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 can't 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. The other criteria provide additional information about whether or not a project truly has a positive NPV.

Chapter Review and Self-Test Problems

9.1 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	−$200
1	50
2	60
3	70
4	200

Calculate the payback, the discounted payback, and the NPV at a required return of 10 percent.

9.2 Mutually Exclusive Investments Consider the following two mutually exclusive investments. Calculate the IRR for each and the crossover rate. Under what circumstances will the IRR and NPV criteria rank the two projects differently?

Year	Investment A	Investment B
0	−$75	−$75
1	20	60
2	40	50
3	70	15

9.3 Average Accounting Return You are looking at a three-year project with a projected net income of $2,000 in Year 1, $4,000 in Year 2, and $6,000 in Year 3. The cost is $12,000, which will be depreciated straight-line to zero over the three-year life of the project. What is the average accounting return (AAR)?

Answers to Chapter Review and Self-Test Problems

9.1 In the following table, we have listed the cash flow, cumulative cash flow, discounted cash flow (at 10 percent), and cumulative discounted cash flow for the proposed project.

	Cash Flow		Accumulated Cash Flow	
Year	Undiscounted	Discounted	Undiscounted	Discounted
1	$ 50	$ 45.45	$ 50	$ 45.45
2	60	49.59	110	95.04
3	70	52.59	180	147.63
4	200	136.60	380	284.23

Recall that the initial investment was $200. When we compare this to accumulated undiscounted cash flows, we see that payback occurs between Years 3 and 4. The cash flows for the first three years are $180 total, so, going into the fourth year, we are short by $20. The total cash flow in Year 4 is $200, so the payback is 3 + ($20/200) = 3.10 years.

Looking at the accumulated discounted cash flows, we see that the discounted payback occurs between Years 3 and 4. The sum of the discounted cash flows is $284.23, so the NPV is $84.23. Notice that this is the present value of the cash flows that occur after the discounted payback.

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

Discount Rate	NPV(A)	NPV(B)
0%	$55.00	$50.00
10	28.83	32.14
20	9.95	18.40
30	– 4.09	7.57
40	– 14.80	– 1.17

Several things are immediately apparent from our guesses. First, the IRR on A must be between 20 percent and 30 percent (why?). With some more effort, we find that it's 26.79 percent. For B, the IRR must be a little less than 40 percent (again, why?); it works out to be 38.54 percent. Also, notice that at rates between 0 percent and 10 percent, the NPVs are very close, indicating that the crossover is in that vicinity.

To find the crossover exactly, we can compute the IRR on the difference in the cash flows. If we take the cash flows from A minus the cash flows from B, the resulting cash flows are:

Year	A – B
0	$ 0
1	– 40
2	– 10
3	55

These cash flows look a little odd, but the sign only changes once, so we can find an IRR. With some trial and error, you'll see that the NPV is zero at a discount rate of 5.42 percent, so this is the crossover rate.

The IRR for B is higher. However, as we've seen, A has the larger NPV for any discount rate less than 5.42 percent, so the NPV and IRR rankings will conflict in that range. Remember, if there's 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 5.42 per-

cent, take B if the required return is between 5.42 percent and 38.54 percent (the IRR on B), and take neither if the required return is more than 38.54 percent.

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

$$\text{Average net income} = (\$2{,}000 + 4{,}000 + 6{,}000)/3 = \$4{,}000$$

Average book value is:

$$\text{Average book value} = \$12{,}000/2 = \$6{,}000$$

So the average accounting return is:

$$\text{AAR} = \$4{,}000/6{,}000 = 66.67\%$$

This is an impressive return. Remember, however, that it isn't really a rate of return like an interest rate or an IRR, so the size doesn't tell us a lot. In particular, our money is probably not going to grow at a rate of 66.67 percent per year, sorry to say.

Concepts Review and Critical Thinking Questions

1. **Payback Period and Net Present Value** If a project with conventional cash flows has a payback period less than the project's life, can you definitively state the algebraic sign of the NPV? Why or why not? If you know that the discounted payback period is less than the project's life, what can you say about the NPV? Explain.
2. **Net Present Value** Suppose a project has conventional cash flows and a positive NPV. What do you know about its payback? Its discounted payback? Its profitability index? Its IRR? Explain.
3. **Payback Period** Concerning payback:
   a. Describe how the payback period is calculated and describe the information this measure provides about a sequence of cash flows. 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. What are the advantages of using the payback period to evaluate cash flows? Are there any circumstances under which using payback might be appropriate? Explain.
4. **Discounted Payback** Concerning discounted payback:
   a. Describe how the discounted payback period is calculated and describe the information this measure provides about a sequence of cash flows. What is the discounted payback criterion decision rule?
   b. What are the problems associated with using the discounted payback period as a means of evaluating cash flows?
   c. What conceptual advantage does the discounted payback method have over the regular payback method? Can the discounted payback ever be longer than the regular payback? Explain.
5. **Average Accounting Return** Concerning AAR:
   a. Describe how the average accounting return is usually calculated and describe the information this measure provides about a sequence of cash flows. What is the AAR criterion decision rule?

b. What are the problems associated with using the AAR as a means of evaluating a project's cash flows? What underlying feature of AAR is most troubling to you from a financial perspective? Does the AAR have any redeeming qualities?

