8 Net Present Value and Other Investment Criteria

In 2004 Paul Stoddart, former head of the Minardi Formula One racing team, announced his intention to start a new Australian airline (Ozjet) to compete with Qantas in the business passenger market. His initial plans were to run eight flights a day between Sydney and Melbourne using three Boeing 737-300 aircraft. Then, as passenger numbers increased, he planned to expand operations to possibly ten aircraft and fly to other major capital cities: Brisbane, Adelaide and Perth. The Ozjet configuration was for a business class only with sixty business seats per plane. Although taking on Qantas is no easy task, Paul believed there was plenty of room for competition and was aiming to obtain only about 2% of the market. For example the Sydney–Melbourne market carried between 600 000 and 700 000 passengers a month. Ozjet started carrying passengers in early 2006, but after several months of operations, with losses of $10 million dollars and few forward bookings, Paul Stoddart announced the closure of Ozjet.

AFTER STUDYING THIS CHAPTER, YOU SHOULD HAVE A GOOD UNDERSTANDING OF:

- The payback rule and some of its shortcomings.
- Accounting rates of return and some of the problems with them.
- The internal rate of return criterion and its strengths and weaknesses.
- Why the net present value criterion is the best way to evaluate proposed investments.

Ozjet's announcement of starting a new airline in Australia offers an example of a capital budgeting decision. An investment such as this, with a big price tag, is obviously a major undertaking, and the potential risks and rewards must be carefully evaluated. In this chapter, we discuss the basic tools used in making such capital investment decisions.

This chapter introduces you to the practice of capital budgeting. Back in Chapter 1 we saw that maximising the value of the company is the goal of financial management.

Thus what we need to learn is how to tell whether a particular investment will achieve that goal or not. This chapter considers a variety of techniques that are used in practice. More importantly, it shows how many of these techniques can be misleading, and it explains why the net present value approach is the right one to maximise shareholder wealth.

In Chapter 1 we identified the three key areas of concern to the financial manager. The first of these was the following: what long-term investments should we make? We called this the *capital budgeting decision*, which is sometimes called the investment decision. In this chapter, we begin to deal with the issues that arise in answering this question.

The process of allocating, or budgeting, capital is usually more involved than just deciding whether or not to buy a particular fixed asset or start a new project. We will frequently face broader issues, such as whether we should launch a new product or enter a new market. Decisions such as these will determine the nature of a firm's operations and products for years to come, primarily because fixed asset investments are generally long lived and not easily reversed once they are made.

For these reasons, the capital budgeting question is probably the most important issue in corporate finance. How a firm chooses to finance its operations (the capital structure question or financing decision) and how a firm manages its short-term operating activities (the working capital question) are certainly issues of concern, but it is the fixed assets that define the business of the firm. Airlines, for example, are airlines because they operate aircraft, regardless of how they finance them.

Any firm possesses a huge number of possible investments. Each possible investment is an option available to the firm. Some options are valuable and some are not. The essence of successful financial management, of course, is learning to identify which are which. With this in mind, our goal in this chapter is to introduce you to the techniques used to analyse potential business ventures (or options) to decide which are worth undertaking.

We present and compare several different procedures used in practice. Our primary goal is to acquaint you with the advantages and disadvantages of the various approaches. As we shall see, the most important concept in this area is the idea of net present value. We consider this next.

NET PRESENT VALUE 8.1

In Chapter 1, we argued that the goal of financial management is to maximise value for the shareholders. The financial manager must therefore examine a potential investment in light of its likely effect on the price of the firm's shares. In this section, we describe a widely used procedure for doing this, the net present value approach.

The Basic Idea

An investment is worth undertaking if it creates value for its owners. In the most general sense, we create value by identifying an investment worth more in the marketplace than it costs us to acquire. How can something be worth more than it costs? It is a case of the whole being worth more than the cost of the parts.

For example, suppose you buy a run-down house for $325 000 and spend another $125 000 on painters, plumbers and so on to fix it up. Your total investment is $450 000.

When the work is completed, you put the house back on the market and find that it is worth $500 000. The market value ($500 000) exceeds the cost ($450 000) by $50 000. What you have done here is to act as a manager and bring together some fixed assets (a house), some labour (plumbers, carpenters and others), and some materials (carpeting, paint and so on). The net result is that you have created $50 000 in value. Put another way, this $50 000 is the *value added* by management. This does not happen overnight and will take time—how long is something we will take into account later in the chapter. With our house example, it turned out *after the fact* that $50 000 in value was created. Things thus worked out very nicely. The real challenge, of course, would have been to somehow identify *ahead of time* whether or not investing the necessary $50 000 was a good idea in the first place. This is what capital budgeting is all about: namely, trying to determine whether a proposed investment or project will be worth more than it costs once it is in place.

net present value (NPV)
The difference between an investment's market value and its initial investment.

For reasons that will be obvious in a moment, the difference between an investment's market value and its cost is called the **net present value** of the investment, abbreviated **NPV**. In other words, net present value is a measure of how much value is created or added today by undertaking an investment. Given our goal of creating value for the shareholders, the capital budgeting process can be viewed as a search for investments with positive net present values.

With our run-down house, you can probably imagine how we would go about making the capital budgeting decision. We would first look at what comparable, fixed-up properties were selling for in the market. We would then get estimates of the cost of buying a particular property, fixing it up and bringing it to market. At this point, we have an estimated total cost and an estimated market value. If the difference is positive, then this investment is worth undertaking because it has a positive estimated net present value. This assumes that it takes little time to fix up the house and sell it. There is risk, of course, because there is no guarantee that our estimates will turn out to be correct.

As our example illustrates, investment decisions are greatly simplified when there is a market for assets similar to the investment we are considering. Capital budgeting becomes much more difficult when we cannot observe the market price for at least roughly comparable investments. The reason is that we are then faced with the problem of estimating the value of an investment using only indirect (or secondary) market information. Unfortunately, this is precisely the situation the financial manager usually encounters. We examine this issue next.

Estimating Net Present Value

Imagine we are thinking of starting a business to produce and sell a new product, say, organic fertiliser. We can estimate the start-up costs with reasonable accuracy because we know what we will need to buy to begin production. Would this be a good investment? Based on our discussion, you know that the answer depends on whether or not the value of the new business exceeds the cost of starting it. In other words, does this investment have a positive NPV?

This problem is much more difficult than our house example, because entire fertiliser companies are not routinely bought and sold in the marketplace, so it is essentially impossible to observe the market value of a similar investment. As a result, we must somehow estimate this value by other means.

Based on our work in Chapters 4 and 5, you may be able to guess how we will go about estimating the value of our fertiliser business. We will first try to estimate the future cash flows we expect the new business to produce. We will then apply our basic discounted cash flow procedure to estimate the present value of those cash flows. Once we have this estimate, we then estimate NPV as the difference between the present value of the future cash flows and the cost of the investment. As we mentioned in Chapter 5, this procedure is often called **discounted cash flow**, or **DCF**, **valuation**.

discounted cash flow (DCF) valuation
The process of valuing an investment by discounting its future cash flows.

To see how we might go about estimating NPV, suppose we believe the cash revenues from our fertiliser business will be $20 000 per year, assuming everything goes as expected. Cash costs (including taxes) will be $14 000 per year. We will wind down the business in eight years. The plant, property and equipment will be worth $2000 as salvage value at that time. The project costs $30 000 to launch. We use a 15% discount rate on new projects such as this one. Is this a good investment? If there are 1000 shares outstanding, what will be the effect on the price per share from taking the investment?

From a purely mechanical perspective, we need to calculate the present value of the future cash flows at 15% discount rate. The net cash inflow will be $20 000 cash income less $14 000 in costs per year for eight years. These cash flows are illustrated in Figure 8.1.

FIGURE 8.1

Project cash flows ($ in thousands)

Time (years)	0	1	2	3	4	5	6	7	8
Initial cost	–$30								
Inflows		$20	$20	$20	$20	$20	$20	$20	$20
Outflows		– 14	– 14	– 14	– 14	– 14	– 14	– 14	– 14
Net inflow		$ 6	$ 6	$ 6	$ 6	$ 6	$ 6	$ 6	$ 6
Salvage									2
Net cash flow	–$30	$ 6	$ 6	$ 6	$ 6	$ 6	$ 6	$ 6	$ 8

As Figure 8.1 suggests, we effectively have an eight-year annuity of $20 000 – 14 000 = $6000 per year along with a single lump-sum inflow of $2000 in the eighth year. Calculating the present value of the future cash flows thus comes down to the same type of problem we considered in Chapter 5: a present value of an annuity and a single amount. The total present value is:

$$\begin{aligned}\text{Present value} &= \$6000 \times \left(1 - 1/(1.15)^8\right)/0.15 + 2000/(1.15)^8 \\ &= \$6000 \times 4.4873 + 2000/3.0590 \\ &= \$26\,924 + 654 \\ &= \$27\,578\end{aligned}$$

When we compare this with the $30 000 estimated cost, the NPV is:

$$\text{NPV} = -\$30\,000 + 27\,578 = -\$2422$$

Therefore, this is *not* a good investment. Based on our estimates, taking it would *decrease* the total value of the firm's shares by $2422. With 1000 shares outstanding, our best estimate of the impact of taking this project is a loss of value of $2422/1000 = $2.422 per share.

Our fertiliser example illustrates how NPV estimates can be used to determine whether an investment is desirable in that negative NPV values decrease shareholder wealth and positive ones increase it. From our example, notice that if the NPV is negative, the effect on share value will be unfavourable. If the NPV were positive, the effect would be favourable. As a consequence, all we need to know about a particular proposal for the purpose of making an accept–reject decision is whether the NPV is positive or negative.

