$20,000 = \$100,000$, the original investment. What this shows is that a project's payback period is exactly equal to its life if the project breaks even every period. Similarly, a project that does better than break even has a payback that is shorter than the life of the project and has a positive rate of return.

The bad news is that a project that just breaks even on an accounting basis has a negative NPV and a zero return. For our sailboat project, the fact that Wettway will almost surely break even on an accounting basis is partially comforting because it means that the firm's "downside" risk (its potential loss) is limited, but we still don't know if the project is truly profitable. More work is needed.

Sales Volume and Operating Cash Flow

At this point, we can generalize our example and introduce some other break-even measures. From our discussion in the previous section, we know that, ignoring taxes, a project's operating cash flow, OCF, can be written simply as EBIT plus depreciation:

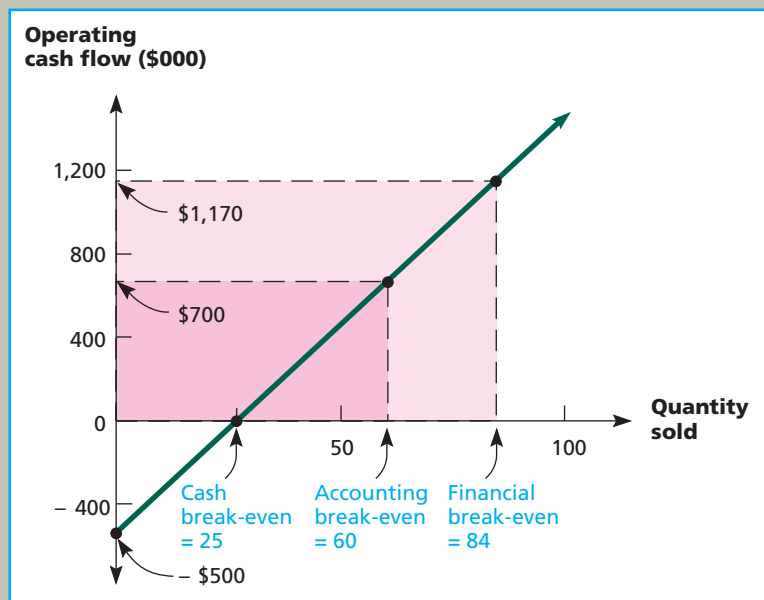
$$\begin{aligned} \text{OCF} &= [(P - v) \times Q - \text{FC} - D] + D \\ &= (P - v) \times Q - \text{FC} \end{aligned} \quad [11.2]$$

For the Wettway sailboat project, the general relationship (in thousands of dollars) between operating cash flow and sales volume is thus:

$$\begin{aligned} \text{OCF} &= (P - v) \times Q - \text{FC} \\ &= (\$40 - 20) \times Q - 500 \\ &= -\$500 + 20 \times Q \end{aligned}$$

What this tells us is that the relationship between operating cash flow and sales volume is given by a straight line with a slope of \$20 and a y-intercept of -\$500. If we calculate some different values, we get:

Quantity Sold	Operating Cash Flow
0	-\$ 500
15	- 200
30	100
50	500
75	1,000

**FIGURE 11.5**Operating Cash Flow
and Sales Volume

These points are plotted in Figure 11.5. In Figure 11.5, we have indicated three different break-even points. We discuss these next.

Cash Flow, Accounting, and Financial Break-Even Points

We know from the preceding discussion that the relationship between operating cash flow and sales volume (ignoring taxes) is:

$$OCF = (P - v) \times Q - FC$$

If we rearrange this and solve for Q , we get:

$$Q = (FC + OCF)/(P - v) \quad [11.3]$$

This tells us what sales volume (Q) is necessary to achieve any given OCF, so this result is more general than the accounting break-even. We use it to find the various break-even points in Figure 11.5.

Accounting Break-Even Revisited Looking at Figure 11.5, suppose that operating cash flow is equal to depreciation (D). Recall that this situation corresponds to our break-even point on an accounting basis. To find the sales volume, we substitute the \$700 depreciation amount for OCF in our general expression:

$$\begin{aligned} Q &= (FC + OCF)/(P - v) \\ &= (\$500 + 700)/20 \\ &= 60 \end{aligned}$$

This is the same quantity we had before.

