Project Analysis and Evaluation 11

IN THE SUMMER OF 2013, the movie *R.I.P.D.,* starring Ryan Reynolds and Jeff Bridges, was dead on arrival at the box office. The *R.I.P.D.* slogan was “To protect and serve the living,” but many critics and movie-goers disagreed. One critic said “Expect a sad afterlife for it on cable.”Others were even more harsh, saying “Unfortunately, the interesting drabness of the afterlife’s police department is paired with the colorless paucity of the film’s heavies” and “Less a bad movie than simply not a movie, *R.I.P.D.* gives every indication of having been a sloppy first-draft script.”

Looking at the numbers, Universal Pictures spent close to $130 million making the movie, plus millions more for marketing and distribution. Unfortunately for Universal Pictures, *R.I.P.D.* did not allow the executives to rest peacefully, pulling in only $33.6 million worldwide. In fact, about four of 10 movies lose money at the box office, though DVD sales often help the final tally. Of course, there are movies that do quite well. Also in 2013, the Lions Gate movie *Hunger Games: Catching Fire* raked in about $425 million in the U.S. at a production cost of $130 million.

So, obviously, Universal Pictures didn’t *plan* to lose $100 or so million on *R.I.P.D.*, but it happened. As this particular box office bomb shows, projects don’t always go as companies think they will. This chapter explores how this can happen, and what companies can do to analyze and possibly avoid these situations.

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Learning Objectives

After studying this chapter, you should understand:

LO1 How to perform and interpret a sensitivity analysis for a proposed investment.
LO2 How to perform and interpret a scenario analysis for a proposed investment.
LO3 How to determine and interpret cash, accounting, and financial break-even points.
LO4 How the degree of operating leverage can affect the cash flows of a project.

LO5 How capital rationing affects the ability of a company to accept projects.

In our previous chapter, we discussed how to identify and organize the relevant cash flows for capital investment decisions. Our primary interest there was in coming up with a preliminary estimate of the net present value for a proposed project. In this chapter, we focus on assessing the reliability of such an estimate and on some additional considerations in project analysis.

We begin by discussing the need for an evaluation of cash flow and NPV estimates. We go on to develop some useful tools for such an evaluation. We also examine additional complications and concerns that can arise in project evaluation.

11.1 Evaluating NPV Estimates

As we discussed in Chapter 9, an investment has a positive net present value if its market value exceeds its cost. Such an investment is desirable because it creates value for its owner. The primary problem in identifying such opportunities is that most of the time we can't actually observe the relevant market value. Instead, we estimate it. Having done so, it is only natural to wonder whether our estimates are at least close to the true values. We consider this question next.

THE BASIC PROBLEM

Suppose we are working on a preliminary discounted cash flow analysis along the lines we described in the previous chapter. We carefully identify the relevant cash flows, avoiding such things as sunk costs, and we remember to consider working capital requirements. We add back any depreciation; we account for possible erosion; and we pay attention to opportunity costs. Finally, we double-check our calculations; when all is said and done, the bottom line is that the estimated NPV is positive.

Now what? Do we stop here and move on to the next proposal? Probably not. The fact that the estimated NPV is positive is definitely a good sign; but, more than anything, this tells us that we need to take a closer look.

If you think about it, there are two circumstances under which a DCF analysis could lead us to conclude that a project has a positive NPV. The first possibility is that the project really does have a positive NPV. That's the good news. The bad news is the second possibility: A project may appear to have a positive NPV because our estimate is inaccurate.

Notice that we could also err in the opposite way. If we conclude that a project has a negative NPV when the true NPV is positive, we lose a valuable opportunity.

PROJECTED VERSUS ACTUAL CASH FLOWS

There is a somewhat subtle point we need to make here. When we say something like "The projected cash flow in Year 4 is $700,"what exactly do we mean? Does this mean that we think the cash flow will actually be $700? Not really. It could happen, of course, but we would be surprised to see it turn out exactly that way. The reason is that the $700 projection is based on only what we know today. Almost anything could happen between now and then to change that cash flow.

Loosely speaking, we really mean that if we took all the possible cash flows that could occur in four years and averaged them, the result would be $700. So, we don't really expect a projected cash flow to be exactly right in any one case. What we do expect is that if we evaluate a large number of projects, our projections will be right on average.

FORECASTING RISK

The key inputs into a DCF analysis are projected future cash flows. If the projections are seriously in error, then we have a classic GIGO (garbage in, garbage out) system. In such a case, no matter how carefully we arrange the numbers and manipulate them, the resulting answer can still be grossly misleading. This is the danger in using a relatively sophisticated technique like DCF. It is sometimes easy to get caught up in number crunching and forget the underlying nuts-and-bolts economic reality.