Given that the goal of financial management is to maximise share value, our discussion in this section leads us to the *net present value decision rule*:

> An investment should be accepted if the net present value is positive and rejected if it is negative.

In the unlikely event that the net present value turned out to be exactly zero, we would be indifferent between taking the investment and not taking it.

Two comments about our example are in order. First and foremost, it is not the rather mechanical process of discounting the cash flows that is important. Once we have the cash flows and the appropriate discount rate, the required calculations are fairly straightforward. The task of coming up with the cash flows and the discount rate in the first place is much more challenging. We will have much more to say about this in our next chapter. For the remainder of this chapter, we take it as given that we have estimates of the cash revenues and costs and, where needed, an appropriate discount rate.

The second thing to keep in mind about our example is that the –$2422 NPV is an estimate. Like any estimate, it can be high or low. The only way to find out the true NPV would be to put the investment up for sale and see what we could get for it. We generally will not be doing this, so it is important that our estimates be reliable. Once again, we will have more to say about this later. For the rest of this chapter, we will assume that the estimates are accurate.

EXAMPLE 8.1 Using the NPV Rule

Suppose we are asked to decide whether a new consumer product should be launched. Based on projected sales and costs, we expect that the cash flows over the five-year life of the project will be $2000 in the first two years, $4000 in the next two and $5000 in the last year. It will cost about $10 000 to begin production. We use a 10% discount rate to evaluate new products. What should we do here—should we accept or reject the project?

Given the cash flows and discount rate, we can calculate the total value of the product by discounting the cash flows back to the present:

$$\begin{aligned}\text{Present value} &= \$2000/1.1 + 2000/(1.1)^2 + 4000/(1.1)^3 + 4000/1.1^4 + 5000/(1.1)^5 \\ &= \$1818 + 1653 + 3005 + 2732 + 3105 \\ &= \$12\,313\end{aligned}$$

The present value of the expected cash flows is $12 313, but the cost of getting those cash flows is only $10 000, so the NPV is $12 313 – 10 000 = $2313. This is positive, so, based on the net present value rule, we should take on (accept) the project.

As we have seen in this section, estimating NPV is one way of assessing the ‘profitability’ of a proposed investment. It is certainly not the only way profitability is assessed, and we now turn to some alternatives. As we will see, when compared to NPV, each of the ways of assessing profitability that we examine is flawed in some key way, so, NPV is the preferred approach in principle, if not always in practice.

In our nearby *Spreadsheet Strategies* box, we rework Example 8.1. Notice that we have provided two answers. By comparing the answers with that found in Example 8.1, we see that the first answer is wrong even though we used the spreadsheet’s NPV formula.

Calculating NPVs with a Spreadsheet

SPREADSHEET STRATEGIES

Spreadsheets and financial calculators are commonly used to calculate NPVs. The procedures used by various financial calculators are too different for us to illustrate here, so we will focus on using a spreadsheet (financial calculators are covered at the text book website). Examining the use of spreadsheets in this context also allows us to issue an important warning covered later in this chapter. We will rework Example 8.1:

	A	B	C	D	E	F	G	H
1								
2	**Using a spreadsheet to calculate net present values**							
3								
4	From Example 8.1, the project's cost is $10 000. The cash flows are $2000 per year for the first two							
5	years, $4000 for the next two, and $5000 in the last year.							
6	The discount rate is 10 percent; what is the NPV?							
7								
8		Year	Cash flow					
9		0	–$10 000	Discount rate =		10%		
10		1	2,000					
11		2	2,000		**NPV =**	**$2 102.72**	(*wrong* answer)	
12		3	4,000		**NPV =**	**$2 312.99**	(*right* answer)	
13		4	4,000					
14		5	5,000					
15								
16	The formula entered in cell F11 is = NPV(F9,C9:C14). This gives the wrong answer because the							
17	NPV function actually calculates present values, not net present values.							
18								
19	The formula entered in cell F12 is = NPV(F9,C10:C14) + C9. This gives the right answer because the							
20	NPV function is used to calculate the present value of the cash flows and then the initial cost is							
21	subtracted to calculate the answer. Notice that we added cell C9 because it is already negative.							

What happened is that the 'NPV' function in our spreadsheet is actually a PV function; unfortunately, one of the original spreadsheet programs many years ago got the definition wrong, and subsequent spreadsheets have copied it! Our second answer shows how to use the formula properly.

The example here illustrates the danger of blindly using calculators or computers without understanding what is going on; we shudder to think of how many capital budgeting decisions in the real world are based on incorrect use of this particular function. We will see another example of something that can go wrong with a spreadsheet later in the chapter.

CONCEPT QUESTIONS

8.1a What is the net present value rule?

8.1b If we say an investment has a positive NPV of $1000, what exactly do we mean?

8.2 THE PAYBACK RULE

It is common in practice to talk of the payback on a proposed investment. Loosely, the *payback* is the length of time it takes to recover our initial investment, or 'get our bait back'. Because of this, it is often called the *payback period*. Because this idea is widely understood and used, we will examine it in some detail.

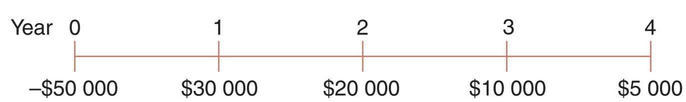
Defining the Payback Rule

We can illustrate how to calculate a payback with an example. Figure 8.2 below shows the cash flows from a proposed investment. How many years do we have to wait until the accumulated cash flows from this investment equal or exceed the cost of the investment? As Figure 8.2 indicates, the initial investment is $50 000. After the first year, the firm has recovered $30 000, leaving $20 000 outstanding. The cash flow in the second year is exactly $20 000, so this investment 'pays for itself' in exactly two years. Put another way, the **payback period** (or just payback) is two years. If we require a payback of, say, three years or less, then this investment is acceptable. This illustrates the *payback period rule*:

payback period
The amount of time required for an investment to generate net cash flows sufficient to recover its initial cost (investment).

> Based on the payback rule, an investment is acceptable if its calculated payback period is less than some pre-specified number of years.

FIGURE 8.2
Net project cash flows



In our example the payback works out to be exactly two years. This will not usually happen, of course. When the numbers do not work out exactly, it is customary to work with fractional years. For example, suppose the initial investment is $60 000, and the cash flows are $20 000 in the first year and $90 000 in the second. The cash flows over the first two years are $110 000, so the project obviously pays back sometime in the second year. After the first year, the project has paid back $20 000, leaving $40 000 to be recovered. To work out the fractional year, note that this $40 000 is $40 000/90 000 = 4/9 of the second year's cash flow. Assuming that the $90 000 cash flow is paid uniformly throughout the year, the payback would thus be $1\frac{4}{9}$ years.

Now that we know how to calculate the payback period on an investment, using the payback period rule for making decisions is straightforward. A particular cut-off time is selected, say, two years, and all investment projects that have payback periods of two years or less are accepted, and all of those that pay back in more than two years are rejected.

Table 8.1 illustrates cash flows for five different projects. The figures shown as the Year 0 cash flows are the cost of the investment. We examine these to indicate some peculiarities that can, in principle, arise with payback periods.

The payback for the first project, A, is easily calculated. The sum of the cash flows for the first two years is $70, leaving us with $100 – 70 = $30 to go. Since the cash flow in the third year is $50, the payback occurs sometime in that year. When we compare the $30 we need with the $50 that will be coming in, we get $30/50 = 0.60; so, payback will occur 60% of the way into the year. The payback period is thus 2.6 years.

TABLE 8.1

Expected cash flows for Projects A to E

Year	A	B	C	D	E
0	–$100	–$200	–$200	–$200	–$50
1	30	40	40	100	100
2	40	20	20	100	–50 000 000
3	50	10	0	–200	
4	60		130	200	

Project B's payback is also easy to calculate: it *never* pays back because the cash flows never total up to the original investment. Project C has a payback of exactly four years because it supplies the $130 that B is missing in Year 4. Project D is a little strange. Because of the negative cash flow in Year 3, you can easily verify that it has two different payback periods, two years and four years. Which of these is correct? Both of them: the way the payback period is calculated does not guarantee a single answer. Finally, Project E is obviously unrealistic, but it does pay back in six months, illustrating the point that a rapid payback does not guarantee a good investment.

Calculating Payback — EXAMPLE 8.2

The projected cash flows from a proposed investment are:

Year	Cash Flow
1	$100
2	200
3	500

This project costs $500. What is the payback period for this investment?

The initial cost is $500. After the first two years, the cash flows total $300. After the third year, the total cash flow is $800, so the project pays back sometime between the end of Year 2 and the end of Year 3. Since the accumulated cash flows for the first two years are $300, we need to recover $200 in the third year. The third-year cash flow is $500, so we will have to wait $200/500 = 0.40 year to recover the $200. The payback period is thus 2.4 years, or about two years and five months.

Analysing the Payback Rule

When compared with the NPV decision rule, the payback period rule has some rather severe shortcomings. First, the payback period is calculated by simply adding up the future cash flows. There is no discounting involved, so the time value of money is completely ignored. Second, the payback rule also fails to consider risk differences between projects. The payback would be calculated the same way for both very risky and very safe projects. Third, it completely ignores cash flows after the payback. For example a project may last twenty years. The calculation of payback for the project is seven years, and all of the following thirteen years of cash flows are ignored.

Perhaps the biggest problem with the payback period rule is coming up with the right cut-off period, because we do not really have an objective basis for choosing a particular number. Put another way, there is no economic rationale for looking at payback in the first place, so we have no guide as to how to pick the cut-off. As a result, we end up using a number that is arbitrarily chosen.