Cash Break-Even We have seen that a project that breaks even on an accounting basis has a net income of zero, but it still has a positive cash flow. At some sales level below

cash break-even

The sales level that
results in a zero
operating cash flow.

the accounting break-even, the operating cash flow actually goes negative. This is a particularly unpleasant occurrence. If it happens, we actually have to supply additional cash to the project just to keep it afloat.

To calculate the **cash break-even** (the point where operating cash flow is equal to zero), we put in a zero for OCF:

$$\begin{aligned} Q &= (FC + 0) / (P - v) \\ &= \$500 / 20 \\ &= 25 \end{aligned}$$

Wettway must therefore sell 25 boats to cover the \$500 in fixed costs. As we show in Figure 11.5, this point occurs right where the operating cash flow line crosses the horizontal axis.

Notice that a project that just breaks even on a cash flow basis can cover its own fixed operating costs, but that is all. It never pays back anything, so the original investment is a complete loss (the IRR is -100 percent).

financial break-even

The sales level that
results in a zero NPV.

Financial Break-Even The last case we consider is that of **financial break-even**, the sales level that results in a zero NPV. To the financial manager, this is the most interesting case. What we do is first determine what operating cash flow has to be for the NPV to be zero. We then use this amount to determine the sales volume.

To illustrate, recall that Wettway requires a 20 percent return on its \$3,500 (in thousands) investment. How many sailboats does Wettway have to sell to break even once we account for the 20 percent per year opportunity cost?

The sailboat project has a five-year life. The project has a zero NPV when the present value of the operating cash flows equals the \$3,500 investment. Because the cash flow is the same each year, we can solve for the unknown amount by viewing it as an ordinary annuity. The five-year annuity factor at 20 percent is 2.9906, and the OCF can be determined as follows:

$$\begin{aligned} \$3,500 &= \text{OCF} \times 2.9906 \\ \text{OCF} &= \$3,500 / 2.9906 \\ &= \$1,170 \end{aligned}$$

Wettway thus needs an operating cash flow of \$1,170 each year to break even. We can now plug this OCF into the equation for sales volume:

$$\begin{aligned} Q &= (\$500 + 1,170) / 20 \\ &= 83.5 \end{aligned}$$

So, Wettway needs to sell about 84 boats per year. This is not good news.

As indicated in Figure 11.5, the financial break-even is substantially higher than the accounting break-even point. This will often be the case. Moreover, what we have discovered is that the sailboat project has a substantial degree of forecasting risk. We project sales of 85 boats per year, but it takes 84 just to earn the required return.

Conclusion Overall, it seems unlikely that the Wettway sailboat project would fail to break even on an accounting basis. However, there appears to be a very good chance that the true NPV is negative. This illustrates the danger in looking at just the accounting break-even.

What should Wettway do? Is the new project all wet? The decision at this point is essentially a managerial issue—a judgment call. The crucial questions are:

1. How much confidence do we have in our projections?
2. How important is the project to the future of the company?
3. How badly will the company be hurt if sales do turn out to be low? What options are available to the company in this case?

We will consider questions such as these in a later section. For future reference, our discussion of the different break-even measures is summarized in Table 11.1.

CONCEPT QUESTIONS

- 11.4a** If a project breaks even on an accounting basis, what is its operating cash flow?
11.4b If a project breaks even on a cash basis, what is its operating cash flow?
11.4c If a project breaks even on a financial basis, what do you know about its *discounted* payback?

I. The general break-even expression

Ignoring taxes, the relation between operating cash flow (OCF) and quantity of output or sales volume (Q) is:

$$Q = \frac{FC + OCF}{P - v}$$

where

FC = Total fixed costs

P = Price per unit

v = Variable cost per unit

As shown next, this relation can be used to determine the accounting, cash, and financial break-even points.

II. The accounting break-even point

Accounting break-even occurs when net income is zero. Operating cash flow is equal to depreciation when net income is zero, so the accounting break-even point is:

$$Q = \frac{FC + D}{P - v}$$

A project that always just breaks even on an accounting basis has a payback exactly equal to its life, a negative NPV, and an IRR of zero.

III. The cash break-even point

Cash break-even occurs when operating cash flow is zero. The cash break-even point is thus:

$$Q = \frac{FC}{P - v}$$

A project that always just breaks even on a cash basis never pays back, has an NPV that is negative and equal to the initial outlay, and has an IRR of -100 percent.