6. Net Present Value Concerning NPV:

a. Describe how NPV is calculated and describe the information this measure provides about a sequence of cash flows. What is the NPV criterion decision rule?

b. Why is NPV considered to be a superior method of evaluating the cash flows from a project? Suppose the NPV for a project's cash flows is computed to be $2,500. What does this number represent with respect to the firm's shareholders?

7. Internal Rate of Return Concerning IRR:

a. Describe how the IRR is calculated and describe the information this measure provides about a sequence of cash flows. What is the IRR criterion decision rule?

b. What is the relationship between IRR and NPV? Are there any situations in which you might prefer one method over the other? Explain.

c. Despite its shortcomings in some situations, why do most financial managers use IRR along with NPV when evaluating projects? Can you think of a situation in which IRR might be a more appropriate measure to use than NPV? Explain.

8. Profitability Index Concerning the profitability index:

a. Describe how the profitability index is calculated and describe the information this measure provides about a sequence of cash flows. What is the profitability index decision rule?

b. What is the relationship between the profitability index and NPV? Are there any situations in which you might prefer one method over the other? Explain.

9. 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. What is the relationship between the project's payback and its IRR? What implications does your answer have for long-lived projects with relatively constant cash flows?

10. International Investment Projects In 1996, Fuji Film, the Japanese manufacturer of photo film and related products, broke ground on a film plant in South Carolina. Fuji apparently thought that it would be better able to compete and create value with a U.S.-based facility. Other companies, such as BMW and Mercedes-Benz, have reached similar conclusions and taken similar actions. What are some of the reasons that foreign manufacturers of products as diverse as photo film and luxury automobiles might arrive at this same conclusion?

11. Capital Budgeting Problems What are some of the difficulties that might come up in actual applications of the various criteria we discussed in this chapter? Which one would be the easiest to implement in actual applications? The most difficult?

12. Capital Budgeting in Not-for-Profit Entities Are the capital budgeting criteria we discussed applicable to not-for-profit corporations? How should such entities make capital budgeting decisions? What about the U.S. government? Should it evaluate spending proposals using these techniques?

Questions and Problems

Basic (Questions 1–18)

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

Year	Cash Flow
0	−$4,400
1	900
2	2,500
3	3,800
4	1,700

2. **Calculating Payback** An investment project provides cash inflows of $780 per year for eight years. What is the project payback period if the initial cost is $3,000? What if the initial cost is $5,000? What if it is $7,000?
3. **Calculating Payback** Tulip Mania, Inc., imposes a payback cutoff of three years for its international investment projects. If the company has the following two projects available, should they accept either of them?

Year	Cash Flow (A)	Cash Flow (B)
0	−$40,000	−$ 60,000
1	25,000	8,000
2	10,000	20,000
3	10,000	30,000
4	5,000	425,000

4. **Calculating Discounted Payback** An investment project has annual cash inflows of $7,000, $7,500, $8,000, and $8,500, and a discount rate of 12 percent. What is the discounted payback period for these cash flows if the initial cost is $8,000? What if the initial cost is $13,000? What if it is $18,000?
5. **Calculating Discounted Payback** An investment project costs $8,000 and has annual cash flows of $1,700 for six years. What is the discounted payback period if the discount rate is zero percent? What if the discount rate is 5 percent? If it is 15 percent?
6. **Calculating AAR** You're trying to determine whether or not to expand your business by building a new manufacturing plant. The plant has an installation cost of $12 million, which will be depreciated straight-line to zero over its four-year life. If the plant has projected net income of $1,416,000, $1,032,000, $1,562,000, and $985,000 over these four years, what is the project's average accounting return (AAR)?
7. **Calculating IRR** A firm evaluates all of its projects by applying the IRR rule. If the required return is 18 percent, should the firm accept the following project?

Year	Cash Flow
0	−$30,000
1	19,000
2	9,000
3	14,000

Basic (*continued*)

8. Calculating NPV For the cash flows in the previous problem, suppose the firm uses the NPV decision rule. At a required return of 11 percent, should the firm accept this project? What if the required return was 21 percent?