The possibility that we will make a bad decision because of errors in the projected cash flows is called **forecasting risk** (or *estimation risk*). Because of forecasting risk, there is the danger that we will think a project has a positive NPV when it really does not. How is this possible? It happens if we are overly optimistic about the future, and, as a result, our projected cash flows don't realistically reflect the possible future cash flows.

forecasting risk
The possibility that errors in projected cash flows will lead to incorrect decisions. Also known as *estimation risk*.

Forecasting risk can take many forms. For example, Microsoft spent several billion dollars developing and bringing the Xbox One game console to market. Technologically more sophisticated than its competition, the Xbox One was the best way to play against competitors over the Internet and included other features, such as the Kinect motion detector. However, Microsoft sold only four million Xboxes in the first four months of sales, which was at the low end of Microsoft's expected range and noticeably fewer than the 6.6 million Sony PS4s sold. Since the Xbox was arguably the best available game console at the time, why didn't it sell better? A major reason given by analysts was that the Xbox cost $100 more than the PS4.

So far, we have not explicitly considered what to do about the possibility of errors in our forecasts; so one of our goals in this chapter is to develop some tools that are useful in identifying areas where potential errors exist and where they might be especially damaging. In one form or another, we will be trying to assess the economic "reasonableness" of our estimates. We will also be wondering how much damage will be done by errors in those estimates.

SOURCES OF VALUE

The first line of defense against forecasting risk is simply to ask, "What is it about this investment that leads to a positive NPV?"We should be able to point to something specific as the source of value. For example, if the proposal under consideration involves a new product, then we might ask questions such as the following: Are we certain that our new product is significantly better than that of the competition? Can we truly manufacture at lower cost, or distribute more effectively, or identify undeveloped market niches, or gain control of a market?

These are just a few of the potential sources of value. There are many others. For example, in 2004, Google announced a new, free e-mail service: Gmail. Why? Free e-mail service is widely available from big hitters like Microsoft and Yahoo! and, obviously, it's free! The answer is that Google's mail service is integrated with its acclaimed search engine, thereby giving it an edge. Also, offering e-mail lets Google expand its lucrative keyword-based advertising delivery. So, Google's source of value is leveraging its proprietary Web search and ad delivery technologies.

A key factor to keep in mind is the degree of competition in the market. A basic principle of economics is that positive NPV investments will be rare in a highly competitive environment. Therefore, proposals that appear to show significant value in the face of stiff competition are particularly troublesome, and the likely reaction of the competition to any innovations must be closely examined.

To give an example, in 2008, demand for flat screen LCD televisions was high, prices were high, and profit margins were fat for retailers. But, also in 2008, manufacturers of the screens, such as Samsung and Sony, were projected to pour several billion dollars into new production facilities. Thus, anyone thinking of entering this highly profitable market would do well to reflect on what the supply (and profit margin) situation will look like in just a few years. And, in fact, the high prices did not last. By 2014, television sets that had been selling for well over $1,000 only two years before were selling for around $300–$400.

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It is also necessary to think about *potential* competition. For example, suppose home improvement retailer Lowe's identifies an area that is underserved and is thinking about opening a store. If the store is successful, what will happen? The answer is that Home Depot (or another competitor) will likely also build a store, thereby driving down volume and profits. So, we always need to keep in mind that success attracts imitators and competitors.

The point to remember is that positive NPV investments are probably not all that common, and the number of positive NPV projects is almost certainly limited for any given firm. If we can't articulate some sound economic basis for thinking ahead of time that we have found something special, then the conclusion that our project has a positive NPV should be viewed with some suspicion.

Concept Questions

11.1a What is forecasting risk? Why is it a concern for the financial manager?

11.1b What are some potential sources of value in a new project?

11.2 Scenario and Other What-If Analyses

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Our basic approach to evaluating cash flow and NPV estimates involves asking what-if questions. Accordingly, we discuss some organized ways of going about a what-if analysis. Our goal in performing such an analysis is to assess the degree of forecasting risk and to identify the most critical components of the success or failure of an investment.

GETTING STARTED

We are investigating a new project. Naturally, the first thing we do is estimate NPV based on our projected cash flows. We will call this initial set of projections the *base case*. Now, however, we recognize the possibility of error in these cash flow projections. After completing the base case, we thus wish to investigate the impact of different assumptions about the future on our estimates.

One way to organize this investigation is to put upper and lower bounds on the various components of the project. For example, suppose we forecast sales at 100 units per year. We know this estimate may be high or low, but we are relatively certain it is not off by more than 10 units in either direction. We thus pick a lower bound of 90 and an upper bound of 110. We go on to assign such bounds to any other cash flow components we are unsure about.