IV. The financial break-even point

Financial break-even occurs when the NPV of the project is zero. The financial break-even point is thus:

$$Q = \frac{FC + OCF^*}{P - v}$$

where OCF^* is the level of OCF that results in a zero NPV. A project that breaks even on a financial basis has a discounted payback equal to its life, a zero NPV, and an IRR just equal to the required return.

TABLE 11.1

Summary of Break-Even
Measures

11.5

OPERATING LEVERAGE

We have discussed how to calculate and interpret various measures of break-even for a proposed project. What we have not explicitly discussed is what determines these points and how they might be changed. We now turn to this subject.

The Basic Idea

operating leverage

The degree to which a firm or project relies on fixed costs.

Operating leverage is the degree to which a project or firm is committed to fixed production costs. A firm with low operating leverage will have low fixed costs compared to a firm with high operating leverage. Generally speaking, projects with a relatively heavy investment in plant and equipment will have a relatively high degree of operating leverage. Such projects are said to be *capital intensive*.

Anytime we are thinking about a new venture, there will normally be alternative ways of producing and delivering the product. For example, Wettway Corporation can purchase the necessary equipment and build all of the components for its sailboats in-house. Alternatively, some of the work could be farmed out to other firms. The first option involves a greater investment in plant and equipment, greater fixed costs and depreciation, and, as a result, a higher degree of operating leverage.

Implications of Operating Leverage

Regardless of how it is measured, operating leverage has important implications for project evaluation. Fixed costs act like a lever in the sense that a small percentage change in operating revenue can be magnified into a large percentage change in operating cash flow and NPV. This explains why we call it operating “leverage.”

The higher the degree of operating leverage, the greater is the potential danger from forecasting risk. The reason is that relatively small errors in forecasting sales volume can get magnified, or “levered up,” into large errors in cash flow projections.

From a managerial perspective, one way of coping with highly uncertain projects is to keep the degree of operating leverage as low as possible. This will generally have the effect of keeping the break-even point (however measured) at its minimum level. We will illustrate this point in a bit, but first we need to discuss how to measure operating leverage.

Measuring Operating Leverage

One way of measuring operating leverage is to ask, If quantity sold rises by 5 percent, what will be the percentage change in operating cash flow? In other words, the **degree of operating leverage (DOL)** is defined such that:

$$\text{Percentage change in OCF} = \text{DOL} \times \text{Percentage change in } Q$$

Based on the relationship between OCF and Q , DOL can be written as:¹

¹To see this, note that if Q goes up by one unit, OCF will go up by $(P - v)$. In this case, the percentage change in Q is $1/Q$, and the percentage change in OCF is $(P - v)/\text{OCF}$. Given this, we have:

$$\text{Percentage change in OCF} = \text{DOL} \times \text{Percentage change in } Q$$

$$(P - v)/\text{OCF} = \text{DOL} \times 1/Q$$

$$\text{DOL} = (P - v) \times Q/\text{OCF}$$

Also, based on our definitions of OCF:

$$\text{OCF} + \text{FC} = (P - v) \times Q$$

Thus, DOL can be written as:

$$\begin{aligned} \text{DOL} &= (\text{OCF} + \text{FC})/\text{OCF} \\ &= 1 + \text{FC}/\text{OCF} \end{aligned}$$

degree of operating leverage (DOL)

The percentage change in operating cash flow relative to the percentage change in quantity sold.

$$\text{DOL} = 1 + \text{FC}/\text{OCF}$$

[11.4]

The ratio FC/OCF simply measures fixed costs as a percentage of total operating cash flow. Notice that zero fixed costs would result in a DOL of 1, implying that percentage changes in quantity sold would show up one for one in operating cash flow. In other words, no magnification, or leverage, effect would exist.

To illustrate this measure of operating leverage, we go back to the Wettway sailboat project. Fixed costs were \$500 and $(P - v)$ was \$20, so OCF was:

$$\text{OCF} = -\$500 + 20 \times Q$$

Suppose Q is currently 50 boats. At this level of output, OCF is $-\$500 + 1,000 = \500 .

If Q rises by 1 unit to 51, then the percentage change in Q is $(51 - 50)/50 = .02$, or 2%. OCF rises to \$520, a change of $P - v = \$20$. The percentage change in OCF is $(\$520 - 500)/500 = .04$, or 4%. So a 2 percent increase in the number of boats sold leads to a 4 percent increase in operating cash flow. The degree of operating leverage must be exactly 2.00. We can check this by noting that:

$$\begin{aligned}\text{DOL} &= 1 + \text{FC}/\text{OCF} \\ &= 1 + \$500/500 \\ &= 2\end{aligned}$$

This verifies our previous calculations.