Suppose we have somehow decided on an appropriate payback period, say two years or less. As we have seen, the payback period rule ignores the time value of money for the first two years. More seriously, cash flows after the second year are ignored entirely. To see this, consider the two investments, Long and Short, in Table 8.2. Both projects cost $250. Based on our discussion, the payback on Long is 2 + $50/100 = 2.5 years, and the payback on Short is 1 + $150/200 = 1.75 years. With a cut-off of two years, Short is acceptable and Long is not.

TABLE 8.2

Investment projected cash flows

Year	Long	Short
0	–$250	–$250
1	100	100
2	100	200
3	100	0
4	100	0

Is the payback period rule giving us the right decisions? Maybe not. Suppose again that we require a 15% return on this type of investment. We can calculate the NPV for these two investments as:

$$\text{NPV (Short)} = -\$250 + 100/1.15 + 200/(1.15)^2 = -\$11.81$$
$$\text{NPV (Long)} = -\$250 + 100 \times \left(1 - 1/(1.15)^4\right)/0.15 = \$35.50$$

Now we have a problem. The NPV of the shorter-term investment is actually negative, meaning that taking it diminishes the value of the shareholders' equity. The opposite is true for the longer-term investment—it increases share value.

Our example illustrates two primary shortcomings of the payback period rule. First, by ignoring time value, we may be led to take investments (like Short) that actually are worth less than they cost. Second, by ignoring cash flows beyond the cut-off, we may be led to reject profitable long-term investments (like Long). More generally, using a payback period rule will tend to bias us towards shorter-term investments.

Redeeming Qualities of the Rule

Despite its shortcomings, the payback period rule is often used by large and sophisticated companies when they are making relatively minor decisions. There are several reasons for this. The primary reason is that many decisions simply do not warrant detailed analysis because the cost of the analysis would exceed the possible loss from a mistake. As a practical matter, an investment that pays back rapidly and has benefits extending beyond the cut-off period probably has a positive NPV.

Small investment decisions are made by the hundreds every day in large organisations. Moreover, they are made at all levels. As a result, it would not be uncommon for a corporation to require, for example, a two-year payback on all investments of less than $10 000. Investments larger than this are subjected to greater scrutiny. The requirement of a two-year payback is not perfect for the reasons we have seen, but it does exercise some control over expenditures and thus has the effect of limiting possible losses.

In addition to its simplicity, the payback rule has two other positive features. First, because it is biased towards short-term projects, it is biased towards liquidity. In other words, a payback rule tends to favour investments that free up cash for other uses more quickly. This could be very important for a small business; it would be less so for a large corporation. Second, the cash flows that are expected to occur later in a project's life are probably more uncertain. Arguably, a payback period rule adjusts for the extra riskiness of later cash flows, but it does so in a rather draconian fashion—by ignoring them altogether.

We should note here that some of the apparent simplicity of the payback rule is an illusion. The reason is that we must still come up with the cash flows first, and, as we discuss above, this is not at all easy to do. Thus, it would probably be more accurate to say that the *concept* of a payback period is both intuitive and easy to understand.

Summary of the Rule

To summarise, the payback period is a kind of 'break-even' measure. Because time value of money is ignored, you can think of the payback period as the length of time it takes to break even in an accounting sense, but not in an economic sense. The biggest drawback to the pay-back period rule is that it does not ask the right question. The relevant issue is the impact an investment will have on the value of our shares, not how long it takes to recover the initial investment.

Nevertheless, because it is so simple, companies often use it as a screen for dealing with the myriad of minor investment decisions they have to make. There is certainly nothing wrong with this practice. Like any simple rule of thumb, there will be some errors in using it, but it would not have survived all this time if it were not useful. Now that you understand the rule, you can be on the alert for those circumstances under which it might lead to problems. To help you remember, the following table lists the pros and cons of the payback period rule.

Advantages and Disadvantages of the Payback Period Rule

Advantages	Disadvantages
1. Easy to understand	1. Ignores the time value of money
2. Adjusts for uncertainty of later cash flows	2. Requires an arbitrary cut-off point
3. Biased towards liquidity	3. Ignores cash flows beyond the cut-off date
	4. Biased against long-term projects, such as research and development, and new projects

CONCEPT QUESTIONS

8.2a In words, what is the payback period? The payback period rule?

8.2b Why do we say that the payback period is, in a sense, an accounting break-even measure?

THE AVERAGE ACCOUNTING RETURN 8.3

Another attractive, but flawed, approach to making capital budgeting decisions involves the **average accounting return (AAR)** sometimes called the *accounting rate of return* (ARR). There are many different definitions of the AAR. However, in one form or another, the AAR is always defined as:

average accounting return (AAR) also known as **accounting rate of return (ARR)**
An investment's average net income divided by its average book value.

$$\frac{\text{Some measure of average accounting profit}}{\text{Some measure of average accounting value}}$$

The specific definition we will use is:

$$\frac{\text{Average net income}}{\text{Average book value}}$$

To see how we might calculate this number, suppose we are deciding whether or not to open a shop in a new shopping mall. The required investment to fit out the shop is $500 000. The store would have a five-year life because everything reverts to the mall owners after that time. The required investment of $500 000 would be 100% depreciated (straight-line) over five years, so the depreciation would be $500 000/5 = $100 000 per year. The tax rate is 25%. Table 8.3 contains the projected revenues and expenses. Based on these figures, net income in each year is also shown.

To calculate the average book value for this investment, we note that we started out with a book value of $500 000 (the initial cost) and ended up at $0. The average book value during the life of the investment is thus ($500 000 + 0)/2 = $250 000. As long as we use straight-line depreciation and a zero salvage value, the average investment will always be one-half of the initial investment.[1]

Looking at Table 8.3, we see that net income is $100 000 in the first year, $150 000 in the second year, $50 000 in the third year, $0 in Year 4, and –$50 000 in Year 5. The average net income, then, is:

$$[\$100\,000 + 150\,000 + 50\,000 + 0 + (-50\,000)]/5 = \$50\,000$$

The average accounting return is:

$$\text{AAR} = \frac{\text{Average net income}}{\text{Average book value}} = \frac{\$50\,000}{250\,000} = 20\%$$

If the firm has a target AAR less than 20%, then this investment is acceptable; otherwise it is not. The *average accounting return rule* is thus:

> Based on the average accounting return rule, a project is acceptable if its average accounting return exceeds a target average accounting return.

TABLE 8.3

Projected yearly revenue and costs for average accounting return

	Year 1	Year 2	Year 3	Year 4	Year 5
Revenue	$433 333	$450 000	$266 667	$200 000	$133 333
Expenses	200 000	$150 000	100 000	100 000	100 000
Earnings before depreciation	$233 333	$300 000	$166 667	$100 000	$ 33 333
Depreciation	100 000	100 000	100 000	100 000	100 000
Earnings before taxes	$133 333	$200 000	$ 66 667	$ 0	–$ 66 667
Taxes (25%)	33 333	50 000	16 667	0	– 16 667
Net Income	**$100 000**	**$150 000**	**$ 50 000**	**$ 0**	**–$ 50 000**

$$\text{Average net income} = \frac{(\$100\,000 + \$150\,000 + \$50\,000 + 0 - \$50\,000)}{5} = \$50\,000$$

$$\text{Average book value} = \frac{\$500\,000 + 0}{2} = \$250\,000$$

[1] We could, of course, calculate the average of the six book values directly. In thousands, we would have ($500 + 400 + 300 + 200 + 100 + 0)/6 = $250.

As we will see next, this rule has a number of problems.

You should recognise the chief drawback to the AAR immediately. Above all else, the AAR is not a rate of return in any meaningful economic sense. Instead, it is the ratio of two accounting numbers, and it is not comparable to the returns offered, for example, in financial markets.[2]

One of the reasons the AAR is not a true rate of return is that it ignores the time value of money. When we average figures that occur at different times, we are treating the near future and the more distant future in the same way. There was no discounting involved when we computed the average net income, for example.

The second problem with the AAR is similar to the problem we had with the payback period rule concerning the lack of an objective cut-off period. Since a calculated AAR is really not comparable to a market return, the target AAR must somehow be specified. There is no generally agreed-upon way to do this. One way of doing it is to calculate the AAR for the firm as a whole and use this as a benchmark, but there are lots of other ways as well.

The third, and perhaps worst, flaw in the AAR is that it does not even look at the right things. Instead of cash flow and market value, it uses net income and book value. These are both poor substitutes. As a result, an AAR does not tell us what the effect on share price will be from making an investment, so it does not tell us what we really want to know.

Does the AAR have any redeeming features? About the only one is that it almost always can be computed. The reason is that accounting information will almost always be available, both for the project under consideration and for the firm as a whole. We hasten to add that once the accounting information is available, we can always convert it to cash flows, and so even its availability is not a particularly important advantage. The advantages and disadvantages of the AAR are summarised in the table that follows.

Advantages and Disadvantages of the Average Accounting Return (AAR)

Advantages	Disadvantages
1. Easy to calculate 2. Needed information will usually be available	1. Not a true rate of return; time value of money is ignored 2. Uses an arbitrary benchmark cut-off rate 3. Based on accounting net income and book values, not cash flows and market values

CONCEPT QUESTIONS

8.3a What is an average accounting rate of return, or AAR?

8.3b What are the weaknesses of the AAR decision rule?

THE INTERNAL RATE OF RETURN 8.4

We now come to the most important alternative to NPV, the **internal rate of return**, universally known as the **IRR**. As we will see, the IRR is closely related to NPV. With the IRR we try to find a single rate of return that summarises the merits of a project.

internal rate of return (IRR)
The discount rate that makes the NPV of an investment zero.