9. Calculating NPV and IRR A project that provides annual cash flows of $1,200 for nine years costs $6,000 today. Is this a good project if the required return is 8 percent? What if it's 24 percent? At what discount rate would you be indifferent between accepting the project and rejecting it?

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

Year	Cash Flow
0	−$4,000
1	1,500
2	2,100
3	2,900

11. Calculating NPV For the cash flows in the previous problem, what is the NPV at a discount rate of zero percent? What if the discount rate is 10 percent? If it is 20 percent? If it is 30 percent?

12. NPV versus IRR Bumble's Bees, Inc., has identified the following two mutually exclusive projects:

Year	Cash Flow (A)	Cash Flow (B)
0	−$17,000	−$17,000
1	8,000	2,000
2	7,000	5,000
3	5,000	9,000
4	3,000	9,500

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

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

c. Over what range of discount rates would you choose Project A? Project B? At what discount rate would you be indifferent between these two projects? Explain.

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

Year	Cash Flow (X)	Cash Flow (Y)
0	−$4,000	−$4,000
1	2,500	1,500
2	1,500	2,000
3	1,800	2,600

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

14. Problems with IRR Kong Petroleum, Inc., is trying to evaluate a generation project with the following cash flows:

Basic
(*continued*)

Year	Cash Flow
0	−$28,000,000
1	53,000,000
2	− 8,000,000

a. If the company requires a 10 percent return on its investments, should it accept this project? Why?
b. Compute the IRR for this project. How many IRRs are there? If you apply the IRR decision rule, should you accept the project or not? What's going on here?

15. Calculating Profitability Index What is the profitability index for the following set of cash flows if the relevant discount rate is 10 percent? What if the discount rate is 15 percent? If it is 22 percent?

Year	Cash Flow
0	−$1,600
1	1,200
2	550
3	310

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

Year	Cash Flow (I)	Cash Flow (II)
0	−$20,000	−$3,000
1	10,000	2,500
2	10,000	2,500
3	10,000	2,500

a. If the required return is 9 percent and Moby Computer 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.

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

Year	Cash Flow (A)	Cash Flow (B)
0	−$170,000	−$18,000
1	10,000	10,000
2	25,000	6,000
3	25,000	10,000
4	380,000	8,000

Whichever project you choose, if any, you require a 15 percent return on your investment.
a. If you apply the payback criterion, which investment will you choose? Why?
b. If you apply the discounted payback criterion, which investment will you choose? Why?

Basic (*continued*)

c. If you apply the NPV criterion, which investment will you choose? Why?
d. If you apply the IRR criterion, which investment will you choose? Why?
e. If you apply the profitability index criterion, which investment will you choose? Why?
f. Based on your answers in (*a*) through (*e*), which project will you finally choose? Why?

18. NPV and Discount Rates An investment has an installed cost of $412,670. The cash flows over the four-year life of the investment are projected to be $212,817, $153,408, $102,389, and $72,308. If the discount rate is zero, what is the NPV? If the discount rate is infinite, what is the NPV? At what discount rate is the NPV just equal to zero? Sketch the NPV profile for this investment based on these three points.

Intermediate (Questions 19–20)

19. 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?

20. 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.

Challenge (Questions 21–23)

21. Payback and NPV An investment under consideration has a payback of seven years and a cost of $320,000. If the required return is 12 percent, what is the worst-case NPV? The best-case NPV? Explain.

22. Multiple IRRs This problem is useful for testing the ability of financial calculators and computer software. Consider the following cash flows. How many different IRRs are there (hint: search between 20 percent and 70 percent)? When should we take this project?

Year	Cash Flow
0	−$ 504
1	2,862
2	− 6,070
3	5,700
4	− 2,000

23. NPV Valuation The Yurdone Corporation wants to set up a private cemetery business. According to the CFO, Barry M. Deep, business is "looking up." As a result, the cemetery project will provide a net cash inflow of $40,000 for the firm during the first year, and the cash flows are projected to grow at a rate of 7 percent per year forever. The project requires an initial investment of $650,000.
a. If Yurdone requires a 14 percent return on such undertakings, should the cemetery business be started?
b. The company is somewhat unsure about the assumption of a 7 percent growth rate in its cash flows. At what constant growth rate would the company just break even if it still required a 14 percent return on investment?

9.1 Net Present Value You have a project that has an initial cash outflow of −$20,000 and cash inflows of $6,000, $5,000, $4,000 and $3,000, 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 percent, what is the IRR of the project? The NPV?

What's On the Web?

9.2 Internal Rate of Return Using the online calculator from the previous problem, find the IRR for a project with cash flows of −$500, $1,200, and −$400. What is going on here?

Spreadsheet Templates 9–3, 9–6, 9–7, 9–9, 9–12, 9–15, 9–18, 9–23