Chapter 8
Net Present Value and Other Investment Criteria

Financial Management (MGCM10018)

Preview

- The investment decision (a.k.a. capital budgeting) is central to the success of the company.
  - A company's shareholders want the firm to invest in every project that is worth more than it costs.
  - The difference between a project's value and its cost is termed the net present value (NPV).
- This chapter presents multiple valuation techniques in the capital budgeting process.

Outline

- Net Present Value
- The Internal Rate of Return Rule
- The Profitability Index
- The Payback Rule
- Mutually Exclusive Projects
- A Last Look

Net Present Value (8.1)

- Assume we are in real estate business and we're considering to build an office block.
  - The land would cost $50,000, and the construction would cost $300,000.
  - We foresee a shortage of office space in a year and predict that we'll be able to sell the building for $400,000.
  - Suppose Treasury notes offer interest of 7%, would you committee to such project?
  - What would be the net present value of the project?

Net Present Value (continued)

- The present value of $400,000 would be

$$PV = \frac{400{,}000}{1.07} = \$373{,}832$$

  - This is also known as the market price or market value of project.
  - The discount rate of 7% is also known as the opportunity cost of capital.
    - The expected rate of return given up by investing in a project

Net Present Value (continued)

- The net present value (NPV) of this project would be

$$\text{NPV} = \text{PV} - \text{Required Investment}$$
$$= \$373{,}832 - \$350{,}000 = \$23{,}832$$

  - That is, the NPV is present value of cash flows minus initial investment.
  - Thus, we should take this project since it earns higher return than the alternative investment.

Net Present Value (continued)

- The net present value rule states that managers increase shareholder's wealth by accepting projects that are worth more than they cost.
- Therefore, managers should accept all projects with a positive NPV.
- In the last example, we may think that the project is riskier than Treasury note.
  - Suppose we forecast 12% return in stock market.

NPV General Formula

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

Terminology

C_0 = Initial Cash Flow (often negative)

C_1 = Cash Flow at time 1

C_2 = Cash Flow at time 2

C_t = Cash Flow at time t?

t = Time period of the investment?

r = Opportunity cost of capital

NPV: Example 1

Assume you plan to invest $1,000 today and will receive $600 each year for two years (assume the cash is received at the end of the year). What is the net present value if there is a 10% opportunity cost of capital?

NPV: Example 2

Assume you invest $1,000 today and will receive $1,200 in two years (assume the cash is received at the end of the 2nd year). What is the net present value if there is a 10% opportunity cost of capital?

Forecast cash flows and present values in 1986 for the Channel Tunnel project.

	A	B	C	D	E
1			Cash Flow		
2	Year	Time	(£ million)	PV at 13%	Formula in Column D
3	1986	0	–457	–457.0	=C3/1.13^B3
4	1987	1	–476	–421.2	=C4/1.13^B4
5	1988	2	–497	–389.2	=C5/1.13^B5
6	1989	3	–522	–361.8	=C6/1.13^B6
7	1990	4	–551	–337.9	=C7/1.13^B7
8	1991	5	–584	–317.0	=C8/1.13^B8
9	1992	6	–619	–297.3	=C9/1.13^B9
10	1993	7	211	89.7	=C10/1.13^B10
11	1994	8	489	183.9	=C11/1.13^B11
12	1995	9	455	151.5	=C12/1.13^B12
13	1996	10	502	147.9	=C13/1.13^B13
14	1997	11	530	138.2	=C14/1.13^B14
15	1998	12	544	125.5	=C15/1.13^B15
16	1999	13	636	129.8	=C16/1.13^B16
17	2000	14	594	107.3	=C17/1.13^B17
18	2001	15	689	110.2	=C18/1.13^B18
19	2002	16	729	103.2	=C19/1.13^B19
20	2003	17	796	99.7	=C20/1.13^B20
21	2004	18	859	95.2	=C21/1.13^B21
22	2005	19	923	90.5	=C22/1.13^B22
23	2006	20	983	85.3	=C23/1.13^B23
24	2007	21	1,050	80.6	=C24/1.13^B24
25	2008	22	1,113	75.6	=C25/1.13^B25
26	2009	23	1,177	70.8	=C26/1.13^B26
27	2010	24	17,781	946.4	=C27/1.13^B27
28					
29	Sum:			249.8	=SUM(D3:D27)
30					
31	Instead, use Excel's NPV function			249.8	=NPV(0.13,C4:C27) + C3