When we pick these upper and lower bounds, we are not ruling out the possibility that the actual values could be outside this range. What we are saying, again loosely speaking, is that it is unlikely that the true average (as opposed to our estimated average) of the possible values is outside this range.

An example is useful to illustrate the idea here. The project under consideration costs $200,000, has a five-year life, and has no salvage value. Depreciation is straight-line to zero. The required return is 12 percent, and the tax rate is 34 percent. In addition, we have compiled the following information:

	Base Case	Lower Bound	Upper Bound
Unit sales	6,000	5,500	6,500
Price per unit	$ 80	$ 75	$ 85
Variable costs per unit	$ 60	$ 58	$ 62
Fixed costs per year	$50,000	$45,000	$55,000

With this information, we can calculate the base-case NPV by first calculating net income:

Sales	$480,000
Variable costs	360,000
Fixed costs	50,000
Depreciation	40,000
EBIT	$ 30,000
Taxes (34%)	10,200
Net income	$ 19,800

Operating cash flow is thus $30,000 + 40,000 – 10,200 = $59,800 per year. At 12 percent, the five-year annuity factor is 3.6048, so the base-case NPV is:

$$\text{Base-case NPV} = -\$200{,}000 + 59{,}800 \times 3.6048$$
$$= \$15{,}567$$

Thus, the project looks good so far.

SCENARIO ANALYSIS

The basic form of what-if analysis is called **scenario analysis**. What we do is investigate the changes in our NPV estimates that result from asking questions like: What if unit sales realistically should be projected at 5,500 units instead of 6,000?

scenario analysis
The determination of what happens to NPV estimates when we ask what-if questions.

Once we start looking at alternative scenarios, we might find that most of the plausible ones result in positive NPVs. In this case, we have some confidence in proceeding with the project. If a substantial percentage of the scenarios look bad, the degree of forecasting risk is high and further investigation is in order.

We can consider a number of possible scenarios. A good place to start is with the worst-case scenario. This will tell us the minimum NPV of the project. If this turns out to be positive, we will be in good shape. While we are at it, we will go ahead and determine the other extreme, the best case. This puts an upper bound on our NPV.

To get the worst case, we assign the least favorable value to each item. This means *low* values for items like units sold and price per unit and *high* values for costs. We do the reverse for the best case. For our project, these values would be the following:

	Worst Case	Best Case
Unit sales	5,500	6,500
Price per unit	$ 75	$ 85
Variable costs per unit	$ 62	$ 58
Fixed costs per year	$55,000	$45,000

With this information, we can calculate the net income and cash flows under each scenario (check these for yourself):

Scenario	Net Income	Cash Flow	Net Present Value	IRR
Base case	$19,800	$59,800	$ 15,567	15.1%
Worst case*	– 15,510	24,490	– 111,719	–14.4
Best case	59,730	99,730	159,504	40.9

*We assume a tax credit is created in our worst-case scenario.

What we learn is that under the worst scenario, the cash flow is still positive at $24,490. That's good news. The bad news is that the return is –14.4 percent in this case, and the

NPV is −$111,719. Because the project costs $200,000, we stand to lose a little more than half of the original investment under the worst possible scenario. The best case offers an attractive 41 percent return.

The terms *best case* and *worst case* are commonly used, and we will stick with them; but they are somewhat misleading. The absolutely best thing that could happen would be something absurdly unlikely, such as launching a new diet soda and subsequently learning that our (patented) formulation also just happens to cure the common cold. Similarly, the true worst case would involve some incredibly remote possibility of total disaster. We're not claiming that these things don't happen; once in a while they do. Some products, such as personal computers, succeed beyond the wildest expectations; and some turn out to be absolute catastrophes. For example, in April 2010, BP's Gulf of Mexico oil rig *Deepwater Horizon* caught fire and sank following an explosion, leading to a massive oil spill. The leak was finally stopped in July after releasing over 200 million gallons of crude oil into the Gulf. BP's costs associated with the disaster have already exceeded $43 billion, not including opportunity costs such as lost government contracts. Nonetheless, our point is that in assessing the reasonableness of an NPV estimate, we need to stick to cases that are reasonably likely to occur.

Instead of *best* and *worst,* then, it is probably more accurate to use the words *optimistic* and *pessimistic*. In broad terms, if we were thinking about a reasonable range for, say, unit sales, then what we call the best case would correspond to something near the upper end of that range. The worst case would simply correspond to the lower end.

