A COMPANY'S SHAREHOLDERS prefer to be rich rather than poor. Therefore, they want the firm to invest in every project that is worth more than it costs. The difference between a project's value and its cost is its *net present value (NPV).* Companies can best help their shareholders by investing in all projects with a positive NPV and rejecting those with a negative NPV.

We start this chapter with a review of the net present value rule. We then turn to some other measures that companies may look at when making investment decisions. The first two of these measures, the project's payback period and its book rate of return, are little better than rules of thumb, easy to calculate and easy to communicate. Although there is a place for rules of thumb in this world, an engineer needs something more accurate when designing a 100-story building, and a financial manager needs more than a rule of thumb when making a substantial capital investment decision.

Instead of calculating a project's NPV, companies often compare the expected rate of return from investing in the project with the return that shareholders could earn on equivalent-risk investments in the capital market. The company accepts those projects that provide a higher return than shareholders could earn for themselves. If used correctly, this rate of return rule should always identify projects that increase firm value. However, we shall see that the rule sets several traps for the unwary.

We conclude the chapter by showing how to cope with situations when the firm has only limited capital. This raises two problems. One is computational. In simple cases we just choose those projects that give the highest NPV per dollar invested, but more elaborate techniques are sometimes needed to sort through the possible alternatives. The other problem is to decide whether capital rationing really exists and whether it invalidates the net present value rule. Guess what? NPV, properly interpreted, wins out in the end.

5.1 A REVIEW OF THE BASICS

Vegetron's chief financial officer (CFO) is wondering how to analyze a proposed $1 million investment in a new venture called project X. He asks what you think.

Your response should be as follows: "First, forecast the cash flows generated by project X over its economic life. Second, determine the appropriate opportunity cost of capital. This should reflect both the time value of money and the risk involved in project X. Third, use this opportunity cost of capital to discount the future cash flows of project X. The sum of the discounted cash flows is called present value (PV). Fourth, calculate *net* present value (NPV) by subtracting the $1 million investment from PV. Invest in project X if its NPV is greater than zero."

However, Vegetron's CFO is unmoved by your sagacity. He asks why NPV is so important.

Your reply: "Let us look at what is best for Vegetron stockholders. They want you to make their Vegetron shares as valuable as possible."

"Right now Vegetron's total market value (price per share times the number of shares outstanding) is $10 million. That includes $1 million cash we can invest in project X. The value of Vegetron's other assets and opportunities must therefore be $9 million. We have to decide whether it is better to keep the $1 million cash and

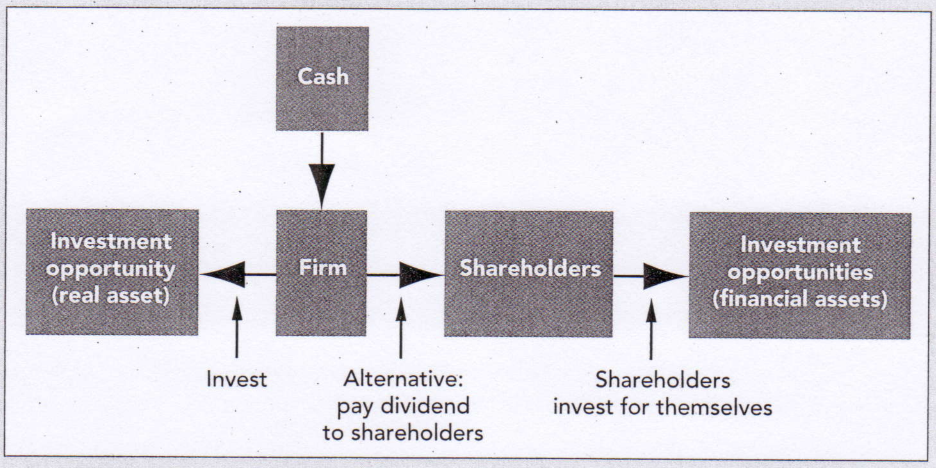

FIGURE 5.1

The firm can either keep and reinvest cash or return it to investors. (Arrows represent possible cash flows or transfers.) If cash is reinvested, the opportunity cost is the expected rate of return that shareholders could have obtained by investing in financial assets.