Note: Cash flow for 2010 includes the value in 2010 of forecast cash flows in all subsequent years. Some of these figures involve guesswork because the prospectus reported accumulated construction costs including interest expenses.
Source: Eurotunnel Equity II Prospectus, October 1986. Reprinted with permission.

The Internal Rate of Return (8.2)

- The companies often ask whether the project's return is higher or lower than the opportunity cost of capital.
  - As the earlier example, we planned to invest \$350,000 to get back a cash flow of C_1 = \$400,000 in one year.
    - The rate of return = (400 – 350)/350 = 14.3%
    - This is higher than the alternative return on Treasury note of 7%.

The Rate of Return Rule

- Thus, the rate of return rule states that managers should invest in any project offering a rate of return that is higher than the opportunity cost of capital.
  - Note that the rate of return is the discount rate of all cash flows at which NPV equals zero.
  - Such rate is known as the project's internal rate of return (IRR).
    - It is also known as discounted cash-flow rate of return.

The IRR Formula

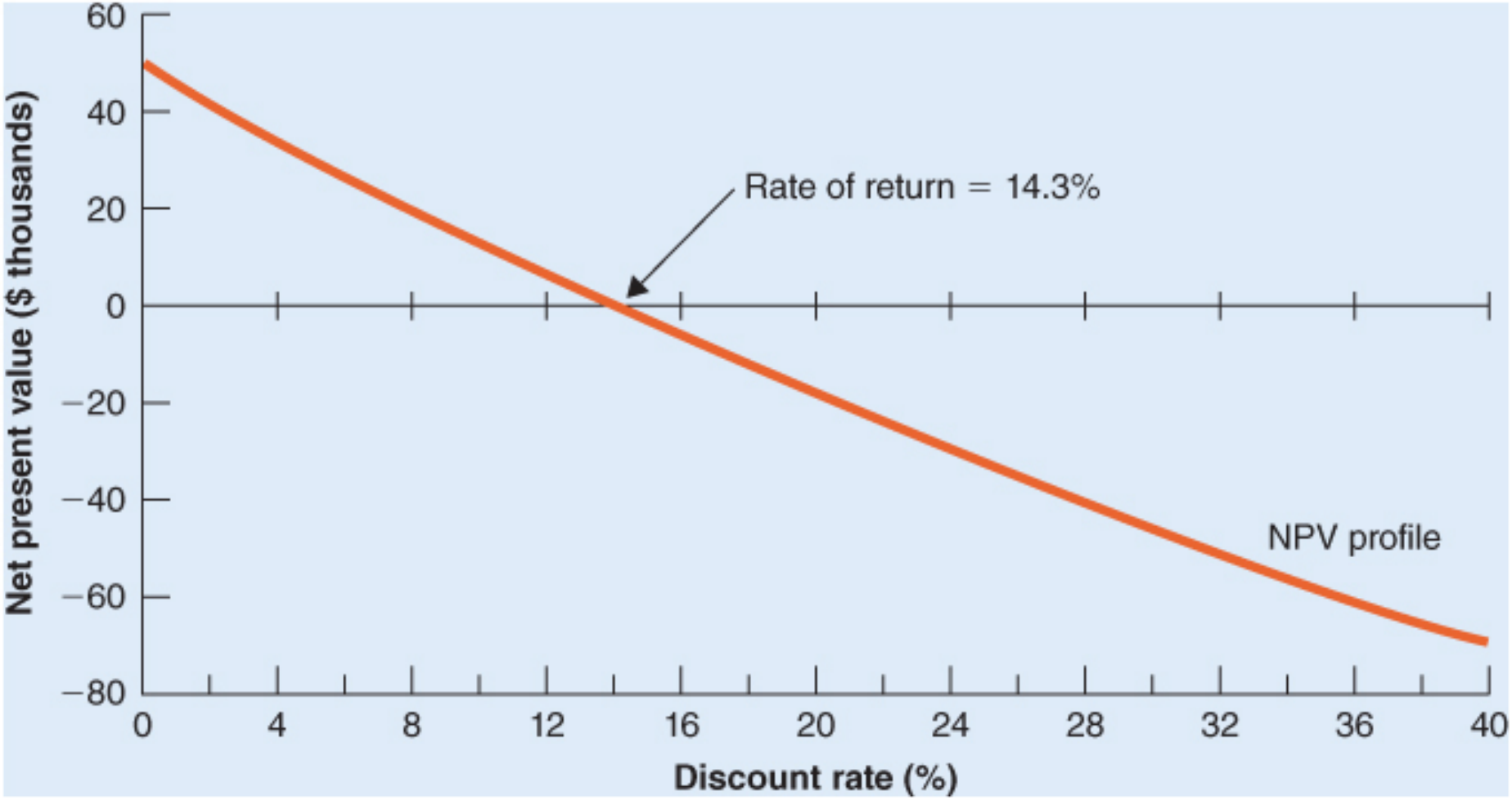
$$0 = C_0 + \frac{C_1}{(1+IRR)^1} + \frac{C_2}{(1+IRR)^2} + \ldots + \frac{C_t}{(1+IRR)^t}$$

