Investment Decision Criteria

Chapter 11

Principles Applied in This Chapter

- Principle 1: Money Has a Time Value.
- Principle 2: There is a Risk-Return Tradeoff.
- Principle 3: Cash Flows Are the Source of Value.
- Principle 5: Individuals Respond to Incentives.

Learning Objectives

1. Understand how to identify the sources and types of profitable investment opportunities.
2. Evaluate investment opportunities using net present value and describe why net present value is the best measure to use.
3. Use the profitability index, internal rate of return, and payback criteria to evaluate investment opportunities.
4. Understand current business practice with respect to the use of capital-budgeting criteria

The Typical Capital-Budgeting Process

- Phase I: The firm's management identifies promising investment opportunities.

- Phase II: The investment opportunity's value- creating potential (for shareholders) is thoroughly evaluated.

Types of Capital Investment Projects

1. Revenue enhancing Investments,
2. Cost-reduction investments, and
3. Mandatory investments that are a result of government mandates

Types of Capital Investment Projects

To determine the desirability of investment proposals, we can use several analytical tools such as:

Net Present Value (NPV),

Equivalent Annual Cost (EAC),

Internal Rate of Return (IRR), and

Profitability Index (PI),

Discounted Payback Period.

Net Present Value

- The **net present value (NPV)** is the difference between the present value of cash inflows and the cash outflows.
- NPV estimates the amount of wealth that the project creates.
- **<u>Decision Criteria</u>:**

Investment projects should be

<u>Accepted</u> if the NPV of the project is positive and

<u>Rejected</u> if the NPV is negative.

Calculating an Investment's NPV

$$\text{Net Present Value or } NPV = \text{Cash Flow for Year 0 } (CF_0) + \frac{\text{Cash Flow for Year 1 } (CF_1)}{\left(1 + \text{Discount Rate } (k)\right)^1} + \frac{\text{Cash Flow for Year 2 } (CF_2)}{\left(1 + \text{Discount Rate } (k)\right)^2} + \cdots + \frac{\text{Cash Flow for Year } n \ (CF_n)}{\left(1 + \text{Discount Rate } (k)\right)^n}$$

Cost of making the investment = Initial cash flow, this is typically a cash outflow taking on a negative value.

Present value of the investment's cash inflows = Present value of the project's future cash inflows.

The Problem

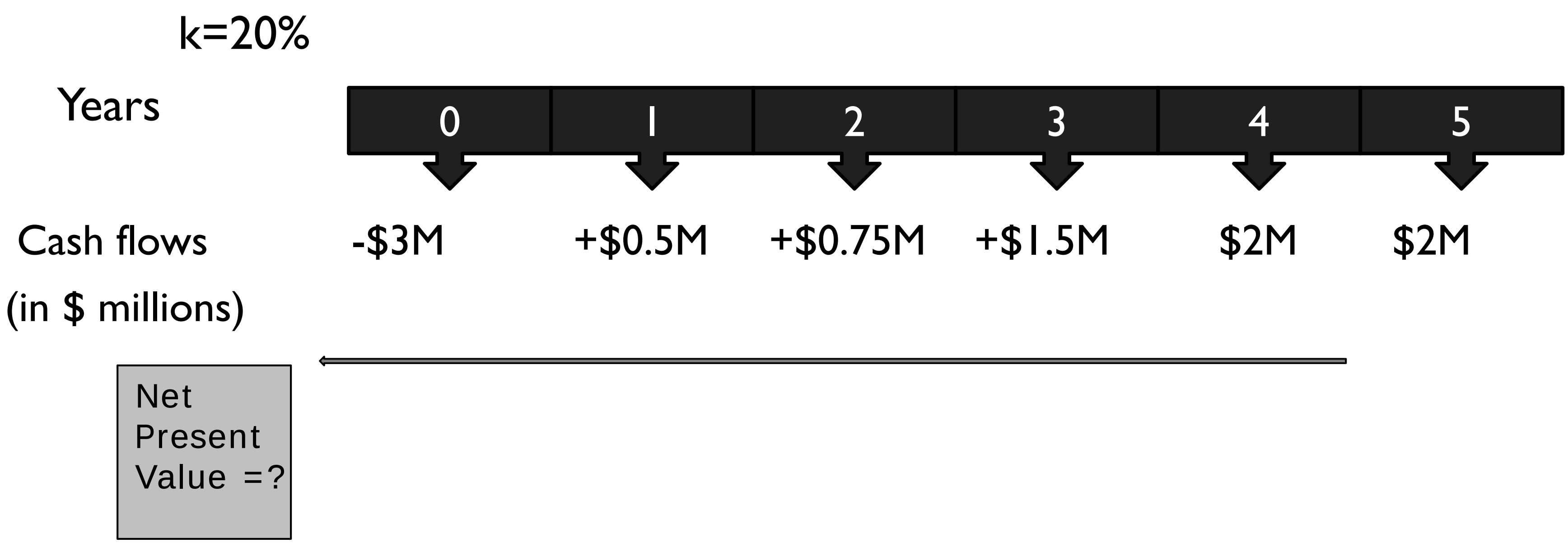
Saber Electronics provides specialty manufacturing services to defense contractors located in the Seattle, WA area.

