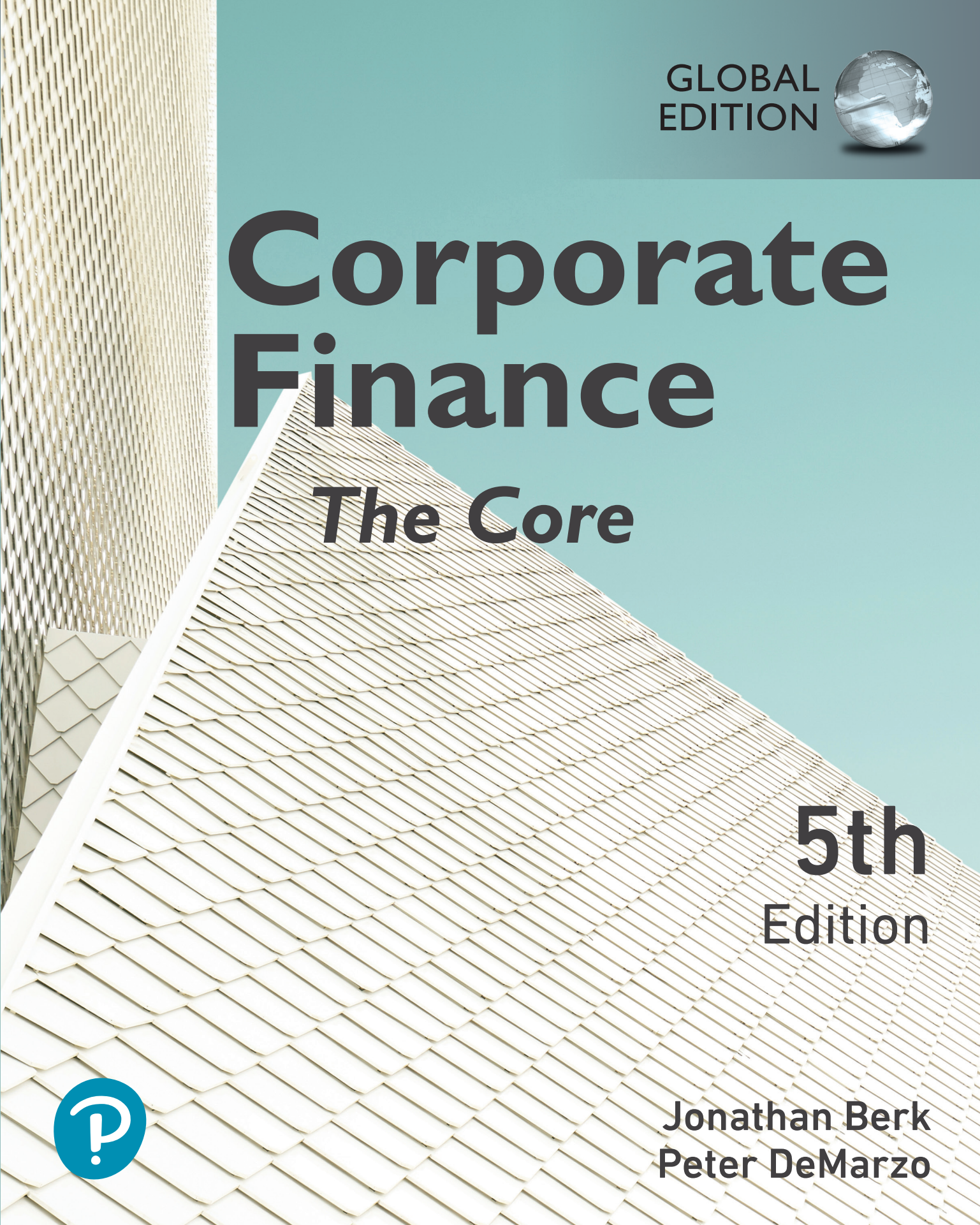
GLOBAL
EDITION
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The Core
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Jonathan Berk
Peter DeMarzo

