Net Present Value and Other Investment Criteria

The difference between a project's value and its cost is its **net present value (NPV).**

Companies can best help their shareholders by *investing in all projects with a positive NPV* and *rejecting those with a negative NPV*.

When NPV > 0, the firm's value increases by the NPV; owners' wealth increases.

A Review of the Basics

$$NPV = C_0 + \frac{C_1}{(1+r)} + \frac{C_2}{(1+r)^2} + \dots$$

The opportunity cost of capital and the discount rate:

The discount rate is the opportunity cost of investing in the project rather than in the capital market. In other words, instead of accepting a project, the firm can always return the cash to the shareholders and let them invest it in financial assets. The opportunity-cost concept makes sense only if assets of equivalent risk are compared. In general, you should identify financial assets that have the same risk as your project, estimate the expected rate of return on these assets, and use this rate as the opportunity cost.

Net Present Value's Competitors

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

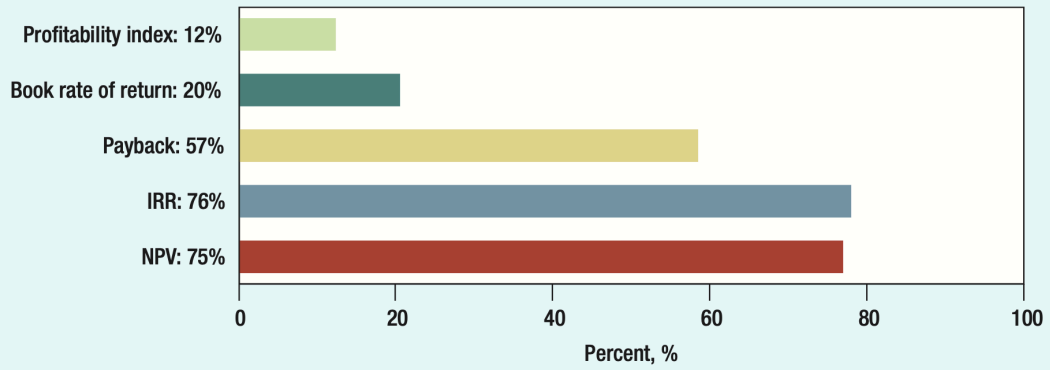

FIGURE 5.2 Survey evidence on the percentage of CFOs who always, or almost always, use a particular technique for evaluating investment projects.

Source: Reprinted from J. R. Graham and C. R. Harvey, "The Theory and Practice of Finance: Evidence from the Field," *Journal of Financial Economics* 60 (2001), pp. 187–243, © 2001 with permission from Elsevier Science.

Criteria in evaluating investment projects:

- NPV Rule
- Payback Period (PP)
- Internal Rate of Return (IRR)
- Profitability Index (PI)
- Book Rate of Return

Three Points to Remember about NPV

Key features of the net present value rule:

1. The NPV rule recognizes that *a dollar today is worth more than a dollar tomorrow,* because the dollar today can be invested to start earning interest immediately. Any investment rule that does not recognize the *time value of money* cannot be sensible.
2. Net present value depends solely on the *forecasted cash flows* from the project and the *opportunity cost of capital.* Any investment rule that is affected by the manager's tastes, the company's choice of accounting method, the profitability of the company's existing business, or the profitability of other independent projects will lead to inferior decisions.
3. *Because present values are all measured in today's dollars, you can add them up.*

How to use NPV in evaluating investments:

- NPV Rule for **an individual project**
  - Accept a project with NPV > 0, reject a project with NPV < 0
  - Indifferent if NPV = 0
- NPV Rule for **independent projects**
  - Accept all projects with NPV > 0

    - Assume no financing constraint

- NPV Rule for **mutually exclusive projects**
    - Accept the project with highest positive NPV
    - Usually they are different plans for one task

NPV Depends on Cash Flow, Not on Book Returns

Net present value depends only on the project's cash flows and the opportunity cost of capital.

Book/accounting income and book assets:

$$Book\ rate\ of\ return = \frac{book\ income}{book\ assets}$$

Cash flows and book income are often very **different**.