[2] The AAR is closely related to the return on assets, or ROA, discussed in Chapter 3. In practice, the AAR is sometimes computed by first calculating the ROA for each year and then averaging the results. This produces a number that is similar, but not identical, to the one we computed.

Furthermore, we want this rate to be an 'internal' rate in the sense that it depends only on the cash flows of a particular investment, not on rates offered elsewhere.

To illustrate the idea behind the IRR, consider a project that costs \$100 today and pays \$110 in one year. Suppose you were asked, 'What is the return on this investment?' What would you say? It seems both natural and obvious to say that the return is 10% because, for every dollar we put in, we get \$1.10 back. In fact, as we will see in a moment, 10% is the internal rate of return, or IRR, on this investment.

Is this project with its 10% IRR a good investment? Once again, it would seem apparent that this is a good investment only if our required return is less than 10%. This intuition is also correct and illustrates the *IRR rule*:

> Based on the IRR rule, an investment is acceptable if the IRR exceeds the required return. It should be rejected otherwise.

Imagine that we wanted to calculate the NPV for our simple investment. At a discount rate of *R,* the NPV is:

$$\text{NPV} = -\$100 + 110/(1 + R)$$

Now, suppose we did not know the discount rate. This presents a problem, but we could still ask how high the discount rate would have to be before this project was unacceptable. We know that we are indifferent between taking and not taking this investment when its NPV is just equal to zero. In other words this investment is *economically* a break-even proposition when the NPV is zero because value is neither created nor destroyed. To find the break-even discount rate, we set NPV equal to zero and solve for *R:*

$$\begin{aligned} \text{NPV} &= -\$100 + 110/(1 + R) \\ \$100 &= \$110/(1 + R) \\ 1 + \text{R} &= \$110/100 = 1.10 \\ \text{R} &= 10\% \end{aligned}$$

This 10% is what we already have called the return on this investment. What we have now illustrated is that the internal rate of return on an investment (or just 'return' for short) is the discount rate that makes the NPV equal to zero. This is an important observation, so it bears repeating:

> The IRR on an investment is the required return that results in a zero NPV when it is used as the discount rate.

The fact that the IRR is simply the discount rate that makes the NPV equal to zero is important because it tells us how to calculate the returns on more complicated investments. As we have seen, finding the IRR turns out to be relatively easy for a single-period investment. However, suppose you were now looking at an investment with the cash flows shown in Figure 8.3. As illustrated, this investment costs \$100 and has a cash flow of \$60 per year for two years, so it is only slightly more complicated than our single-period example. However, if you were asked for the return on this investment, what would you say? There does not seem to be any obvious answer (at least to us). However, based on what we now know, we can set the NPV equal to zero and solve for the discount rate:

$$\text{NPV} = 0 = -100 + 60/(1 + \text{IRR}) + 60/(1 + \text{IRR})^2$$

Unfortunately, the only way to find the IRR in general is by trial and error, either by hand or by calculator. This is precisely the same problem that came up in Chapter 5 when we found the unknown rate for an annuity and in Chapter 6 when we found the yield to maturity on a bond. In fact we now see that, in both of those cases, we were finding an IRR.

In this particular case the cash flows form a two-period, $60 annuity. To find the unknown rate, we can try some different rates until we get the answer. If we were to start with a 0% rate, the NPV would obviously be $120 – 100 = $20. At a 10% discount rate, we would have:

$$NPV = -\$100 + 60/1.1 + 60/(1.1)^2 = 4.13$$

Now we are getting close. We can summarise these and some other possibilities as shown in Table 8.4. From our calculations, the NPV appears to be zero between 10% and 15%, so the IRR is somewhere in that range. With a little more effort, we can find that the IRR is about 13.1%. So, if our required return is less than 13.1%, we would take this investment. If our required return exceeds 13.1%, we would reject it.

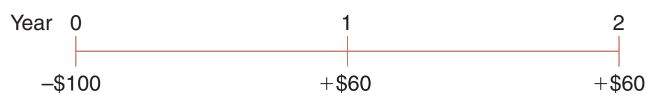


FIGURE 8.3

Project cash flows

TABLE 8.4

NPV at different discount rates

Discount Rate	NPV
0%	$20.00
5	11.56
10	4.13
15	–2.46
20	– 8.33

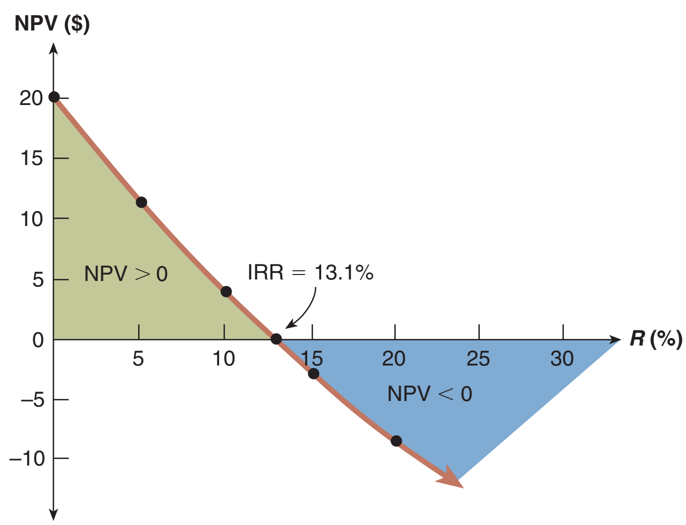


FIGURE 8.4

An NPV profile

net present value profile

A graphical representation of the relationship between an investment's NPVs and various discount rates.

By now you have probably noticed that the IRR rule and the NPV rule appear to be quite similar. In fact the IRR and NPV are referred to as *discounted cash flow techniques,* or *DCF.* The easiest way to illustrate the relationship between NPV and IRR is to plot the numbers we calculated in Table 8.4. We put the different NPVs on the vertical axis, or *y*-axis, and the discount rates on the horizontal axis, or *x*-axis. If we had a very large number of points, the resulting picture would be a smooth curve called a **net present value profile**. Figure 8.4 illustrates the NPV profile for this project. Beginning with a 0% discount rate, we have $20 plotted directly on the *y*-axis. As the discount rate increases, the NPV declines smoothly. Where will the curve cut through the *x*-axis? This will occur where the NPV is just equal to zero, so it will happen right at the IRR of 13.1%.

In our example, the NPV rule and the IRR rule lead to identical accept–reject decisions. We will accept an investment using the IRR rule if the required return is less than 13.1%. As Figure 8.4 illustrates, however, the NPV is positive at any discount rate less than 13.1%, so we would accept the investment using the NPV rule as well. The two rules are equivalent in this case.

EXAMPLE 8.3 Calculating the IRR

A project has a total up-front cost of $435.44. The cash flows are $100 in the first year, $200 in the second year, and $300 in the third year. What is the IRR? If we require an 18% return, should we take this investment?

We will describe the NPV profile and find the IRR by calculating some NPVs at different discount rates. You should check our answers for practice. Beginning with 0%, we have:

Discount Rate	NPV
0%	$164.56
5	100.36
10	46.15
15	0.00
20	–39.61

The NPV is zero at 15%, so 15% is the IRR. If we require an 18% return, then we should not take the investment. The reason is that the NPV is negative at 18% (verify that it is –$24.47). The IRR rule tells us the same thing in this case. We should not take this investment because its 15% return is below our required 18% return.

independent project

The decision to accept or reject the project does not affect the decision to accept or reject any other project.

At this point, you may be wondering whether the IRR and NPV rules always lead to identical decisions. The answer is yes as long as two very important conditions are met. First, the project's cash flows must be *conventional,* meaning that the first cash flow (the initial investment) is negative and all the rest are positive. Second, the project must be an **independent project**, meaning that the decision to accept or reject this project does not affect the decision to accept or reject any other. The first of these conditions is typically met, but the second often is not. In any case, when one or both of these conditions are not met, problems can arise. We discuss some of these in a moment.

Calculating IRRs with a Spreadsheet

SPREADSHEET STRATEGIES

Because IRRs are so tedious to calculate by hand, financial calculators and, especially, spreadsheets are generally used. The procedures used by various financial calculators are too different for us to illustrate here, so we will focus on using a spreadsheet (financial calculators are covered in the textbook website). As the following example illustrates, using a spreadsheet is very easy:

	A	B	C	D	E	F	G	H
1								
2	**Using a spreadsheet to calculate internal rates of return**							
3								
4	Suppose we have a four-year project that costs $500. The cash flows over the four-year life will be							
5	$100, $200, $300, and $400. What is the IRR?							
6								
7		Year	Cash flow					
8		0	−$500					
9		1	100		**IRR =**	27.3%		
10		2	200					
11		3	300					
12		4	400					
13								
14								
15	The formula entered in cell F9 is = IRR(C8:C12). Notice that the Year 0 cash flow has a negative sign,							
16	representing the initial cost of the project.							
17								

Problems with the IRR

The problems with the IRR come about when the cash flows are not conventional or when we are trying to compare two or more investments to see which is best. In the first case, surprisingly, the simple question 'What is the return?' can become very difficult to answer. In the second case, the IRR can be a misleading guide.

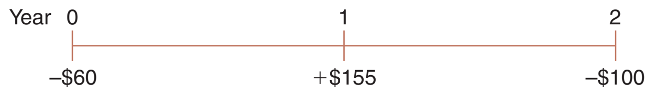
Non-Conventional Cash Flows Suppose we have a strip-mining project that requires a $60 investment. Our cash flow in the first year will be $155. In the second year, the mine is depleted, but we have to spend $100 to restore the terrain. As Figure 8.5 illustrates, both the first and third cash flows are negative.