# CORPORATE FINANCE: THE CORE

FIFTH EDITION
GLOBAL EDITION

JONATHAN BERK
STANFORD UNIVERSITY

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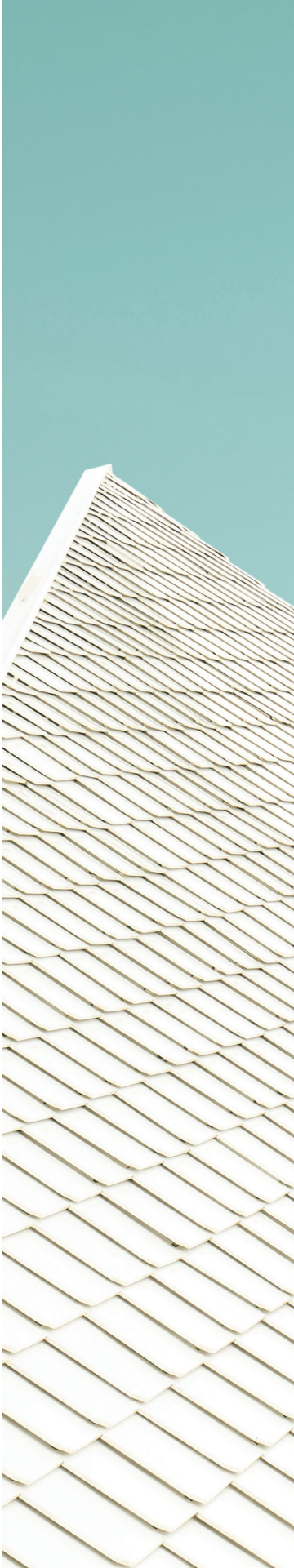

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# 7.1 NPV and Stand-Alone Projects

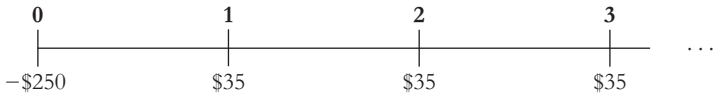
We begin our discussion of investment decision rules by considering a take-it-or-leave-it decision involving a single, stand-alone project. By undertaking this project, the firm does not constrain its ability to take other projects. To analyze such a decision, recall the NPV rule:

***NPV Investment Rule:*** *When making an investment decision, take the alternative with the highest NPV. Choosing this alternative is equivalent to receiving its NPV in cash today.*

In the case of a stand-alone project, we must choose between accepting or rejecting the project. The NPV rule then says we should compare the project's NPV to zero (the NPV of doing nothing) and accept the project if its NPV is positive.

## Applying the NPV Rule

Researchers at Fredrick's Feed and Farm have made a breakthrough. They believe that they can produce a new, environmentally friendly fertilizer at a substantial cost savings over the company's existing line of fertilizer. The fertilizer will require a new plant that can be built immediately at a cost of $250 million. Financial managers estimate that the benefits of the new fertilizer will be $35 million per year, starting at the end of the first year and lasting forever, as shown by the following timeline:




As we explained in Chapter 4, the NPV of this perpetual cash flow stream, given a discount rate $r$, is

$$NPV = -250 + \frac{35}{r} \tag{7.1}$$

The financial managers responsible for this project estimate a cost of capital of 10% per year. Using this cost of capital in Eq. 7.1, the NPV is $100 million, which is positive. The NPV investment rule indicates that by making the investment, the value of the firm will increase by $100 million today, so Fredrick's should undertake this project.

## The NPV Profile and IRR

The NPV of the project depends on the appropriate cost of capital. Often, there may be some uncertainty regarding the project's cost of capital. In that case, it is helpful to compute an **NPV profile**: a graph of the project's NPV over a range of discount rates. Figure 7.1 plots the NPV of the fertilizer project as a function of the discount rate, $r$.

Notice that the NPV is positive only for discount rates that are less than 14%. When $r = 14\%$, the NPV is zero. Recall from Chapter 4 that the internal rate of return (IRR) of an investment is the discount rate that sets the NPV of the project's cash flows equal to zero. Thus, the fertilizer project has an IRR of 14%.

The IRR of a project provides useful information regarding the sensitivity of the project's NPV to errors in the estimate of its cost of capital. For the fertilizer project, if the cost of capital estimate is more than the 14% IRR, the NPV will be negative, as shown in

**FIGURE 7.1**

**NPV of Fredrick's Fertilizer Project**

The graph shows the NPV as a function of the discount rate. The NPV is positive only for discount rates that are less than 14%, the internal rate of return (IRR). Given the cost of capital of 10%, the project has a positive NPV of $100 million.