→ The book rate of return depends on which items the accountant treats as *capital investments* and how rapidly they are depreciated, or treats as *operating expenses* which will be deducted from each year's income immediately.

Payback

A project's **payback period** is found by counting the number of years it takes before the *cumulative cash flow* equals the initial investment.

→ *Just add the original amount of cash flows together* ***without discounting***

The **payback rule** states that a project should be accepted if its payback period is less than some specified cutoff period.

Regardless of the choice of cutoff period, the payback rule gives different answers from the net present value rule.

For *independent projects*, accept projects the payback of which is shorter than prescribed number of years.

For *mutually exclusive projects*, accept the one with **the shortest payback** but also shorter thanprescribed number of years

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Why payback can give misleading answers?

1. The payback rule ignores all cash flows after the cutoff date.
2. The payback rule gives equal weight to all cash flows before the cutoff date.

→ To use the payback rule, a firm must decide on **an appropriate cutoff date**. If it uses the same cutoff regardless of project life, it will tend to accept many poor short-lived projects and reject many good long-lived ones.

Why do many companies continue to use payback rules?

1. Payback may be used because it is the simplest way to *communicate* an idea of project profitability. Investment decisions require discussion and negotiation among people from all parts of the firm, and it is important to have a measure that everyone can understand.
2. Managers of larger corporations may opt for projects with short paybacks because they believe that quicker profits mean quicker promotion.
3. Owners of family firms with limited access to capital may worry about their future ability to raise capital. These worries may lead them to favor rapid payback projects even though a longer-term venture may have a higher NPV.

Discounted Payback

Occasionally companies discount the cash flows before they compute the payback period.

The **discounted payback measure** asks, How many years does the project have to last in order for it to make sense in terms of net present value?

→ *Add the cash flows together **using their present value***

- A discounted payback rule will never accept a negative-NPV project.
- It still takes no account of cash flows after the cutoff date, so that good long-term projects continue to risk rejection

Internal (or Discounted-Cash-Flow) Rate of Return

$$Rate\ of\ return = \frac{payoff}{investment} - 1$$

$$NPV = C_0 + \frac{C_1}{1 + discount\ rate} = 0$$

$$Discount\ rate = \frac{C_1}{-C_0} - 1$$

→ C_1 *is the payoff and* $-C_0$ *is the required investment*

The discount rate that makes NPV = 0 is also the rate of return.

The **discounted-cash-flow (DCF) rate of return** or **internal rate of return (IRR)**: the discount rate that gives a zero NPV.

Calculating the IRR

The internal rate of return is defined as the rate of discount that makes NPV = 0.

$$NPV = C_0 + \frac{C_1}{(1+IRR)} + \frac{C_2}{(1+IRR)^2} + \ldots + \frac{C_T}{(1+IRR)^T} = 0$$

The yield to maturity (YTM) is the IRR on the bond investment.

IRR vs. the opportunity cost of capital:

- The internal rate of return is a *profitability measure* that depends solely on the amount and timing of the project cash flows.
- The opportunity cost of capital is a *standard of profitability* that we use to calculate how much the project is worth. The opportunity cost of capital is established in capital markets. It is the expected rate of return offered by other assets with the same risk as the project being evaluated.

The IRR Rule

The internal rate of return rule is to *accept* an investment project if the opportunity cost of capital is less than the internal rate of return.

- IRR > the opportunity cost of capital : *positive* NPV
- IRR = the opportunity cost of capital: *zero* NPV
- IRR < the opportunity cost of capital: *negative* NPV

The rule will give the same answer as the net present value rule *whenever the NPV of a project is a smoothly declining function of the discount rate.*

In *mutually exclusive projects*, choose the one with **highest IRR > r**.

Pitfall 1—Lending or Borrowing?

Cash Flows ($)				
Project	C_0	C_1	IRR	NPV at 10%
A	–1,000	+1,500	+50%	+364
B	+1,000	–1,500	+50%	–364

→ *Project A: lending money; project B: borrowing money*

When we lend money, we want a *high* rate of return; when we borrow money, we want a *low* rate of return.