Not all companies complete (or at least publish) all three estimates. For example, Almaden Minerals, Ltd., made a press release with information concerning its Elk Gold Project in British Columbia. Here is a table of the possible outcomes given by the company:

Project Summary	Base Case	$1,200 Case	Unit
Assumed gold price	1,000	1,200	$US/tr.oz
Tonnes per day treated	500	1,000	tpd
Life	7	9	years
Total tonnes treated	1.1	2.6	MT
Grade	4.14	3.89	g/t
Waste:Ore ratio	16.4	30.1	
Plant recovery	92	92	%
Ounces Au produced	139,196	297,239	tr.oz
Initial capital expense	9.91	17.50	$CADM
Working and preproduction capital	2.27	9.60	$CADM
Waste mining	2.42	1.90	$CAD/tonne waste
Ore mining	8.38	5.87	$CAD/tonne ore
Processing	20.68	14.74	$CAD/tonne ore
Administration and overheads	2.07	1.27	$CAD/tonne ore
Total operating cost	70.30	78.91	$CAD/tonne ore
Pre-tax NPV @ 8%	28.7	67.9	$CADM
Pre-tax IRR	51%	39%	
Max exposure	13.66	33.53	$CADM
Payback, years from start production	1.85	3.30	years
Ratio, gross earnings:max exposure	5.02	6.00	
Ratio, NPV:max exposure	2.10	2.03	

As you can see, the NPV is projected at C$28.7 million in the base case and C$67.9 million in the best case. Unfortunately, Almaden did not release a worst-case analysis, but we hope the company also examined this possibility.

As we have mentioned, there are an unlimited number of different scenarios that we could examine. At a minimum, we might want to investigate two intermediate cases by going halfway between the base amounts and the extreme amounts. This would give us five scenarios in all, including the base case.

Beyond this point, it is hard to know when to stop. As we generate more and more possibilities, we run the risk of experiencing "paralysis of analysis."The difficulty is that no matter how many scenarios we run, all we can learn are possibilities—some good and some bad. Beyond that, we don't get any guidance as to what to do. Scenario analysis is thus useful in telling us what can happen and in helping us gauge the potential for disaster, but it does not tell us whether to take a project.

Unfortunately, in practice, even the worst-case scenarios may not be low enough. Two recent examples show what we mean. The Eurotunnel, or Chunnel, may be one of the new wonders of the world. The tunnel under the English Channel connects England to France and covers 24 miles. It took 8,000 workers eight years to remove 9.8 million cubic yards of rock. When the tunnel was finally built, it cost $17.9 billion, or slightly more than twice the original estimate of $8.8 billion. And things got worse. Forecasts called for 16.8 million passengers in the first year, but only 4 million actually used it. Revenue estimates for 2003 were $2.88 billion, but actual revenue was only about one-third of that. The major problems faced by the Eurotunnel were increased competition from ferry services, which dropped their prices, and the rise of low-cost airlines. In 2006, things got so bad that the company operating the Eurotunnel was forced into negotiations with creditors to chop its $11.1 billion debt in half to avoid bankruptcy. The debt reduction appeared to help. In 2007, the Eurotunnel reported its first profit of €1 million ($1.6 million). By 2013, the Chunnel had a profit of €101 million ($138 million). Sales for the year were €1.09 billion ($1.49 billion), the first year its sales exceeded €1 billion, and for the first time it transported more than 10 million passengers in a year.

Another example is the personal transporter, or Segway. Trumpeted by inventor Dean Kamen as the replacement for automobiles in cities, the Segway came to market with great expectations. At the end of September 2003, the company recalled all of the transporters due to a mandatory software upgrade. Worse, the company had projected sales of 50,000 to 100,000 units in the first five months of production; but, three years later, only about 23,500 had been sold.

SENSITIVITY ANALYSIS

Sensitivity analysis is a variation on scenario analysis that is useful in pinpointing the areas where forecasting risk is especially severe. The basic idea with a sensitivity analysis is to freeze all of the variables except one and then see how sensitive our estimate of NPV is to changes in that one variable. If our NPV estimate turns out to be very sensitive to relatively small changes in the projected value of some component of project cash flow, then the forecasting risk associated with that variable is high.