- The C_0 is first cash flow
  - It is often the initial investment.
  - It is typically negative.

Internal Rate of Return: Example

Project	Cash Flows C_0	C_1	C_2	NPV (@ 10%)
Project 1	- $1,000	$700	$500	$49.59
Project 2	- $1,000	$500	$700	$33.06

NPV and Internal Rate of Return



The IRR Rule

- When used properly, the NPV and internal rate of return rules lead to the same decision.
- Some examples show the pitfalls of IRR rule.
  - Lending or borrowing?
  - Mutually exclusive projects
  - Multiple rates of return

IRR vs. NPV
Lending or Borrowing?

Project	Cash Flows (dollars) C_0	C_1	IRR, %	NPV at 10%
H	−100	+150	+50	+$36.4
I	+100	−150	+50	− 36.4

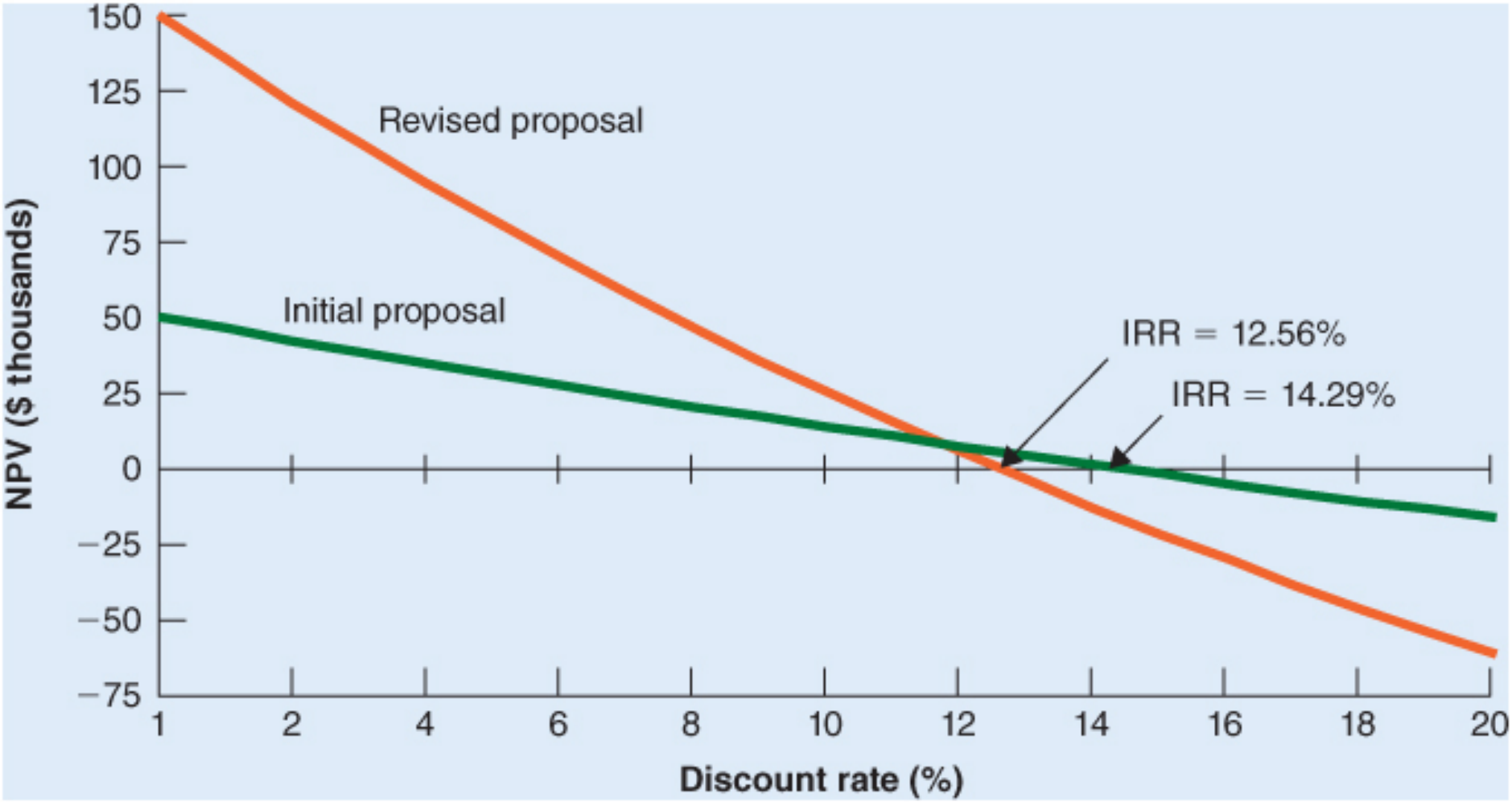
IRR vs. NPV: Mutually Exclusive Projects

- Suppose we invested $375,000 to build the office and rent it for 3 years.
  - We'll be able to sell it for $450,000.

Year:	0	1	2	3	IRR	NPV at 7%
Initial proposal	−350,000	+400,000			14.29%	+$23,832
Revised proposal	−375,000	+25,000	+25,000	+475,000	12.56%	+$57,942

  - If we follow IRR rule, we earn more with initial project.
    - By NPV rule, we'll be nearly $58,000 richer.

NPV vs. IRR Rules



IRR vs. NPV: Mutually Exclusive Projects (continued)

- Note that we want projects that increase the value of the firm.
  - Projects that earn a good rate of return for a long time often have higher NPVs than those that offer high percentage rates of return but die young.

IRR vs. NPV
Multiple Rates of Return

- A coal firm is considering a project to strip-mine coal, and the project requires an investment of $210 million.
  - It will produce cash inflow of $125 million in first 2 years and of $175 million in years 3 and 4.
  - The firm is obliged in year 5 to reclaim the land at cost of $400 million.
  - At a 20% opportunity cost, its NPV = $5.9 million.
- What would be the IRR?