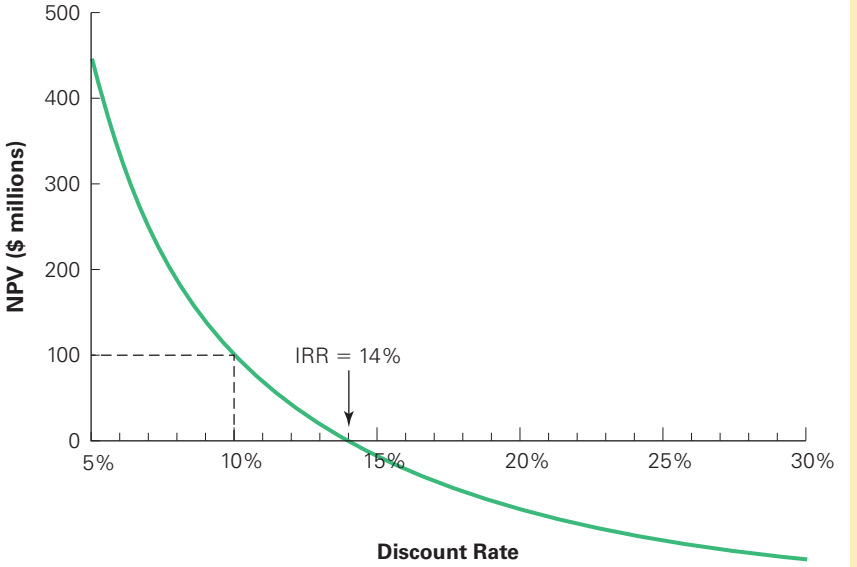



Figure 7.1. Therefore, the decision to accept the project is correct as long as our estimate of 10% is within 4% of the true cost of capital. In general, *the difference between the cost of capital and the IRR is the maximum estimation error in the cost of capital that can exist without altering the original decision.*

## Alternative Rules Versus the NPV Rule

Although the NPV rule is the most accurate and reliable decision rule, in practice a wide variety of tools are applied, often in tandem with the NPV rule. In a 2001 study, 75% of the firms John Graham and Campbell Harvey[1] surveyed used the NPV rule for making investment decisions. This result is substantially different from that found in a similar study in 1977 by L. J. Gitman and J. R. Forrester,[2] who found that only 10% of firms used the NPV rule. MBA students in recent years must have been listening to their finance professors! Even so, Graham and Harvey's study indicates that one-fourth of U.S. corporations do not use the NPV rule. Exactly why other capital budgeting techniques are used in practice is not always clear. However, because you may encounter these techniques in the business world, you should know what they are, how they are used, and how they compare to NPV.

As we evaluate alternative rules for project selection in subsequent sections, keep in mind that sometimes other investment rules may give the same answer as the NPV rule, but at other times they may disagree. When the rules conflict, following the alternative rule means that we are either taking a negative NPV investment or turning down a positive NPV investment. In these cases, the alternative rules lead to bad decisions that reduce wealth.

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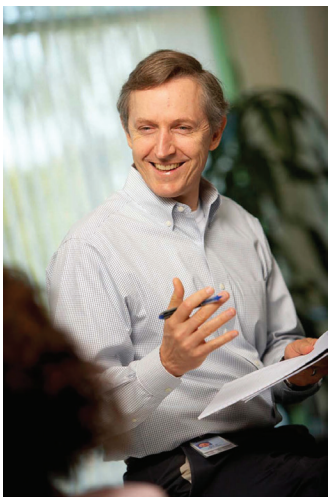
[1] "The Theory and Practice of Corporate Finance: Evidence from the Field," *Journal of Financial Economics* 60 (2001): 187–243.

[2] "A Survey of Capital Budgeting Techniques Used by Major U.S. Firms," *Financial Management* 6 (1977): 66–71.

**CONCEPT CHECK**

1. Explain the NPV rule for stand-alone projects.
2. What does the difference between the cost of capital and the IRR indicate?