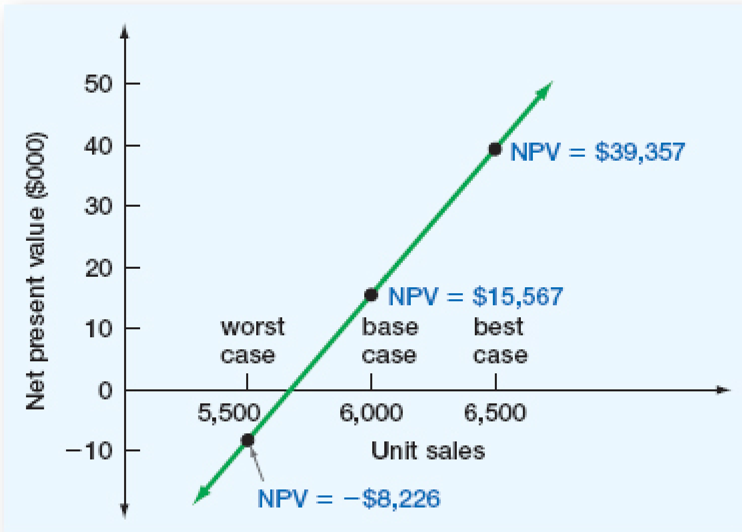
sensitivity analysis
Investigation of what happens to NPV when only one variable is changed.

To illustrate how sensitivity analysis works, we go back to our base case for every item except unit sales. We can then calculate cash flow and NPV using the largest and smallest unit sales figures.

Scenario	Unit Sales	Cash Flow	Net Present Value	IRR
Base case	6,000	$59,800	$15,567	15.1%
Worst case	5,500	53,200	−8,226	10.3
Best case	6,500	66,400	39,357	19.7

FIGURE 11.1

Sensitivity Analysis for Unit Sales



For comparison, we now freeze everything except fixed costs and repeat the analysis:

Scenario	Fixed Costs	Cash Flow	Net Present Value	IRR
Base case	$50,000	$59,800	$15,567	15.1%
Worst case	55,000	56,500	3,670	12.7
Best case	45,000	63,100	27,461	17.4

What we see here is that given our ranges, the estimated NPV of this project is more sensitive to changes in projected unit sales than it is to changes in projected fixed costs. In fact, under the worst case for fixed costs, the NPV is still positive.

The results of our sensitivity analysis for unit sales can be illustrated graphically as in Figure 11.1. Here we place NPV on the vertical axis and unit sales on the horizontal axis. When we plot the combinations of unit sales versus NPV, we see that all possible combinations fall on a straight line. The steeper the resulting line is, the greater the sensitivity of the estimated NPV to changes in the projected value of the variable being investigated.

Sensitivity analysis can produce results that vary dramatically depending on the assumptions. For example, in early 2011, Bard Ventures announced its projections for a molybdenum mine in British Columbia. At a cost of capital of 10 percent and an average molybdenum price of $19 per ton, the NPV of the new mine would be $112 million with an IRR of 12.4 percent. At a high price of $30 per ton, the NPV would be $1.152 billion, and the IRR would be 32.0 percent.

As we have illustrated, sensitivity analysis is useful in pinpointing which variables deserve the most attention. If we find that our estimated NPV is especially sensitive to changes in a variable that is difficult to forecast (such as unit sales), then the degree of forecasting risk is high. We might decide that further market research would be a good idea in this case.

Because sensitivity analysis is a form of scenario analysis, it suffers from the same drawbacks. Sensitivity analysis is useful for pointing out where forecasting errors will do the most damage, but it does not tell us what to do about possible errors.

SIMULATION ANALYSIS

Scenario analysis and sensitivity analysis are widely used. With scenario analysis, we let all the different variables change, but we let them take on only a few values. With sensitivity analysis, we let only one variable change, but we let it take on many values. If we combine the two approaches, the result is a crude form of **simulation analysis**.

simulation analysis
A combination of scenario and sensitivity analysis.

If we want to let all the items vary at the same time, we have to consider a very large number of scenarios, and computer assistance is almost certainly needed. In the simplest case, we start with unit sales and assume that any value in our 5,500 to 6,500 range is equally likely. We start by randomly picking one value (or by instructing a computer to do so). We then randomly pick a price, a variable cost, and so on.

Once we have values for all the relevant components, we calculate an NPV. We repeat this sequence as much as we desire, probably several thousand times. The result is many 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, no simple decision rule 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 creating 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