For a project that **borrowing** money, NPV **increases** as the discount rate increases, and we have to look for an IRR **less** than the opportunity cost of capital.

Pitfall 2—Multiple Rates of Return

As the discount rate increases, NPV will initially rise and then decline in some projects that both have cash inflows and outflows duting the whole period, so such projects have **more than one** IRR.

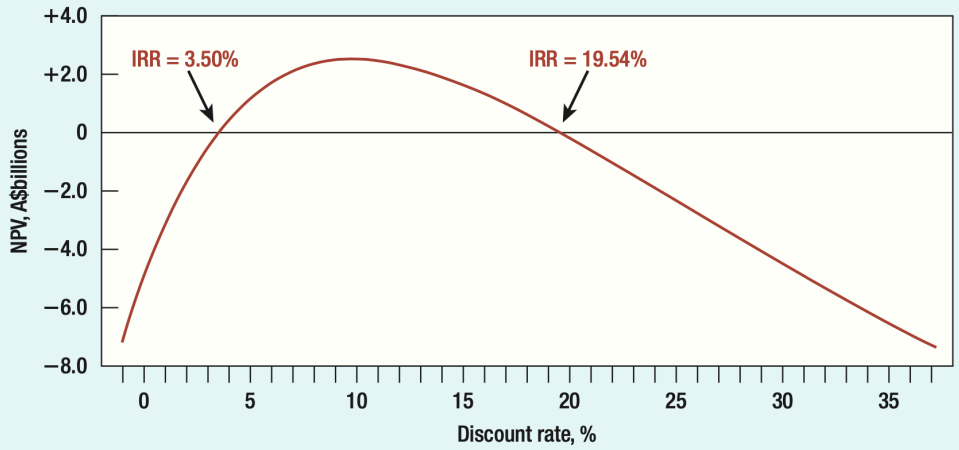

FIGURE 5.4 Helmsley Iron's mine has two internal rates of return. NPV = 0 when the discount rate is +3.50% *and* when it is +19.54%.

→ *Accept the project only when 3.5% < r <19.54%*

There are also cases in which **no** internal rate of return exists, like some projects that have a positivie NPV at all discount rates.

If the IRR rule is not suitable, just use the NPV rule.

Pitfall 3—Mutually Exclusive Projects

Firms often have to choose between several alternative ways of doing the same job or using the same facility. In other words, they need to choose between **mutually exclusive projects.**

In two mutually exclusive projects, the one with lower IRR may have the higher NPV, which **actually should be chosen** but will be forgone according to the IRR rule.

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

Solution: looking at the internal rate of return on the *incremental* flows

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

→ The IRR on the incremental investment is 50%, which is also well in excess of the 10% oppor- tunity cost of capital. So you should prefer project E to project D.

The IRR rule may be also misleading when one exclusive project's cash inflow is larger but tends to occur later. If the actual discount rate is relatively **low**, such projects may have larger NPV.

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

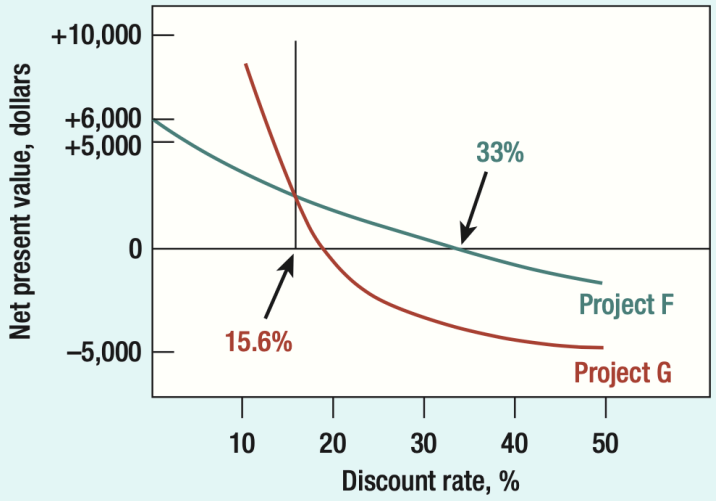

FIGURE 5.5

The IRR of project F exceeds that of project G, but the NPV of project F is higher *only* if the discount rate is greater than 15.6%.