To find the IRR on this project, we can calculate the NPV at various rates:

Discount Rate	NPV
0%	–$5.00
10	–1.74
20	–0.28
30	0.06
40	–0.31

FIGURE 8.5

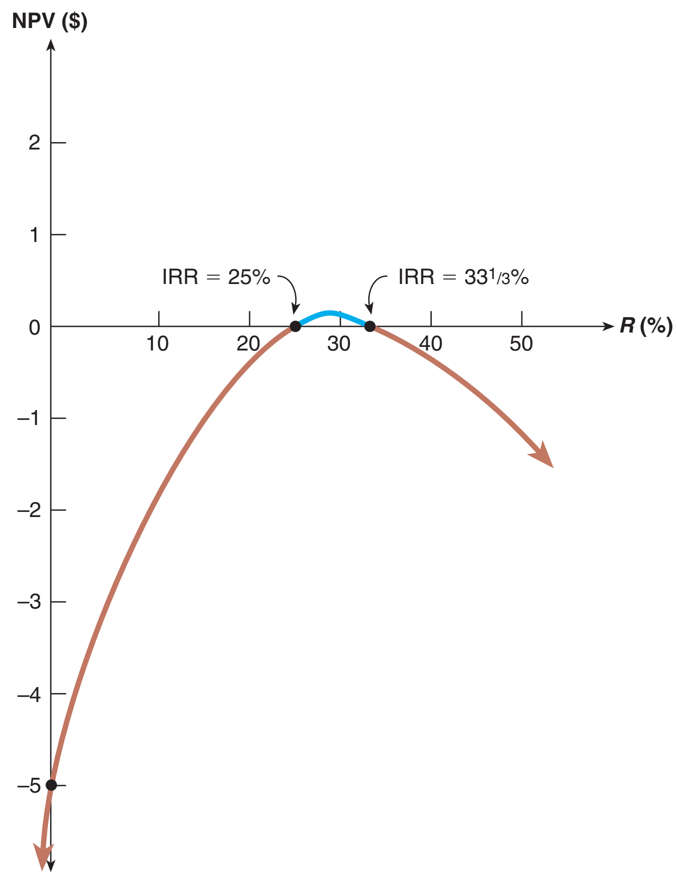
Project cash flows



The NPV appears to be behaving in a very peculiar fashion here. First, as the discount rate increases from 0% to 30%, the NPV starts out negative and becomes positive. This seems backward because the NPV is rising as the discount rate rises. It then starts getting smaller and becomes negative again. What is the IRR? To find out, we draw the NPV profile in Figure 8.6.

FIGURE 8.6

NPV profile



In Figure 8.6, notice that the NPV is zero when the discount rate is 25%, so this is the IRR. Or is it? The NPV is also zero at $33\frac{1}{3}$%. Which of these is correct? The answer is both or neither; more precisely, there is no unambiguously correct answer. This is the **multiple rates of return** problem. Many computer spreadsheet packages are not aware of this problem and just report the first IRR that is found. Others report only the smallest positive IRR, even though this answer is no better than any other. For example, if you enter this problem in our spreadsheet above, it will simply report that the IRR is 25%.

multiple rates of return

The possibility that more than one discount rate makes the NPV of an investment zero.

In our current example, the IRR rule breaks down completely. Suppose our required return were 10%. Should we take this investment? Both IRRs are greater than 10%, so, by the IRR rule, maybe we should. However, as Figure 8.6 shows, the NPV is negative at any discount rate less than 25%, so this is not a good investment. When should we take it? Looking at Figure 8.6 one last time, we see that the NPV is positive only if our required return is between 25% and $33\frac{1}{3}$%.

The moral of the story is that when the cash flows are not conventional, strange things can start to happen to the IRR. This is not anything to get upset about, however, because the NPV rule, as always, works just fine. This illustrates that, oddly enough, the obvious question 'what's the rate of return?' may not always have a good answer.

What Is the IRR? EXAMPLE 8.4

You are looking at an investment that requires you to invest $51 today. You will get $100 in one year, but you must pay out $50 in two years. What is the IRR on this investment?

You are on the alert now to the non-conventional cash flow problem, so you probably will not be surprised to see more than one IRR. However, if you start looking for this IRR by trial and error, it will take you a long time. The reason is that there is no IRR. The NPV is negative at every discount rate, so we should not take this investment under any circumstances. What is the return on this investment? Your guess is as good as ours.

Mutually Exclusive Investments Even if there is a single IRR, another problem can arise concerning **mutually exclusive investment decisions**. If two investments, X and Y, are mutually exclusive, then taking one of them means that we cannot take the other. Two projects that are not mutually exclusive are said to be independent. For example, if we own a corner block of land, then we can build on it either a petrol station or a unit block, but not both. These are mutually exclusive alternatives.

mutually exclusive investment decisions
A situation where taking one investment prevents the taking of another.

Thus far we have asked whether or not a given investment is worth undertaking. There is a related question, however, that comes up very often: given two or more mutually exclusive investments, which one is the best? The answer is simple enough: the best one is the one with the largest NPV. Can we also say that the best one has the highest return? As we show, the answer is no.

To illustrate the problem with the IRR rule and mutually exclusive investments, consider the cash flows from the following two mutually exclusive investments:

Year	Investment A	Investment B
0	–$100	–$100
1	50	20
2	40	40
3	40	50
4	30	60

The IRR for A is 24%, and the IRR for B is 21%. Since these investments are mutually exclusive—we can only take one of them. Simple intuition suggests that Investment A is better because of its higher return. Unfortunately, simple intuition is not always correct.

To see why Investment A is not necessarily the better of the two investments, we have calculated the NPV of these investments for different required returns:

Discount Rate	NPV (A)	NPV (B)
0%	$60.00	$70.00
5	43.13	47.88
10	29.06	29.79
15	17.18	14.82
20	7.06	2.31
25	–1.63	–8.22

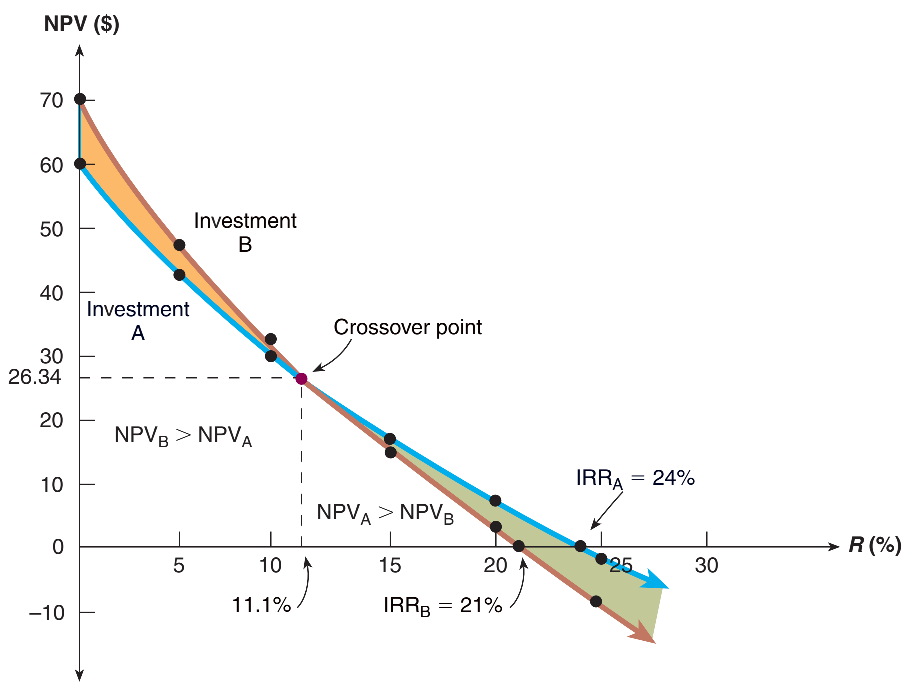
The IRR for A (24%) is larger than the IRR for B (21%). However, if you compute the NPVs, you will see that which investment has the higher NPV depends on the required return. B has greater total cash flow, but it pays back more slowly than A. As a result, it has a higher NPV at lower discount rates.

In our example, the NPV and IRR rankings conflict for some discount rates. If our required return is 10%, for instance, then B has the higher NPV and is thus the better of the two, even though A has the higher return. If our required return is 15%, then there is no ranking conflict: investment A is better.

The conflict between the IRR and NPV for mutually exclusive investments can be illustrated by plotting their NPV profiles as we have done in Figure 8.7. In Figure 8.7, notice that the NPV profiles cross at about 11%. Notice also that at any discount rate less than 11.1%, the NPV for B is higher. In this range, taking B benefits us more than taking A, even though A's IRR is higher. At any rate greater than 11.1%, investment A has the greater NPV.

FIGURE 8.7

NPV profiles for mutually exclusive investments



This example illustrates that whenever we have mutually exclusive projects, we should not rank them on the basis of their IRRs. More generally, any time we are comparing investments to determine which is best, IRRs can be misleading. Instead, we need to look at the relative NPVs to avoid the possibility of choosing incorrectly. Remember, we are ultimately interested in creating value for the shareholders, so the option with the higher NPV is preferred, regardless of the relative returns.

If this seems counterintuitive, think of it this way. Suppose you have two investments. One has a 10% return and makes you $100 richer immediately. The other has a 20% return and makes you $50 richer immediately. Which one do you like better? We would rather have $100 than $50, regardless of the returns, so we like the first one better.