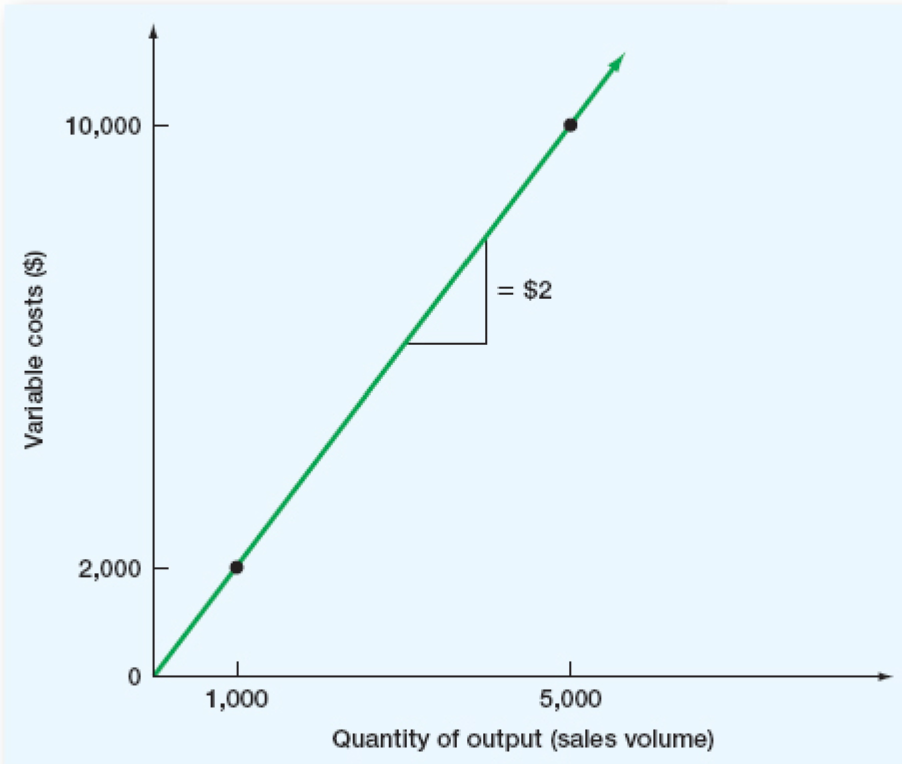
In discussing break-even, the difference between fixed and variable costs becomes very important. As a result, we need to be a little more explicit about the difference than we have been so far.

Variable Costs 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.

variable costs
Costs that change when the quantity of output changes.

FIGURE 11.2

Output Level and Variable Costs



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 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:

$$\text{Total variable cost} = \text{Total quantity of output} \times \text{Cost per unit of output}$$
$$\text{VC} = Q \times v$$

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?

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

Similarly, if Q is 5,000 units, then VC will be 5,000 × $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.

EXAMPLE 11.1 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 to accept the order. From recent experience, the 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:

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$$\begin{aligned} VC &= Q \times v \\ &= 5{,}000 \times \$.55 \\ &= \$2{,}750 \end{aligned}$$

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

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.

fixed costs,
Costs that do not change when the quantity of output charges during a particular time period.

Naturally, fixed costs are not fixed forever. They are fixed only 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 when 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 × 6,000 + $8,000 = $26,000. At other production levels, we have the following:

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

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 equal 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.

marginal, or incremental, cost
The change in costs that occurs when there is a small change in output.

EXAMPLE 11.2 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?

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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:

$$\begin{aligned}\text{Total cost} &= v \times Q + FC \\ &= \$.55 \times 100{,}000 + \$60{,}000 \\ &= \$115{,}000\end{aligned}$$

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 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 toward 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 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.

marginal, or incremental, revenue
The change in revenue that occurs when there is a small change in output.

ACCOUNTING BREAK-EVEN

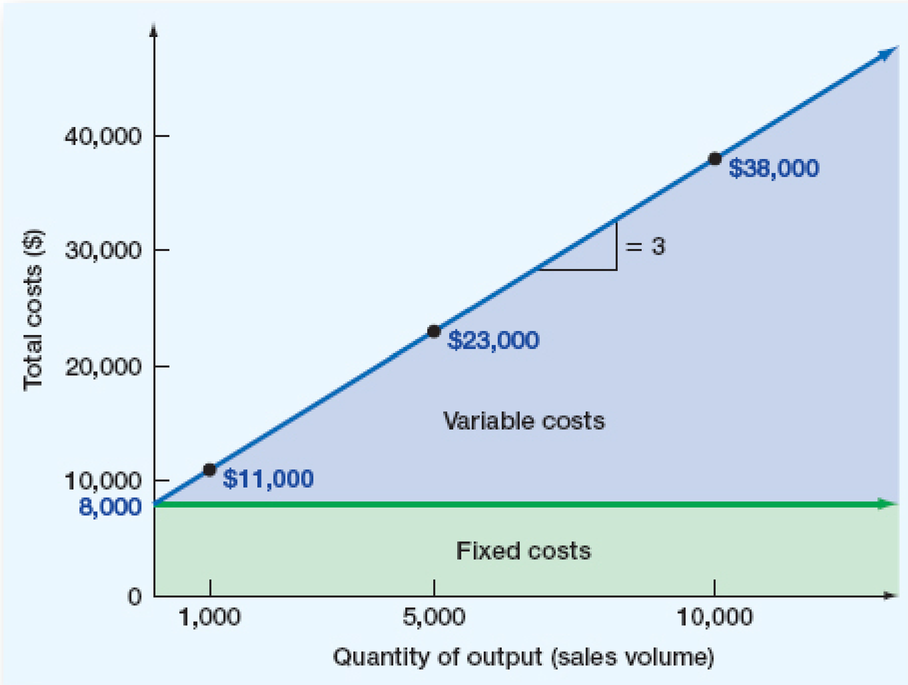
The most widely used measure of break-even is **accounting break-even**. The accounting break-even point is simply the sales level that results in a zero project net income.

accounting break-even
The sales level that results in zero project net income.