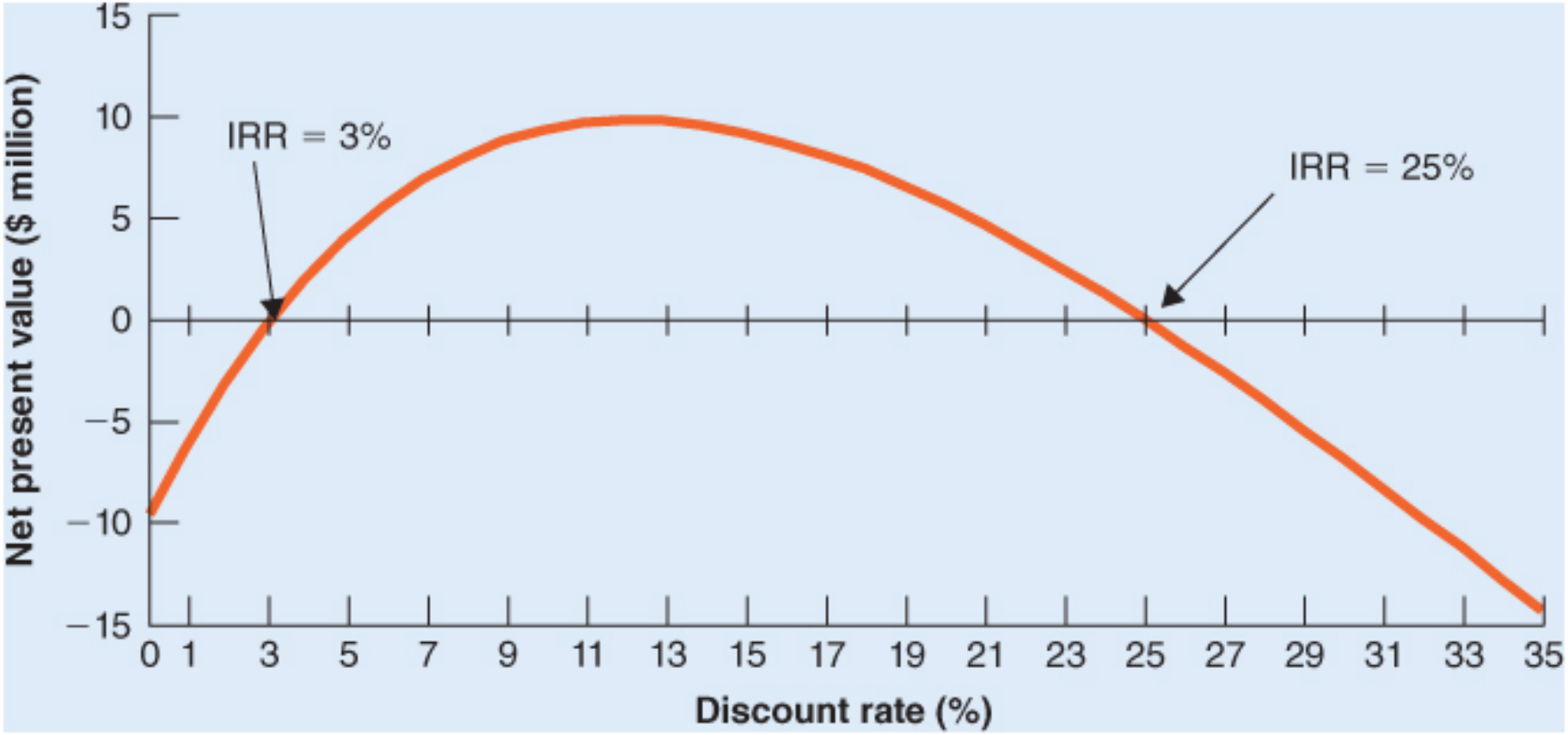
IRR vs. NPV
Multiple Rates of Return (continued)

- There would be two IRRs!

$$NPV = -210 + \frac{125}{1.03} + \frac{125}{1.03^2} + \frac{175}{1.03^3} + \frac{175}{1.03^4} - \frac{400}{1.03^5} = 0$$

$$NPV = -210 + \frac{125}{1.25} + \frac{125}{1.25^2} + \frac{175}{1.25^3} + \frac{175}{1.25^4} - \frac{400}{1.25^5} = 0$$

Multiple rates of return



The Profitability Index (8.3)

- The profitability index measures the net present value of a project per dollar of investment.

$$\text{Profitability Index} = \frac{\text{NPV}}{\text{Initial Investment}}$$

  - For instance, the office building example has profitability index as 23,832 / 350,000 = 0.068
- Any project with positive profitability index must also have a positive NPV.