As we saw from Figure 8.7, the crossover rate for Investment A and Investment B is 11.1%. You might be wondering how we got this number. Actually the calculation is fairly easy. We begin by subtracting the cash flows from one project from the cash flows of the second project. In this case, we will subtract Investment B from Investment A. Doing so, we get:

Year	Investment A	Investment B	Cash Flow Difference (A – B)
0	–$100	–$100	$0
1	50	20	30
2	40	40	0
3	40	50	–10
4	30	60	–30

Now all we have to do is calculate the IRR for these differential cash flows, which works out to be 11.1%. Verify for yourself that if you subtract investment A's cash flows from investment B's cash flows the crossover rate is still 11.1%, so it does not matter which one you subtract from which.

Redeeming Qualities of the IRR

Despite its flaws, the IRR is very popular in practice, NPV and IRR are often used together in the decision making process. IRR probably survives because it fills a need that the NPV does not. In analysing investments, people in general, and financial analysts in particular, seem to prefer talking about rates of return rather than dollar values.

In a similar manner the IRR also appears to provide a simple way of communicating information about a proposal. One manager might say to another, 'Remodelling the clerical wing has a 20% return.' This may somehow be simpler than saying, 'At a 10% discount rate, the net present value is $4000.'

Finally, under certain circumstances, the IRR may have a practical advantage over the NPV. We cannot estimate the NPV unless we know the appropriate discount rate, but we can still estimate the IRR. Suppose we did not know the required rate of return on an investment, but we found, for example, that it had a 40% return. We would probably be inclined to take it since it is very unlikely that the required return would be that high. The advantages and disadvantages of the IRR are summarised below.

Advantages and Disadvantages of the Internal Rate of Return	
Advantages	**Disadvantages**
1. Closely related to NPV, often leading to identical decisions	1. May result in multiple answers with non-conventional cash flows
2. Easy to understand and communicate	2. May lead to incorrect decisions in comparisons of mutually exclusive investments

CONCEPT QUESTIONS

8.4a Under what circumstances will the IRR and NPV rules lead to the same accept–reject decisions? When might they conflict?

8.4b Is it generally true that an advantage of the IRR rule over the NPV rule is that we do not need to know the required return to use the IRR rule?

8.5 THE PROFITABILITY INDEX

profitability index (PI)
The present value of an investment's future cash flows divided by its initial cost. Also, *benefit–cost ratio*.

Another method used to evaluate projects involves the **profitability index (PI)**, or benefit–cost ratio. This index is defined as the present value of the future cash flows divided by the initial investment. So if a project costs $200 and the present value of its future cash flows is $220, the profitability index value would be $220/200 = 1.10. Notice that the NPV for this investment is $20, so it is a desirable investment.

More generally, if a project has a positive NPV, then the present value of the future cash flows must be bigger than the initial investment. The profitability index would thus be bigger than 1.00 for a positive NPV investment and less than 1.00 for a negative NPV investment.

How do we interpret the profitability index? In our example, the PI was 1.10. This tells us that, per dollar invested, $1.10 in value or $0.10 in NPV results. The profitability index thus measures 'bang for the buck', that is, the value created per dollar invested. For this reason, it is often proposed as a measure of performance for government or other not-for-profit investments. Also, when capital is scarce, it may make sense to allocate it to those projects with the highest PIs.

The PI is obviously very similar to the NPV. However, consider Investment A that costs $5 and has a $10 present value, and Investment B that costs $100 with a $150 present value. Investment A has an NPV of $5 and a PI of 2. Investment B has an NPV of $50 and a PI of 1.50. If these are mutually exclusive investments, then Investment B is preferred even though it has a lower PI. This ranking problem is very similar to the IRR ranking problem we saw in the previous section. In all, there seems to be little reason to rely on the PI instead of the NPV. Our discussion of the PI is summarised below.

Advantages and Disadvantages of the Profitability Index

Advantages	Disadvantages
1. Closely related to NPV, generally leading to identical decisions	1. May lead to incorrect decisions in comparisons of mutually exclusive investments
2. Easy to understand and communicate	
3. May be useful when available investment funds are limited	

CONCEPT QUESTIONS

8.5a What does the profitability index measure?

8.5b How would you state the profitability index rule?

THE PRACTICE OF CAPITAL BUDGETING 8.6

Given that NPV seems to be telling us directly what we want to know, you might be wondering why there are so many other procedures and why alternative procedures are commonly used. Recall that we are trying to make an investment decision and that we are frequently operating under considerable uncertainty about the future. We can only *estimate* the NPV of an investment in this case. The resulting estimate can be very 'soft', meaning that the true NPV might be quite different.

Because the true NPV is unknown, the astute financial manager seeks clues to assess whether the estimated NPV is reliable. For this reason, firms would typically use multiple criteria for evaluating a proposal. For example, suppose we have an investment with a positive estimated NPV. Based on our experience with other projects, this one appears to have a short payback and a very high AAR. In this case, the different indicators seem to agree that it is 'all systems go'. Put another way, the payback and the AAR are consistent with the conclusion that the NPV is positive.

On the other hand, suppose we had a positive estimated NPV, a long payback and a low AAR. This could still be a good investment, but it looks like we need to be much more careful in making the decision since we are getting conflicting signals. If the estimated NPV is based on projections in which we have little confidence, then further analysis is probably in order. We will consider how to go about this analysis in more detail in the next chapter.

A number of surveys have asked firms what types of investment criteria they actually use. Table 8.5 summarises the results of several of these surveys. The first part of the table is a historical comparison looking at the primary capital budgeting techniques used by large firms through time. In 1959 only 19% of the firms surveyed used either IRR or NPV, and 68% used either payback periods or accounting returns. It is clear that, by the 1980s, IRR and NPV had become the dominant criteria.

Panel B of Table 8.5 summarises the results of a 1999 survey of chief financial officers (CFOs) at both large and small firms in the United States. A total of 392 CFOs responded. What is shown is the percentage of CFOs who always or almost always use the various capital budgeting techniques we described in this chapter. Not surprisingly, IRR and NPV are the two most widely used techniques, particularly at larger firms. However, more than half of the respondents always, or almost always, use the payback criterion as well. In fact, among smaller firms, payback is used about as much as NPV and IRR. Less commonly used are accounting rates of return (or average accounting return) and the profitability index. For quick reference, these criteria are briefly summarised in Table 8.6.

TABLE 8.5 Capital budgeting techniques in practice

A. Historical Comparison of the Primary Use of Various Capital Budgeting Techniques	1959	1964	1970	1975	1977	1979	1981
Payback period	34%	24%	12%	15%	9%	10%	5.0%
Average accounting return (AAR)	34	30	26	10	25	14	10.7
Internal rate of return (IRR)	19	38	57	37	54	60	65.3
Net present value (NPV)	–	–	–	26	10	14	16.5
IRR or NPV	19	38	57	63	64	74	81.8

(*cont. overleaf*)

B. Percentage of CFOs Who Always or Almost Always Use a Given Technique in 1999

Capital Budgeting Technique	Percentage Always or Almost Always Use	Average Score Scale is 4 (always) to 0 (never) Overall	Large Firms	Small Firms
Internal rate of return	76%	3.09	3.41	2.87
Net present value	75	3.08	3.42	2.83
Payback period	57	2.53	2.53	2.72
Accounting rate of return	20	1.34	1.34	1.41
Profitability index	12	0.83	0.75	0.88

Sources: J. R. Graham and C. R. Harvey, 'The Theory and Practice of Corporate Finance: Evidence from the Field', *Journal of Financial Economics*, May–June 2001, pp. 187–244; J. S. Moore and A. K. Reichert, 'An Analysis of the Financial Management Techniques Currently Employed by Large U.S. Corporations', *Journal of Business Finance and Accounting*, Winter 1983, pp. 623–45; M. T. Stanley and S. R. Block, 'A Survey of Multinational Capital Budgeting', *The Financial Review*, March 1984, pp. 36–51.

TABLE 8.6
Summary of investment criteria

I. Discounted cash flow criteria

A. *Net present value (NPV).* The NPV of an investment is the difference between its market value and its cost/initial investment. The NPV rule is to accept a project if its NPV is positive. NPV is frequently estimated by calculating the present value of the future cash flows (to estimate market value) and then subtracting the cost. NPV has no serious flaws; it is the preferred decision criterion.

B. *Internal rate of return (IRR).* The IRR is the discount rate that makes the estimated NPV of an investment equal to zero; it is sometimes called the *discounted cash flow (DCF) return.* The IRR rule is to take a project when its IRR exceeds the required return. IRR is closely related to NPV, and it leads to exactly the same decisions as NPV for conventional, independent projects. When project cash flows are not conventional, there may be no IRR or there may be more than one. More seriously, the IRR cannot be used to rank mutually exclusive projects; the project with the highest IRR is not necessarily the preferred investment.

C. *Profitability index (PI).* The PI, also called the *benefit–cost ratio*, is the ratio of present value to cost. The PI rule is to take an investment if the index exceeds 1. The PI measures the present value of an investment per dollar invested. It is quite similar to NPV, but, like IRR, it cannot be used to rank mutually exclusive projects. However, it is sometimes used to rank projects when a firm has more positive NPV investments than it can currently finance.

II. Payback criteria

A. *Payback period.* The payback period is the length of time until the sum of an investment's cash flows equals its cost. The payback period rule is to take a project if its payback is *less* than some cut-off. The payback period is a flawed criterion primarily because it ignores risk, the time value of money, and cash flows beyond the cut-off point.

III. Accounting criteria

Average accounting return (AAR). The AAR is a measure of accounting profit relative to book value. It is *not* related to the IRR, but it is similar to the accounting return on assets (ROA) measure in Chapter 3. The AAR rule is to take an investment if its AAR exceeds a benchmark AAR. The AAR is seriously flawed for a variety of reasons, and it has little to recommend it.