→ The reason that IRR is misleading is that the total cash inflow of project G is larger but tends to occur later.

→ If discount rate r < 15.6%, take G; if 15.6% < r < 33%, take F; if r > 33%, take neither.

Some managers tend to choose projects whose payback are quicker, especially under a *shortage of capital*. The introduction of the shortage of capital may raise **two questions**:

1. In fact, most of the executives preferring F to G work for firms that would have no difficulty raising more capital. The answer seems to be that large firms usually impose capital budgets on divisions and subdivisions as a part of the firm's planning and control system.
2. If there is a capital constraint, either real or self-imposed, IRR should not be used to rank

projects.

Solution: looking at the internal rate of return on the *incremental* flows as well

Pitfall 4—What Happens When There Is More than One Opportunity Cost of Capital?

$$NPV = C_0 + \frac{C_1}{(1+r_1)} + \frac{C_2}{(1+r_2)^2} + \frac{C_3}{(1+r_3)^3} + \dots$$

→ compute a complex weighted average of rates $r_1, r_2, r_3, \dots$ to obtain a number comparable to IRR

Choosing Capital Investments When Resources Are Limited

Capital rationing: There are *limitations on the investment program* that prevent the company from undertaking all projects with positive NPVs.

An Easy Problem in Capital Rationing

When funds are limited, we must pick the projects that offer **the highest net present value per dollar** of initial outlay.

Profitability index: the ratio of the net present value of *future cash flows* to the initial investment

$$Profitability\ index = \frac{net\ present\ value}{investment}$$

Decision rules:

- Accept *individual or independent projects* if PI > 0 (NPV >0)
- In *mutually exclusive projects*, choose the one with **highest** PI > 0

If the PI criterion and the NPV criterion **give different answers**, choose the one with **largest NPV** to maximize shareholders' value.

PI works perfect for *single investments and independent projects*.

Problem with PI: It ignores **magnitude** of projects in mutually exclusive projects.

One of the most serious limitations is that **it breaks down whenever more than one resource is rationed**.

e.g. Suppose that the firm can raise only $10 million for investment in *each* of years 0 and 1 and that the menu of possible projects is expanded to include an investment next year in project D:

	Cash Flows ($ millions)				
Project	C_0	C_1	C_2	NPV at 10%	Profitability Index
A	–10	+30	+ 5	21	2.1
B	– 5	+ 5	+20	16	3.2
C	– 5	+ 5	+15	12	2.4
D	0	–40	+60	13	0.4

A and D have *lower* profitability indexes than B and C, but they have a *higher* total net present value.

This can be solved by applying linear programming (LP) techniques like below:

$$\begin{aligned} Max \quad & NPV = 21X_a + 16X_b + 12X_c + 13X_d \\ s.t. \quad & 10X_a + 5X_b + 5X_c + 0X_d \leq 10 \\ & -30X_a - 5X_b - 5X_c + 40X_d \leq 10 \end{aligned}$$

And $PI(D)$ can be calculated as:

$$PI(D) = \frac{60 \div (1+10\%)^2 - 40 \div (1+10\%)}{40 \div (1+10\%)} = 0.36$$

The reason that ranking on the profitability index fails in this example is that resources are constrained in each of two periods.

Uses of Capital Rationing Models

Linear programming models seem tailor-made for solving capital budgeting problems when resources are limited.

Soft rationing: Many firms' capital constraints are "soft." They reflect no imperfections in capital markets. Instead they are provisional limits adopted by management as an aid to financial control.

Hard rationing: Hard rationing implies market imperfections, but that does not necessarily mean we have to throw away net present value as a criterion for capital budgeting. It depends on the nature of the imperfection.

→ A barrier between the firm and capital markets does not undermine net present value so long as the barrier is the *only* market imperfection. The important thing is that the firm's *shareholders* have free access to well-functioning capital markets. The net present value rule *is* undermined when imperfections restrict shareholders' portfolio choice.