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

FIGURE 11.3

Output Level and Total Costs


40,000
30,000
20,000
10,000
8,000
0
Total costs ($)
$38,000
= 3
$23,000
Variable costs
$11,000
Fixed costs
1,000
5,000
10,000
Quantity of output (sales volume)

For every disk we sell, we pick up $5 − 3 = $2 toward 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 disks. We can check this by noting that at a sales level of 450 units, our revenues are $5 × 450 = $2,250 and our variable costs are $3 × 450 = $1,350. Thus, here is the income statement:

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

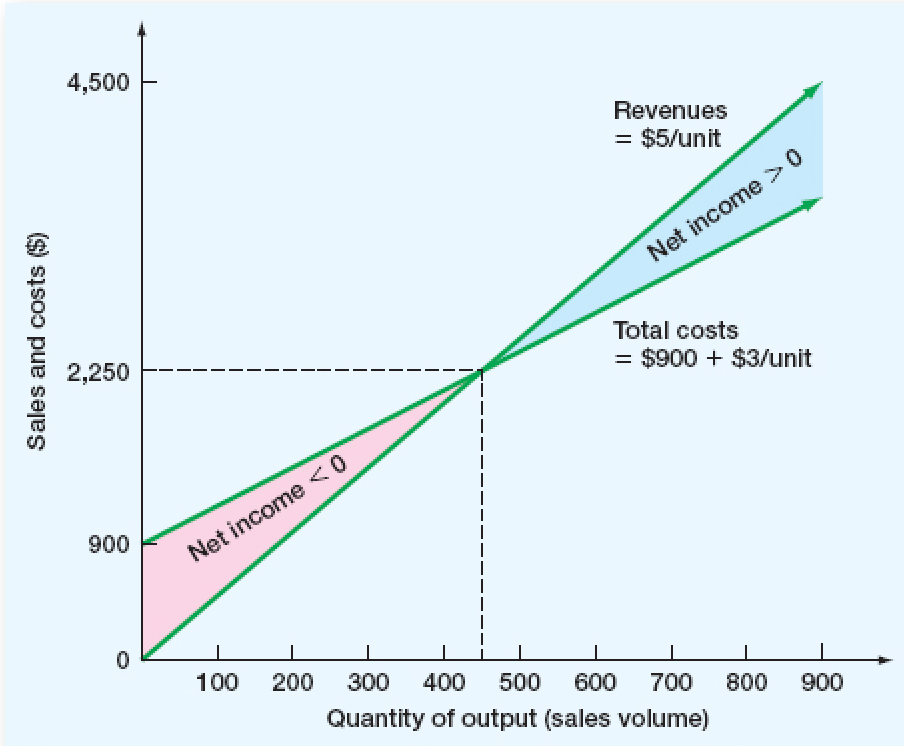
Remember, because we are discussing a proposed new project, we do not consider any interest expense in calculating net income or cash flow from the project. Also, notice that we include depreciation in calculating expenses here, even though depreciation is not a cash outflow. That is why we call it an 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.

FIGURE 11.4

Accounting Break-Even


4,500
2,250
900
0
Sales and costs ($)
Revenues
= $5/unit
Net income > 0
Total costs
= $900 + $3/unit
Net income < 0
100
200
300
400
500
600
700
800
900
Quantity of output (sales volume)

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:

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:

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

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

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

Divide both sides by (1 – T) to get:

$$S - \text{VC} - \text{FC} - D = 0$$

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:

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

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 reasonably well 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 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 sections, 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?