CONCEPT QUESTIONS

8.6a What are the most commonly used capital budgeting procedures?

8.6b Since NPV is conceptually the best tool for capital budgeting, why do you think multiple measures are used in practice?

SUMMARY AND CONCLUSIONS

This chapter has covered the different criteria used to evaluate proposed investments. The five criteria, in the order in which we discussed them, are:

1. Net present value (NPV)
2. Payback period
3. Average accounting return (AAR)
4. Internal rate of return (IRR)
5. Profitability index (PI)

We illustrated how to calculate each of these and discussed the interpretation of the results. We also described the advantages and disadvantages of each of them. Ultimately, a good capital budgeting criterion must tell us two things.

- First, is a particular project a good investment?
- Second, if we have more than one good project, but we can take only one of them, which one should we take?

The main point of this chapter is that only the NPV criterion can always provide the correct answer to both questions.

For this reason, NPV is one of the two or three most important concepts in finance, and we will refer to it many times in the chapters ahead. When we do, keep two things in mind: (1) NPV is always just the difference between the market value of an asset or project and its cost and (2) the financial manager acts in the shareholders' best interests by identifying and taking positive NPV projects.

Finally, we noted that NPVs cannot normally be observed in the market; instead, they must be estimated. Because there is always the possibility of a poor estimate, financial managers use multiple criteria for examining projects. These other criteria provide additional information about whether a project truly has a positive NPV.

CHAPTER REVIEW AND SELF-TEST PROBLEMS

8.1 Investment Criteria. This problem will give you some practice calculating NPVs and paybacks. A proposed overseas expansion has the following cash flows:

Year	Cash Flow
0	–$100
1	50
2	40
3	40
4	15

Calculate the payback and NPV at a required return of 15%.

8.2 Mutually Exclusive Investments. Consider the following two mutually exclusive investments.

a. Calculate the IRR for each.

b. Under what circumstances will the IRR and NPV criteria rank the two projects differently?

Year	Investment A	Investment B
0	–$100	–$100
1	50	70
2	70	75
3	40	10

8.3 Average Accounting Return. You are looking at a three-year project with a projected net income of $1000 in Year 1, $2000 in Year 2, and $4000 in Year 3. The cost is $9000, which will be depreciated straight-line to zero over the three-year life of the project. What is the average accounting return, or AAR?

Answers to Chapter Review and Self-Test Problems

8.1 In the table below, we have listed the cash flows and their discounted values (at 15%).

	Cash Flow	
Year	Undiscounted	Discounted (at 15%)
1	$ 50	$ 43.48
2	40	30.25
3	40	26.30
4	15	8.50
Total	$145	$108.60

Recall that the initial investment is $100. Examining the undiscounted cash flows, we see that the payback occurs between Years 2 and 3. The cash flows for the first two years are $90 total, so, going into the third year, we are short by $10. The total cash flow in Year 3 is $40, so the payback is 2 + $10/40 = 2.25 years.

Looking at the discounted cash flows, we see that the sum is $108.60, so the NPV is $8.60.

8.2 To calculate the IRR, we might try some guesses as in the following table:

Discount Rate	NPV (A)	NPV (B)
0%	$60.00	$55.00
10	33.36	33.13
20	13.43	16.20
30	–1.91	2.78
40	–13.99	–8.09

Several things are immediately apparent from our guesses.

First, the IRR on A must be just a little less than 30% (why?). With some more effort, we find that it is 28.61%. For B, the IRR must be a little more than 30% (again, why?); it works out to be 32.37%.

Also, notice that at 10% the NPVs are very close, indicating that the NPV profiles cross in that vicinity. Verify that the NPVs are the same at 10.61%.

Now, the IRR for B is always higher. As we have seen, A has the larger NPV for any discount rate less than 10.61%, so the NPV and IRR rankings will conflict in that range. Remember, if there is a conflict, we will go with the higher NPV.

Our decision rule is thus very simple: take A if the required return is less than 10.61%, take B if the required return is between 10.61% and 32.37% (the IRR on B), and take neither if the required return is more than 32.37%.

8.3 Here we need to calculate the ratio of average net income to average book value to get the AAR. Average net income is:

$$\text{Average net income} = (\$1000 + 2000 + 4000)/3 = \$2333.33$$

Average book value is:

$$\text{Average book value} = \$9000/2 = \$4500$$

So the average accounting return is:

$$\text{AAR} = \$2333.33/\$4500 = 51.85\%$$

This is an impressive return. Remember, however, that it is not really a rate of return like an interest rate or an IRR, so the size does not tell us a lot. In particular, our money is probably not going to grow at 51.85% per year, sorry to say.

CRITICAL THINKING AND CONCEPTS REVIEW

8.1 **Payback Period and Net Present Value.** If a project with conventional cash flows has a payback period less than its life, can you definitively state the algebraic sign of the NPV? Why or why not?

8.2 Net Present Value. Suppose a project has conventional cash flows and a positive NPV.

a. What do you know about its payback?

b. Its profitability index?

c. Its IRR? Explain.

8.3 Payback Period. Concerning payback:

a. (i) Describe how the payback period is calculated.

(ii) Describe the information this measure provides about a sequence of cash flows.

(iii) What is the payback criterion decision rule?

b. What are the problems associated with using the payback period as a means of evaluating cash flows?

c. (i) What are the advantages of using the payback period to evaluate cash flows?

(ii) Are there any circumstances under which using payback might be appropriate? Explain.

8.4 Average Accounting Return. Concerning AAR:

a. (i) Describe how the average accounting return is usually calculated.

(ii) Describe the information this measure provides about a sequence of cash flows.

(iii) What is the AAR criterion decision rule?

b. (i) What are the problems associated with using the AAR as a means of evaluating a project's cash flows?

(ii) What underlying feature of AAR is most troubling to you from a financial perspective?

(iii) Does the AAR have any redeeming qualities?

8.5 Net Present Value. Concerning NPV:

a. (i) Describe how NPV is calculated.

(ii) Describe the information this measure provides about a sequence of cash flows.

(iii) What is the NPV criterion decision rule?

b. (i) Why is NPV considered to be a superior method of evaluating the cash flows from a project?

(ii) Suppose the NPV for a project's cash flows is computed to be $2500. What does this number represent with respect to the firm's shareholders?

8.6 Internal Rate of Return. Concerning IRR:

a. (i) Describe how the IRR is calculated.

(ii) Describe the information this measure provides about a sequence of cash flows.

(iii) What is the IRR criterion decision rule?

b. (i) What is the relationship between IRR and NPV?

(ii) Are there any situations in which you might prefer one method to the other? Explain.

c. (i) Despite its shortcomings in some situations, why do most financial managers use IRR along with NPV when evaluating projects?

(ii) Can you think of a situation in which IRR might be a more appropriate measure to use than NPV? Explain.

8.7 Profitability Index. Concerning the profitability index:

a. (i) Describe how the profitability index is calculated.

(ii) Describe the information this measure provides about a sequence of cash flows.

(iii) What is the profitability index decision rule?

b. (i) What is the relationship between the profitability index and the NPV?

(ii) Are there any situations in which you might prefer one method to the other? Explain.

8.8 Payback and Internal Rate of Return. A project has perpetual cash flows of C per period, a cost of I, and a required return of R.

a. What is the relationship between the project's payback and its IRR?

b. What implications does your answer have for long-lived projects with relatively constant cash flows?

8.9 International Investment Projects. In 2004 Qantas, the Australian airline, established a new budget airline based in Singapore, JetStar Asia. Qantas believed that it would be better able to compete and create value with a Singapore-based airline. Other South-East Asian airlines, such as Malaysian and Singapore Airlines, have established similar budget airlines. What are some of the reasons that Qantas might consider to arrive at the decision to open a new airline in direct competition with other players?

8.10 Capital Budgeting Problems.

a. What are some of the difficulties that might come up in actual applications of the various criteria we discussed in this chapter?

b. Which one would be the easiest to implement in actual applications?

c. The most difficult?

8.11 Capital Budgeting in Not-for-Profit Entities.

a. Are the capital budgeting criteria we discussed applicable to not-for-profit corporations?

b. How should such entities make capital budgeting decisions?

c. What about the Australian government?

d. Should it evaluate spending proposals using these techniques?

8.12 Internal Rate of Return. In a previous chapter, we discussed the yield to maturity (YTM) of a bond.

a. In what ways are the IRR and the YTM similar?

b. How are they different?

QUESTIONS AND PROBLEMS

Basic
(Questions 1–23)

1. **Calculating Payback.** What is the payback period for the following set of cash flows?

Year	Cash Flow
0	–$2500
1	400
2	1300
3	700
4	600

2. **Calculating Payback.** An investment project provides cash inflows of $700 per year for eight years.
   a. What is the project payback period if the initial cost is $3400?
   b. What if the initial cost is $3750?
   c. What if it is $5800?

3. **Calculating Payback.** Offshore Drilling Limited imposes a payback cut-off of three years for its international investment projects. If the company has the following two projects available, should it accept either of them?

Year	Cash Flow (A)	Cash Flow (B)
0	–$38 000	–$70 000
1	16 000	10 000
2	19 000	15 000
3	18 000	20 000
4	5 000	250 000

4. **Calculating AAR.** You are trying to determine whether to expand your business by building new manufacturing plant. The plant has an installation cost of $13 million, which will be depreciated straight-line to zero over its four-year life. If the plant has the following projected net income over these four years, what is the project's average accounting return (AAR)?

Year	Cash Flow
1	$1 210 000
2	$1 720 000
3	$1 465 000
4	$1 313 000

5. **Calculating IRR.** ABC Limited evaluates all of its projects by applying the IRR rule. If the required return is 18%, should ABC accept the following project?