PI and capital rationing: PI provides a tool for selecting among the project candidates to get the highest NPV within the company budget, or maximize shareholders' value with limited amount of capital.

Appendix

Project Interactions

- Independent Projects

  Project A's cash flows do not affect and are not affected by Project B's cash flows

- Mutually Exclusive Projects

  You can have either Project A or Project B, but not both

- Dependent Projects
  - Complementary: Project A's cash flows have *positive* effect on B, vice versa
  - Substitutive: Project A's cash flows have n*egative* effect on B, vice versa

Pros and Cons of Payback

Advantages of payback period

- Easy to understand and easy to calculate
- Covering the initial investment reflects the protection of capital principal
- Ignoring cash flow beyond the payback reflects larger uncertainty in the future

Caveats for applying payback period

- It is usually used in evaluating real asset investment projects
- The required payback differs in industries
- It does not favor long-term projects full of uncertainty, such as R&D

Summary

Chapter 5

If you are going to persuade your company to use the net present value rule, you must be prepared to explain why other rules may *not* lead to correct decisions. That is why we have examined three alternative investment criteria in this chapter.

Some firms look at the book rate of return on the project. In this case the company decides which cash payments are capital expenditures and picks the appropriate rate to depreciate these expenditures. It then calculates the ratio of book income to the book value of the investment. Few companies nowadays base their investment decision simply on the book rate of return, but

shareholders pay attention to book measures of firm profitability and some managers therefore look with a jaundiced eye on projects that would damage the company's book rate of return.

A few companies use the payback rule to make investment decisions. In other words, they accept only those projects that recover their initial investment within some specified period. Payback is an ad hoc rule. **It ignores the timing of cash flows within the payback period, and it ignores subsequent cash flows entirely.** It therefore takes no account of the opportunity cost of capital.

The internal rate of return (IRR) is defined as the rate of discount at which a project would have zero NPV. It is a handy measure and widely used in finance; you should therefore know how to calculate it. The IRR rule states that companies should accept any investment offering an IRR in excess of the opportunity cost of capital. The IRR rule is, like net present value, a technique based on discounted cash flows. It will therefore give the correct answer if properly used. The problem is that it is easily misapplied. There are four things to look out for:

1. *Lending or borrowing?* If a project offers positive cash flows followed by negative flows, NPV can *rise* as the discount rate is increased. You should accept such projects if their IRR is *less* than the opportunity cost of capital.
2. *Multiple rates of return.* If there is more than one change in the sign of the cash flows, the project may have several IRRs or no IRR at all.
3. *Mutually exclusive projects.* The IRR rule may give the wrong ranking of mutually exclusive projects that differ in economic life or in scale of required investment. If you insist on using IRR to rank mutually exclusive projects, you must examine the IRR on each **incremental investment**.
4. *The cost of capital for near-term cash flows may be different from the cost for distant cash flows.* The IRR rule requires you to compare the project's IRR with the opportunity cost of capital. But sometimes there is more than one opportunity cost of capital. For example, if the term structure of interest rates is steeply upward-sloping, the financial manager may decide to use a lower discount rate for near than for distant cash flows. In these cases there is no simple yardstick for evaluating the IRR of a project.

In developing the NPV rule, we assumed that the company can maximize shareholder wealth by accepting every project that is worth more than it costs. But, if capital is strictly limited, then it may not be possible to take every project with a positive NPV. If capital is rationed in only one period, then the firm should follow a simple rule: **Calculate each project's profitability index, which is the project's net present value per dollar of investment**. Then **pick the projects with the highest profitability indexes until you run out of capital**. Unfortunately, this procedure fails when capital is rationed in more than one period or when there are other constraints on project choice. The only general solution is linear programming.

Hard capital rationing always reflects a market imperfection—a barrier between the firm and capital markets. If that barrier also implies that the firm's shareholders lack free access to a well-functioning capital market, the very foundations of net present value crumble. Fortunately, hard rationing is rare for corporations in the United States. Many firms do use soft capital rationing, however. That is, they set up self-imposed limits as a means of financial planning and control.