## INTERVIEW WITH DICK GRANNIS



Dick Grannis is Senior Vice President and Treasurer of QUALCOMM Incorporated, a world leader in digital wireless communications technology and semiconductors, headquartered in San Diego. He joined the company in 1991 and oversees the company's $10 billion cash investment portfolio. He works primarily on investment banking, capital structure, and international finance.

**QUESTION:** *QUALCOMM has a wide variety of products in different business lines. How does your capital budgeting process for new products work?*

**ANSWER:** QUALCOMM evaluates new projects (such as new products, equipment, technologies, research and development, acquisitions, and strategic investments) by using traditional financial measurements including discounted cash flow/NPV models, IRR levels, peak funding requirements, the time needed to reach cumulative positive cash flows, and the short-term impact of the investment on our reported net earnings. For strategic investments, we consider the possible value of financial, competitive, technology and/or market value enhancements to our core businesses—even if those benefits cannot be quantified. Overall, we make capital budgeting decisions based on a combination of objective analyses and our own business judgment.

We do not engage in capital budgeting and analysis if the project represents an immediate and necessary requirement for our business operations. One example is new software or production equipment to start a project that has already received approval.

We are also mindful of the opportunity costs of allocating our internal engineering resources on one project vs. another project. We view this as a constantly challenging but worthwhile exercise, because we have many attractive opportunities but limited resources to pursue them.

**QUESTION:** *How often does QUALCOMM evaluate its hurdle rates and what factors does it consider in setting them? How do you allocate capital across areas and regions and assess the risk of non-U.S. investments?*

**ANSWER:** QUALCOMM encourages its financial planners to utilize hurdle (or discount) rates that vary according to the risk of the particular project. We expect a rate of return commensurate with the project's risk. Our finance staff considers a wide range of discount rates and chooses one that fits the project's expected risk profile and time horizon. The range can be from 6% to 8% for relatively safe investments in the domestic market to 50% or more for equity investments in foreign markets that may be illiquid and difficult to predict. We re-evaluate our hurdle rates at least every year.

We analyze key factors including: (1) market adoption risk (whether or not customers will buy the new product or service at the price and volume we expect), (2) technology development risk (whether or not we can develop and patent the new product or service as expected), (3) execution risk (whether we can launch the new product or service cost effectively and on time), and (4) dedicated asset risk (the amount of resources that must be consumed to complete the work).

**QUESTION:** *How are projects categorized and how are the hurdle rates for new projects determined? What would happen if QUALCOMM simply evaluated all new projects against the same hurdle rate?*

**ANSWER:** We primarily categorize projects by risk level, but we also categorize projects by the expected time horizon. We consider short-term and long-term projects to balance our needs and achieve our objectives. For example, immediate projects and opportunities may demand a great amount of attention, but we also stay focused on long-term projects because they often create greater long-term value for stockholders.

If we were to evaluate all new projects against the same hurdle rate, then our business planners would, by default, consistently choose to invest in the highest risk projects because those projects would appear to have the greatest expected returns in DCF models or IRR analyses. That approach would probably not work well for very long.

# 7.2 The Internal Rate of Return Rule

One interpretation of the internal rate of return is the average return earned by taking on the investment opportunity. The **internal rate of return (IRR) investment rule** is based on this idea: If the average return on the investment opportunity (i.e., the IRR) is greater than the return on other alternatives in the market with equivalent risk and maturity (i.e., the project's cost of capital), you should undertake the investment opportunity. We state the rule formally as follows:

***IRR Investment Rule:*** *Take any investment opportunity where the IRR exceeds the opportunity cost of capital. Turn down any opportunity whose IRR is less than the opportunity cost of capital.*

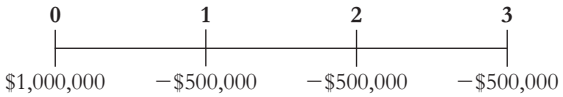
## Applying the IRR Rule

Like the NPV rule, the internal rate of return investment rule is applied to single, stand-alone projects within the firm. The IRR investment rule will give the correct answer (that is, the same answer as the NPV rule) in many—but not all—situations. For instance, it gives the correct answer for Fredrick's fertilizer opportunity. Looking again at Figure 7.1, whenever the cost of capital is below the IRR (14%), the project has a positive NPV and you should undertake the investment.