Profitability Index: Example

Project	Cash Flows			NPV (@ 10%)
	C_0	C_1	C_2	
Project 1	- $1,000	$700	$500	$49.59
Project 2	- $1,000	$500	$700	$33.06

The Profitability Index (continued)

- Why do we use profitability index?
  - When there is a limit on the firm's budgeting, we can concentrate on getting the biggest return for each investment.

	Cash Flows ($ millions)				
Project	C_0	C_1	C_2	NPV at 10%	Profitability Index
J	−10	+30	+5	21	21/10 = 2.1
K	−5	+5	+20	16	16/5 = 3.2
L	−5	+5	+15	12	12/5 = 2.4

The Profitability Index (continued)

- Economists use the term capital rationing to refer to a shortage of funds available for investment.
  - Profitability index provides a measure of which project to accept under capital rationing.
  - Soft rationing: limits on funds imposed by management.
  - Hard rationing: limits on funds imposed by the lack of available funds in the capital market.

The Payback Rule (8.4)

- A project's payback period is the length of time before we recover our initial investment.
  - The payback rule says that a project should be accepted if its payback period is less than a specified cutoff period.

Payback Method: Example

The three projects below are available. The company accepts all projects with a 2 year or less payback period. Show how this will impact your decision.

Project	Cash Flows				Payback Period
	C_0	C_1	C_2	C_3	
Project 1	- $1,000	$700	$500		1.6 years
Project 2	- $1,000	$500	$700		1.7 years
Project 3	- $1,000	$500	$700	$700	1.7 years

The Payback Rule (continued)

- Drawbacks of payback rule.
  - Though Projects 1, 2 and 3 have payback periods less than 2 years, notice the differences in NPV.
  - The Payback Rule ignores the time value of money.
- Sometimes managers calculate the discounted payback period.
  - This is the number of periods before the present value of prospective cash flows equals or exceeds the initial investment.

Mutually Exclusive Projects (8.5)

- The previous examples are mostly take-it-or-leave-it decisions.
  - Real world decisions entail either-or choices.
  - For example, we could build an apartment block. Or, a 7-story office building instead of 10-story.
- When choosing among mutually exclusive projects, calculate their NPV and choose the one with highest positive NPV.

Using the NPV Rule to Choose among Projects

Example: Consider two projects, assuming a 10% opportunity cost of capital. Which project should be selected?

Project	Cash Flows			
	C_0	C_1	C_2	NPV
Project 1	- $1,000	$700	$500	$49.59
Project 2	- $1,000	$500	$700	$33.06

Using the NPV Rule to Choose among Projects (continued)

- Challenges to the NPV rule:
  - The investment timing decision
  - The choice between long and short-lived equipment
  - When to replace an old machine

Investment Timing

Sometimes you have the ability to defer an investment and select a time that is more ideal at which to make the investment decision.

Example: A common example involves a tree farm. You may defer the harvesting of trees. By doing so, you defer the receipt of the cash flow, yet increase the cash flow. Assume an opportunity cost of capital of 10%.

Year	Cost	Sales	Value	NPV
0	50	70	20	20.0
1	55	80	25	22.7
2	60	88	28	23.1
3	64	95	31	**23.3**
4	68	102	34	23.2
5	70	105	35	21.7

Investment Timing: Example

- Obsolete Technologies: The gain from purchase of a computer is rising, but the NPV today is highest if the computer is purchased in 3 years.

Year of Purchase	Cost of Computer	PV Savings	NPV at Year of Purchase (r = 10%)	NPV Today	
0	$50	$70	$20	$20.0	
1	45	70	25	22.7	
2	40	70	30	24.8	
3	36	70	34	25.5	⟵ optimal purchase date
4	33	70	37	25.3	
5	31	70	39	24.2	

Long- vs. Short-Lived Equipment: Equivalent Annual Annuity

- Suppose the firm is forced to choose between two machines, A and B.
  - The two machines do the same job but cost differently.