11.4 Operating Cash Flow, Sales Volume, and Break-Even

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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 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:

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

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 $(\text{FC} + D)/(P - v)$ = $1.2 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 Wett-way 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 equal 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 × $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:

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

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

These points are plotted in Figure 11.5, where 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:

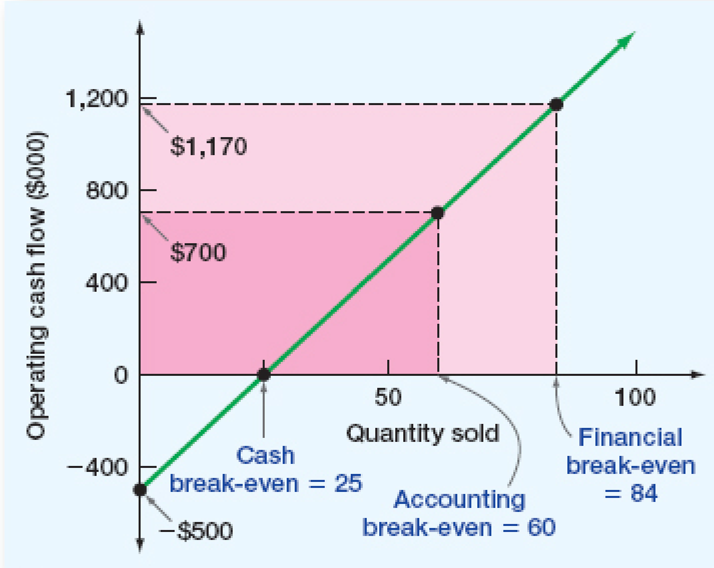
$$\text{OCF} = (P - v) \times Q - \text{FC}$$

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

$$Q = (\text{FC} + \text{OCF})/(P - v) \qquad [11.3]$$

FIGURE 11.5

Operating Cash Flow and Sales Volume


1,200
800
400
0
−400
Operating cash flow ($000)
$1,170
$700
−$500
50
100
Quantity sold
Cash
break-even = 25
Accounting
break-even = 60
Financial
break-even
= 84

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 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:

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

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 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:

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

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

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 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.

financial break-even
The sales level that results in a zero NPV.

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:

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

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. 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 these:

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 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.

TABLE 11.1 Summary of Break-Even Measures

I. The General Break-Even Expression

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

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

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:

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

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:

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

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:

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

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.

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?

11.5 Operating Leverage

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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 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*.

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

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:

degree of operating leverage (DOL)
The percentage change in operating cash flow relative to the percentage change in quantity sold.

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

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

$$\text{DOL} = 1 + \text{FC}/\text{OCF} \qquad [11.4]$$

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.

EXAMPLE 11.3 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:

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

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 × 1.1 = 1,155,000. Ignoring taxes, the operating cash flow will be 1,155,000 × $.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 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:

NPV at 20% (85 units) = $74,720
Accounting break-even = 55 boats

Degree of operating leverage = 1.16

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 a later chapter, 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?

11.6 Capital Rationing

Capital rationing is said to exist when we have profitable (positive NPV) investments available but we can't get the funds needed to undertake them. For example, as division managers for a large corporation, we might identify $5 million in excellent projects, but find that, for whatever reason, we can spend only $2 million. Now what? Unfortunately, for reasons we will discuss, there may be no truly satisfactory answer.

capital rationing
The situation that exists if a firm has positive NPV projects but cannot find the necessary financing.

SOFT RATIONING

The situation we have just described is called **soft rationing**. This occurs when, for example, different units in a business are allocated some fixed amount of money each year for capital spending. Such an allocation is primarily a means of controlling and keeping track of overall spending. The important thing to note about soft rationing is that the corporation as a whole isn't short of capital; more can be raised on ordinary terms if management so desires.

soft rationing
The situation that occurs when units in a business are allocated a certain amount of financing for capital budgeting.

If we face soft rationing, the first thing to do is to try to get a larger allocation. Failing that, one common suggestion is to generate as large a net present value as possible within the existing budget. This amounts to choosing projects with the largest benefit–cost ratio (profitability index).

Strictly speaking, this is the correct thing to do only if the soft rationing is a one-time event—that is, it won't exist next year. If the soft rationing is a chronic problem, then something is amiss. The reason goes all the way back to Chapter 1. Ongoing soft rationing means we are constantly bypassing positive NPV investments. This contradicts the goal of our firm. If we are not trying to maximize value, then the question of which projects to take becomes ambiguous because we no longer have an objective goal in the first place.

HARD RATIONING

With **hard rationing**, a business cannot raise capital for a project under any circumstances. For large, healthy corporations, this situation probably does not occur very often. This is fortunate because, with hard rationing, our DCF analysis breaks down, and the best course of action is ambiguous.

hard rationing
The situation that occurs when a business cannot raise financing for a project under any circumstances.

The reason DCF analysis breaks down has to do with the required return. Suppose we say our required return is 20 percent. Implicitly, we are saying we will take a project with a return that exceeds this. However, if we face hard rationing, then we are not going to take a new project no matter what the return on that project is, so the whole concept of a required return is ambiguous. About the only interpretation we can give this situation is that the required return is so large that no project has a positive NPV in the first place.