In the Fredrick fertilizer example, the NPV rule and the IRR rule coincide, so the IRR rule gives the correct answer. This need not always be the case, however. In fact, *the IRR rule is only guaranteed to work for a stand-alone project if all of the project's negative cash flows precede its positive cash flows*. If this is not the case, the IRR rule can lead to incorrect decisions. Let's examine several situations in which the IRR fails.

## Pitfall #1: Delayed Investments

John Star, the founder of SuperTech, the most successful company in the last 20 years, has just retired as CEO. A major publisher has offered to pay Star $1 million upfront if he agrees to write a book about his experiences. He estimates that it will take him three years to write the book. The time that he spends writing will cause him to forgo alternative sources of income amounting to $500,000 per year. Considering the risk of his alternative income sources and available investment opportunities, Star estimates his opportunity cost of capital to be 10%. The timeline of Star's investment opportunity is




The NPV of Star's investment opportunity is

$$NPV = 1{,}000{,}000 - \frac{500{,}000}{1+r} - \frac{500{,}000}{(1+r)^2} - \frac{500{,}000}{(1+r)^3}$$

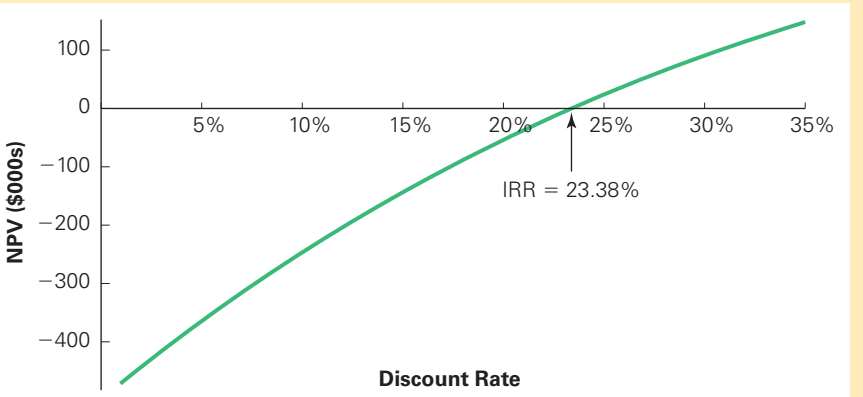
By setting the NPV equal to zero and solving for $r$, we find the IRR. Using the annuity spreadsheet:

| | NPER | RATE | PV | PMT | FV | Excel Formula |
|---|---|---|---|---|---|---|
| Given | 3 | | 1,000,000 | −500,000 | 0 | |
| Solve for I | | 23.38% | | | | =RATE(3,−500000,1000000, 0) |

**FIGURE 7.2**

**NPV of Star's $1 Million Book Deal**

When the benefits of an investment occur before the costs, the NPV is an *increasing* function of the discount rate, and the IRR rule fails.




The 23.38% IRR is larger than the 10% opportunity cost of capital. According to the IRR rule, Star should sign the deal. But what does the NPV rule say?

$$NPV = 1{,}000{,}000 - \frac{500{,}000}{1.1} - \frac{500{,}000}{1.1^2} - \frac{500{,}000}{1.1^3} = -\$243{,}426$$

At a 10% discount rate, the NPV is negative, so signing the deal would reduce Star's wealth. He should not sign the book deal.

To understand why the IRR rule fails, Figure 7.2 shows the NPV profile of the book deal. No matter what the cost of capital is, the IRR rule and the NPV rule will give exactly opposite recommendations. That is, the NPV is positive only when the opportunity cost of capital is *above* 23.38% (the IRR). In fact, Star should accept the investment only when the opportunity cost of capital is greater than the IRR, the opposite of what the IRR rule recommends.