	Costs (thousands of dollars)				
Year:	0	1	2	3	PV at 6%
Machine A	15	4	4	4	$25.69
Machine B	10	6	6	—	21.00

  - So, should we choose B because of lower PV of costs?

Long- vs. Short-Lived Equipment: Equivalent Annual Annuity (continued)

- Not necessarily. We need to find the equivalent annual annuity.
  - The cash flow per period with the same present value as the cost of buying and operating a machine.

$$\text{EAA} = \frac{\text{present value of cash flows}}{\text{annuity factor}} = \frac{PV_{Cash\ Flows}}{\left[\frac{1}{r} - \frac{1}{r \times (1+r)^t}\right]}$$

Long- vs. Short-Lived Equipment: Equivalent Annual Annuity (continued)

	Costs (thousands of dollars)				
Year:	0	1	2	3	PV at 6%
Machine A	15	4	4	4	$25.69
Equivalent annual annuity		9.61	9.61	9.61	25.69

	Costs (thousands of dollars)			
Year:	0	1	2	PV at 6%
Machine B	10	6	6	$21.00
Equivalent annual annuity		11.45	11.45	21.00

- We now see that machine A is better choice, because its equivalent annual annuity is less.

When to Replace an Old Machine

- We are operating an old machine that will last 2 more years.
  - It costs $12,000 each year to operate.
  - We can replace it with new machine that costs $25,000 with $8,000 per year in operating costs.
    - The new machine will last 5 years.

	Costs (thousands of dollars)						
Year:	0	1	2	3	4	5	PV at 6%
New machine	25	8	8	8	8	8	$58.70
Equivalent annual annuity		13.93	13.93	13.93	13.93	13.93	58.70

A Last Look (8.6)

- We've seen several investment criteria. Clearly, NPV is the gold standard.
- For managers in the field, discounted cash-flow analysis is in fact the dominant tool for project evaluation.

A comparison of investment decision rules

Criterion	Definition	Investment Rule	Comments
Net present value (NPV)	Present value of cash inflows minus present value of cash outflows	Accept project if NPV is positive. For mutually exclusive projects, choose the one with the highest (positive) NPV.	The "gold standard" of investment criteria. Only criterion necessarily consistent with maximizing the value of the firm. Provides proper rule for choosing among mutually exclusive investments. Only pitfall involves capital rationing, when one cannot accept all positive-NPV projects.
Internal rate of return (IRR)	The discount rate at which project NPV equals zero	Accept project if IRR is greater than opportunity cost of capital	If used properly, results in same accept-reject decision as NPV in the absence of project interactions. However, beware of the following pitfalls: IRR cannot rank mutually exclusive projects—the project with higher IRR may have lower NPV. The simple IRR rule cannot be used in cases of multiple IRRs or an upward-sloping NPV profile.
Payback period	Time until the sum of project cash flows equals the initial investment	Accept project if payback period is less than some specified number of years	A quick and dirty rule of thumb, with several critical pitfalls. Ignores cash flows beyond the acceptable payback period. Ignores discounting. Tends to improperly reject long-lived projects.
Profitability index	Ratio of net present value to initial investment	Accept project if profitability index is greater than 0. In case of capital rationing, accept projects with highest profitability index.	Results in same accept-reject decision as NPV in the absence of project interactions. Useful for ranking projects in case of capital rationing, but misleading in the presence of interactions. Cannot rank mutually exclusive projects.

資本限額

Capital budgeting techniques used in practice

Investment Criterion	Percentage of Firms That Always or Almost Always Use Criterion	Average Score on 0–4 Scale (0 = never use; 4 = always use)		
		All Firms	Small Firms	Large Firms
Internal rate of return	76	3.1	2.9	3.4
Net present value	75	3.1	2.8	3.4
Payback period	57	2.5	2.7	2.3
Profitability index	12	0.8	0.9	0.8

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