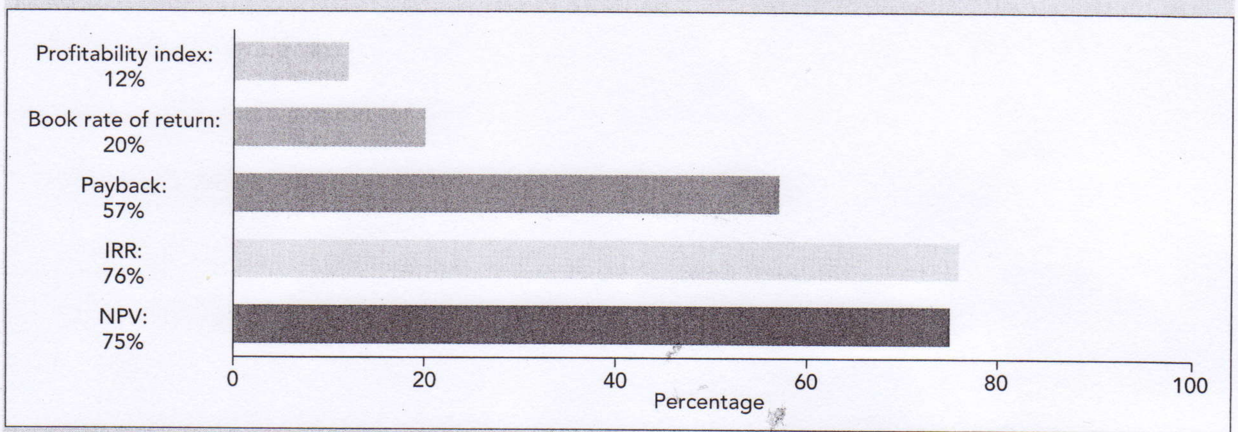

FIGURE 5.2

Survey evidence on the percentage of CFOs who always, or almost always, use a particular technique for evaluating investment projects.

Source: Reprinted from J. R. Graham and C. R. Harvey, "The Theory and Practice of Finance: Evidence from the Field," *Journal of Financial Economics* 61 (2001), pp. 187–243, © 2001 with permission from Elsevier Science.

Net Present Value's Competitors

When you advised the CFO to calculate the project's NPV, you were in good company. These days 75 percent of firms always, or almost always, calculate net present value when deciding on investment projects. However, as you can see from Figure 5.2, NPV is not the only investment criterion that companies use, and firms often look at more than one measure of a project's attractiveness.

About three-quarters of firms calculate the project's internal rate of return (or IRR); that is roughly the same proportion as use NPV. The IRR rule is a close relative of NPV and, when used properly, it will give the same answer. You therefore need to understand the IRR rule and how to take care when using it.

Pitfall 2—Multiple Rates of Return

Helmsley Iron is proposing to develop a new strip mine in Western Australia. The mine involves an initial investment of $A60 million and is expected to produce a cash inflow of $A12 million a year for the next nine years. At the end of that time the company will incur $A15 million of cleanup costs. Thus the cash flows from the project are:

Cash flows (millions of Australian dollars)				
C_0	C_1	. . .	C_9	C_{10}
−60	12		12	−15

Helmsley calculates the project's IRR and its NPV as follows:

IRR (%)	NPV at 10%
−44.0 *and* 11.6	$A3.3 million

Note that there are *two* discount rates that make NPV = 0. That is, *each* of the following statements holds:

$$\text{NPV} = -60 + \frac{12}{.56} + \frac{12}{.56^2} + \cdots + \frac{12}{.56^9} - \frac{15}{.56^{10}} = 0$$

$$\text{NPV} = -60 + \frac{12}{1.116} + \frac{12}{1.116^2} + \cdots + \frac{12}{1.116^9} - \frac{15}{1.116^{10}} = 0$$