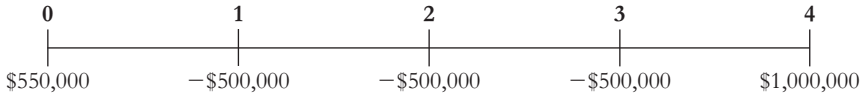
Figure 7.2 also illustrates the problem with using the IRR rule in this case. For most investment opportunities, expenses occur initially and cash is received later. In this case, Star gets cash *upfront* and incurs the costs of producing the book *later*. It is as if Star borrowed money—receiving cash today in exchange for a future liability—and when you borrow money you prefer as *low* a rate as possible. In this case the IRR is best interpreted as the rate Star is paying rather than earning, and so Star's optimal rule is to borrow money so long as this rate is *less* than his cost of capital.

Even though the IRR rule fails to give the correct answer in this case, the IRR itself still provides useful information *in conjunction* with the NPV rule. As mentioned earlier, IRR indicates how sensitive the investment decision is to uncertainty in the cost of capital estimate. In this case, the difference between the cost of capital and the IRR is large—13.38%. Star would have to have underestimated the cost of capital by 13.38% to make the NPV positive.

## Pitfall #2: Multiple IRRs

Star has informed the publisher that it needs to sweeten the deal before he will accept it. In response, the publisher offers to give him a royalty payment when the book is published in exchange for taking a smaller upfront payment. Specifically, Star will receive $1 million when the book is published and sold four years from now, together with an upfront payment of $550,000. Should he accept or reject the new offer?

We begin with the new timeline:




The NPV of Star's new offer is

$$NPV = 550{,}000 - \frac{500{,}000}{1 + r} - \frac{500{,}000}{(1 + r)^2} - \frac{500{,}000}{(1 + r)^3} + \frac{1{,}000{,}000}{(1 + r)^4}$$

By setting the NPV equal to zero and solving for $r$, we find the IRR. In this case, there are *two* IRRs—that is, there are two values of $r$ that set the NPV equal to zero. You can verify this fact by substituting IRRs of 7.164% and 33.673% into the equation. Because there is more than one IRR, we cannot apply the IRR rule.

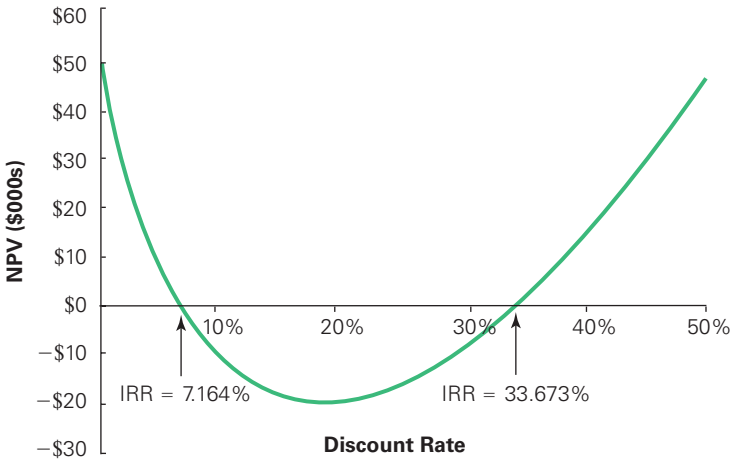
For guidance, let's turn to the NPV rule. Figure 7.3 shows the NPV profile of the new offer. If the cost of capital is *either* below 7.164% or above 33.673%, Star should undertake the opportunity. Otherwise, he should turn it down. Notice that even though the IRR rule fails in this case, the two IRRs are still useful as bounds on the cost of capital. If the cost of capital estimate is wrong, and it is actually smaller than 7.164% or larger than 33.673%, the decision not to pursue the project will change. Even if Star is uncertain whether his actual cost of capital is 10%, as long as he believes it is within these bounds, he can have a high degree of confidence in his decision to reject the deal.

There is no easy fix for the IRR rule when there are multiple IRRs. Although the NPV is negative between the IRRs in this example, the reverse is also possible. Furthermore, there are situations in which more than two IRRs exist.[3] When multiple IRRs exist, our only choice is to rely on the NPV rule.

## FIGURE 7.3

**NPV of Star's Book Deal with Royalties**

In this case, there is more than one IRR, invalidating the IRR rule. In this case, Star should only take the offer if the opportunity cost of capital is *either* below 7.164% or above 33.673%.




[3] In general, there can be as many IRRs as the number of times the project's cash flows change sign over time.