Our formulation of DOL depends on the current output level, Q . However, it can handle changes from the current level of any size, not just one unit. For example, suppose Q rises from 50 to 75, a 50 percent increase. With DOL equal to 2, operating cash flow should increase by 100 percent, or exactly double. Does it? The answer is yes, because, at a Q of 75, OCF is:

$$\text{OCF} = -\$500 + 20 \times 75 = \$1,000$$

Notice that operating leverage declines as output (Q) rises. For example, at an output level of 75, we have:

$$\begin{aligned}\text{DOL} &= 1 + \$500/1,000 \\ &= 1.50\end{aligned}$$

The reason DOL declines is that fixed costs, considered as a percentage of operating cash flow, get smaller and smaller, so the leverage effect diminishes.

Operating Leverage

The Sasha Corp. currently sells gourmet dog food for \$1.20 per can. The variable cost is 80 cents per can, and the packaging and marketing operations have fixed costs of \$360,000 per year. Depreciation is \$60,000 per year. What is the accounting break-even? Ignoring taxes, what will be the increase in operating cash flow if the quantity sold rises to 10 percent above the break-even point?

The accounting break-even is $\$420,000/.40 = 1,050,000$ cans. As we know, the operating cash flow is equal to the \$60,000 depreciation at this level of production, so the degree of operating leverage is:

$$\begin{aligned}\text{DOL} &= 1 + \text{FC}/\text{OCF} \\ &= 1 + \$360,000/60,000 \\ &= 7\end{aligned}$$

EXAMPLE 11.3

Given this, a 10 percent increase in the number of cans of dog food sold will increase operating cash flow by a substantial 70 percent.

To check this answer, we note that if sales rise by 10 percent, then the quantity sold will rise to $1,050,000 \times 1.1 = 1,155,000$. Ignoring taxes, the operating cash flow will be $1,155,000 \times \$0.40 - 360,000 = \$102,000$. Compared to the \$60,000 cash flow we had, this is exactly 70 percent more: $\$102,000/\$60,000 = 1.70$.

Operating Leverage and Break-Even

We illustrate why operating leverage is an important consideration by examining the Wettway sailboat project under an alternative scenario. At a Q of 85 boats, the degree of operating leverage for the sailboat project under the original scenario is:

$$\begin{aligned} \text{DOL} &= 1 + \text{FC}/\text{OCF} \\ &= 1 + \$500/1,200 \\ &= 1.42 \end{aligned}$$

Also, recall that the NPV at a sales level of 85 boats was \$88,720, and that the accounting break-even was 60 boats.

An option available to Wettway is to subcontract production of the boat hull assemblies. If the company does this, the necessary investment falls to \$3,200,000 and the fixed operating costs fall to \$180,000. However, variable costs will rise to \$25,000 per boat because subcontracting is more expensive than producing in-house. Ignoring taxes, evaluate this option.

For practice, see if you don't agree with the following:

$$\begin{aligned} \text{NPV at 20\% (85 units)} &= \$74,720 \\ \text{Accounting break-even} &= 55 \text{ boats} \\ \text{Degree of operating leverage} &= 1.16 \end{aligned}$$

What has happened? This option results in a slightly lower estimated net present value, and the accounting break-even point falls to 55 boats from 60 boats.

Given that this alternative has the lower NPV, is there any reason to consider it further? Maybe there is. The degree of operating leverage is substantially lower in the second case. If Wettway is worried about the possibility of an overly optimistic projection, then it might prefer to subcontract.

There is another reason why Wettway might consider the second arrangement. If sales turned out to be better than expected, the company would always have the option of starting to produce in-house at a later date. As a practical matter, it is much easier to increase operating leverage (by purchasing equipment) than to decrease it (by selling off equipment). As we discuss in the following pages, one of the drawbacks to discounted cash flow analysis is that it is difficult to explicitly include options of this sort in the analysis, even though they may be quite important.

CONCEPT QUESTIONS

11.5a What is operating leverage?

11.5b How is operating leverage measured?

11.5c What are the implications of operating leverage for the financial manager?