In other words, the investment has an IRR of both −44.0 *and* 11.6 percent. Figure 5.4 shows how this comes about. As the discount rate increases, NPV initially rises and then declines. The reason for this is the double change in the sign of the cash-flow stream. There can be as many internal rates of return for a project as there are changes in the sign of the cash flows.[3]

Decommissioning costs are an obvious reason that cash flows can go from positive to negative, but you can probably think of a number of other cases where the company needs to plan for later expenditures. Ships periodically need to go into dry dock for a refit, hotels may receive a major face-lift, machine parts may need replacement, and so on.

Whenever the cash-flow stream is expected to change sign more than once, the company typically sees more than one IRR.

As if this is not difficult enough, there are also cases in which *no* internal rate of return exists. For example, project C has a positive net present value at all discount rates:

	Cash Flows ($)				
Project	C_0	C_1	C_2	IRR (%)	NPV at 10%
C	+1,000	−3,000	+2,500	None	+339

[3] By Descartes's "rule of signs" there can be as many different solutions to a polynomial as there are changes of sign. For a discussion of the problem of multiple rates of return, see J. H. Lorie and L. J. Savage, "Three Problems in Rationing Capital," *Journal of Business* 28 (October 1955), pp. 229–239; and E. Solomon, "The Arithmetic of Capital Budgeting," *Journal of Business* 29 (April 1956), pp. 124–129.

Consider projects D and E:

Project	Cash Flows ($) C_0	C_1	IRR (%)	NPV at 10%
D	−10,000	+20,000	100	+ 8,182
E	−20,000	+35,000	75	+11,818

Perhaps project D is a manually controlled machine tool and project E is the same tool with the addition of computer control. Both are good investments, but E has the higher NPV and is, therefore, better. However, the IRR rule seems to indicate that if you have to choose, you should go for D since it has the higher IRR. If you follow the IRR rule, you have the satisfaction of earning a 100 percent rate of return; if you follow the NPV rule, you are $11,818 richer.

You can salvage the IRR rule in these cases by looking at the internal rate of return on the incremental flows. Here is how to do it: First, consider the smaller project (D in our example). It has an IRR of 100 percent, which is well in excess of the 10 percent opportunity cost of capital. You know, therefore, that D is acceptable. You now ask yourself whether it is worth making the additional $10,000 investment in E. The incremental flows from undertaking E rather than D are as follows:

Project	Cash Flows ($) C_0	C_1	IRR (%)	NPV at 10%
E − D	−10,000	+15,000	50	+3,636

The IRR on the incremental investment is 50 percent, which is also well in excess of the 10 percent opportunity cost of capital. So you should prefer project E to project D.[5]

Unless you look at the incremental expenditure, IRR is unreliable in ranking projects of different scale. It is also unreliable in ranking projects which offer different patterns of cash flow over time. For example, suppose the firm can take project F *or* project G but not both (ignore H for the moment):

	Cash Flows ($)								
Project	C_0	C_1	C_2	C_3	C_4	C_5	Etc.	IRR (%)	NPV at 10%
F	−9,000	+6,000	+5,000	+4,000	0	0	. . .	33	3,592
G	−9,000	+1,800	+1,800	+1,800	+1,800	+1,800	. . .	20	9,000
H		−6,000	+1,200	+1,200	+1,200	+1,200	. . .	20	6,000

Project F has a higher IRR, but project G has the higher NPV. Figure 5.5 shows why the two rules give different answers. The blue line gives the net present value of project F at different rates of discount. Since a discount rate of 33 percent produces a net present value of zero, this is the internal rate of return for project F. Similarly, the green line shows the net present value of project G at different discount rates.

[5]You may, however, find that you have jumped out of the frying pan into the fire. The series of incremental cash flows may involve several changes in sign. In this case there are likely to be multiple IRRs and you will be forced to use the NPV rule after all.