Year	Cash Flow
0	–$90 000
1	35 000
2	43 000
3	40 000

6. **Calculating NPV.** For the cash flows in the previous problem, suppose the firm uses the NPV decision rule.
   - **a.** At a required return of 9%, should the firm accept this project?
   - **b.** What if the required return was 23%?

7. **Calculating NPV and IRR.** A project that provides annual cash flows of $1000 for eight years costs $4900 today.
   - **a.** Is this a good project if the required return is 8%?
   - **b.** What if it is 24%?
   - **c.** At what discount rate would you be indifferent between accepting the project and rejecting it?

8. **Calculating IRR.** What is the IRR of the following set of cash flows?

Year	Cash Flow
0	–$2200
1	640
2	800
3	1900

9. **Calculating NPV.** For the cash flows in the previous problem:
   - **a.** What is the NPV at a discount rate of 0%?
   - **b.** What if the discount rate is 10%?
   - **c.** What if the discount rate is 20%?
   - **d.** What if the discount rate is 30%?

10. **NPV versus IRR.** Blue Bottles Limited has identified the following two mutually exclusive projects:

Year	Cash Flow (A)	Cash Flow (B)
0	–$20 000	–$20 000
1	10 000	4 000
2	7 000	4 500
3	5 000	9 000
4	3 000	9 500

a. (i) What is the IRR for each of these projects?
(ii) If you apply the IRR decision rule, which project should the company accept?
(iii) Is this decision necessarily correct?

b. (i) If the required return is 11%, what is the NPV for each of these projects? Which project will you choose if you apply the NPV decision rule?

c. (i) Over what range of discount rates would you choose project A?
(ii) Over what range of discount rates would you choose project B?
(iii) At what discount rate would you be indifferent between these two projects? Explain.

11. NPV versus IRR. Consider the following two mutually exclusive projects:

Year	Cash Flow (X)	Cash Flow (Y)
0	–$5000	–$5000
1	2700	1700
2	1700	2100
3	1800	2600

Sketch the NPV profiles for X and Y over a range of discount rates from 0 to 25%. What is the crossover rate for these two projects?

12. Problems with IRR. Hitch Hiker Limited is trying to evaluate a generation project with the following cash flows:

Year	Cash Flow
0	–$28 000 000
1	53 000 000
2	–8 000 000

a. If the company requires a 12% return on its investments, should it accept this project? Why?

b. Compute the IRR for this project.
(i) How many IRRs are there?
(ii) If you apply the IRR decision rule, should you accept the project or not?
(iii) What's going on here?

13. Calculating Profitability Index.

a. What is the profitability index for the following set of cash flows if the relevant discount rate is 10%?

b. What if the discount rate is 15%?

c. What if the discount rate is 22%?

Year	Cash Flow
0	–$10 000
1	6 500
2	4 000
3	2 500

14. Problems with Profitability Index. The Curbo Computer Corporation is trying to choose between the following two mutually exclusive design projects:

Year	Cash Flow (I)	Cash Flow (II)
0	–$30 000	–$4500
1	13 000	2600
2	13 000	2600
3	13 000	2600

a. If the required return is 9% and Curbo applies the profitability index decision rule, which project should the firm accept?

b. If the company applies the NPV decision rule, which project should it take?

c. Explain why your answers in **a** and **b** are different.

15. Comparing Investment Criteria. Consider the following two mutually exclusive projects:

Year	Cash Flow (A)	Cash Flow (B)
0	–$210 000	–$20 000
1	15 000	12 000
2	30 000	10 500
3	32 000	9 500
4	425 000	8 200

Whichever project you choose, if any, you require a 15% return on your investment.

a. (i) If you apply the payback criterion, which investment will you choose?
(ii) Why?

b. (i) If you apply the NPV criterion, which investment will you choose?
(ii) Why?

c. (i) If you apply the IRR criterion, which investment will you choose?
(ii) Why?

d. (i) If you apply the profitability index criterion, which investment will you choose?
(ii) Why?

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e. (i) Based on your answers in **a** to **d**, which project will you finally choose?
(ii) Why?

16. NPV and IRR. Auckland Limited is presented with the following two mutually exclusive projects. The required return for both projects is 15%.

Year	Project M	Project N
0	–$35 000	–$420 000
1	10 000	180 000
2	21 000	200 000
3	15 000	170 000
4	14 000	110 000

a. What is the IRR for each project?

b. What is the NPV for each project?

c. Which, if either, of the projects should the company accept?

17. NPV and Profitability Index. Perth Constructions has the following two possible projects. The required return is 12%.

Year	Project Y	Project Z
0	–$35 000	–$70 000
1	14 000	27 000
2	14 000	27 000
3	14 000	27 000
4	14 000	27 000

a. What is the profitability index for each project?

b. What is the NPV for each project?

c. Which, if either, of the projects should the company accept?

18. Crossover Point. Sandoval Enterprises has gathered projected cash flows for two projects.

a. At what interest rate would Sandoval be indifferent between the two projects?

b. Which project is better if the required return is above this interest rate?

c. Why?

Year	Project I	Project J
0	–$90 000	–$90 000
1	40 000	33 000
2	38 000	37 000
3	36 000	39 000
4	34 000	43 000

19. NPV and Profitability Index. OZ travel Limited is presented with the following two mutually exclusive projects. The required return is 13%.

Year	Project K	Project S
0	–$40 000	–$380 000
1	20 000	130 000
2	19 000	120 000
3	18 000	118 000
4	17 000	115 000
5	16 000	110 000

a. What is the profitability index for each project?

b. What is the NPV for each project?

c. Which, if either, of the projects should the company choose?

20. Payback Period and IRR. Suppose you have a project with a payback period exactly equal to the life of the project.

a. What do you know about the IRR of the project?

b. Suppose that the payback period never pays back. What do you know about the IRR of the project now?

21. NPV and Discount Rates. An investment has an installed cost of $418 570. The cash flows over the four-year life of the investment are projected to be as follows.

Year	Cash Flow
1	$142 180
2	$172 148
3	$118 473
4	$ 97 123

a. If the discount rate is zero, what is the NPV?

b. If the discount rate is infinite (9999%), what is the NPV?

c. At what discount rate is the NPV just equal to zero?

d. Sketch the NPV profile for this investment based on these three points.

22. NPV and Payback Period. Outback Builders Limited has the following three mutually exclusive projects available. The company has historically used a three-year cut-off for projects. The required return is 12%.

Year	Project F	Project G	Project H
0	–$100 000	–$150 000	–$200 000
1	50 000	95 000	60 000
2	30 000	60 000	70 000
3	30 000	35 000	60 000
4	20 000	35 000	160 000
5	20 000	20 000	40 000

a. Calculate the payback period for all three projects.

b. Calculate the NPV for all three projects.

c. Which project, if any, should the company accept?

23. NPV and IRR. Heard Machinery Limited has the following two mutually exclusive projects available. The required return is 12%.

Year	Project X	Project Y
0	–$25 000	–$60 000
1	11 000	40 000
2	7 000	25 000
3	15 000	20 000
4	25 000	15 000

a. Calculate the IRR for each project.

b. Calculate the NPV for each project.

c. Which project, if either, should the company accept?

Intermediate
(Questions 24–29)

24. Crossover and NPV. Banjos Auto has the following two mutually exclusive projects available.

Year	Project X	Project Y
0	–$30 000	–$42 000
1	18 000	19 000
2	12 000	19 000
3	12 000	18 000
4	6 000	11 000
5	6 000	11 000

a. What is the crossover rate for these two projects?

b. What is the NPV of each project at the crossover rate?

25. NPV and IRR. Bedknobs and Broomsticks Limited has the following two mutually exclusive projects available. The required return is 14%.

Year	Project C	Project D
0	–$100 000	–$150 000
1	30 000	65 000
2	40 000	60 000
3	35 000	50 000
4	30 000	30 000

a. What is the IRR for each project?

b. What is the NPV for each project?

c. Which, if either, of these two projects should the company choose?

26. Calculating IRR. A project has the following cash flows:

Year	Cash Flow
0	$45 000
1	– 20 000
2	– 38 000

a. What is the IRR for this project?

b. If the required return is 12%, should the firm accept the project?

c. What is the NPV of this project?

d. What is the NPV of the project if the required return is 0%? 25%?

e. What is going on here? Sketch the NPV profile to help you with your answer.

27. Multiple IRRs. This problem is useful for testing the ability of financial calculators and computer software. Consider the following cash flows.

Year	Cash Flow
0	–$ 252
1	1 431
2	– 3 305
3	2 850
4	– 1 000

When should we take this project? (Hint: search for IRRs between 20% and 70%.)

28. NPV and the Profitability Index. If we define the NPV index as the ratio of NPV to cost, what is the relationship between this index and the profitability index?

29. Cash Flow Intuition. A project has an initial cost of I, has a required return of R, and pays C annually for N years.

a. Find C in terms of I and N such that the project has a payback period just equal to its life.

b. Find C in terms of I, N and R such that this is a profitable project according to the NPV decision rule.

c. Find C in terms of I, N and R such that the project has a benefit–cost ratio of 2.

WHAT'S ON THE WEB?

8.1 **Net Present Value.** You have a project that has an initial cash outflow of $20 000 and cash inflows of $6000, $5000, $4000 and $3000, respectively, for the next four years. Go to <www.datadynamica.com> and follow the 'On-line IRR NPV Calculator' link. Enter the cash flows. If the required return is 12%, what is the IRR of the project? The NPV?

8.2 **Internal Rate of Return.** Using the online calculator from the previous problem, find the IRR for a project with cash flows of $500, $1200, and $400. What is going on here?