The initial outlay is $3 million and, management estimates that the firm might generate cash flows for years one through five equal to $500,000; $750,000; $1,500,000; $2,000,000; and $2,000,000.

Saber uses a 20% discount rate for projects of this type.

Is this a good investment opportunity?

Step 1: Picture the Problem



Step 2: Decide on a Solution Strategy

- We need to analyze if this is a good investment opportunity.
- We can do that by computing the Net Present Value (NPV), which requires computing the present value of all cash flows.

Step 3: Solve

<u>Using a Mathematical Formula</u>

$$\text{Net Present Value or } NPV = \text{Cash Flow for Year 0 } (CF_0) + \frac{\text{Cash Flow for Year 1 } (CF_1)}{\left(1 + \text{Discount Rate } (k)\right)^1} + \frac{\text{Cash Flow for Year 2 } (CF_2)}{\left(1 + \text{Discount Rate } (k)\right)^2} + \cdots + \frac{\text{Cash Flow for Year } n \ (CF_n)}{\left(1 + \text{Discount Rate } (k)\right)^n}$$

<u>Cost of making the investment</u> = Initial cash flow, this is typically a cash outflow taking on a negative value.

<u>Present value of the investment's cash inflows</u> = Present value of the project's future cash inflows.

Step 3: Solve

- NPV = -\$3m + \$.5m/(1.2) + \$.75m/$(1.2)^2$ + \$1.5m/$(1.2)^3$ + \$2m/$(1.2)^4$ + \$2m/$(1.2)^4$

- NPV = -\$3,000,000 + \$416,666.67 + \$520,833.30 + \$868,055.60 + \$964,506 + \$803,755.10
- NPV = **\$573,817**

- **Use the cash flow keys**

Step 4: Analyze

- The project requires an initial investment of $3,000,000 and generates futures cash flows that have a present value of $3,573,817.
- Consequently, the project cash flows are $573,817 more than the required investment.
- Since the NPV is positive, the project is an acceptable project.

Independent Versus Mutually Exclusive Investment Projects

- An **independent investment project** is one that stands alone and can be undertaken without influencing the acceptance or rejection of any other project.

- Accepting a **mutually exclusive project** prevents another project from being accepted.

Choosing Between Mutually Exclusive Investments

If mutually exclusive investments have equal lives, we will calculate the NPVs and choose the one with the higher NPV.

Choosing Between Mutually Exclusive Investments

If mutually exclusive investments do not have equal lives, we must calculate the Equivalent Annual Cost (EAC), the cost per year.

- We will then select the one that has a lower EAC.

- We convert the PV into an <u>annuity payment</u>
- EAC = NPV/PVAIF

Choosing Between Mutually Exclusive Investments

<u>Computation of EAC</u>

$$EAC = \frac{PV\ of\ Costs}{PVAIF}$$

$$= \frac{CF_0 + \frac{CF_1}{(1+i)} + \frac{CF_2}{(1+i)^2} + \cdots + \frac{CF_n}{(1+i)^n}}{\frac{1}{i}(1 - \frac{1}{(1+i)^n}}$$

The Problem

What is the EAC for a machine that costs $50,000, requires payment of $6,000 per year for maintenance and operation expense, and lasts for 6 years?

Assume that the discount rate is 9% and there will be no salvage value associated with the machine.

In addition, you intend to replace this machine at the end of its life with an identical machine with identical costs.

Step 1: Picture the Problem

k=9%

Years	0	1	2	3	4	5	6
Cash flows (in $, thousands)	-$50	-$6	-$6	-$6	-$6	-$6	-$6

EAC =?

Step 2: Decide on a Solution Strategy

Here we need to calculate the EAC, which will tell us the annual cost for a machine that lasts 6 years.

EAC can be computed using a mathematical formula or financial calculator.

Step 3: Solve

Using a Mathematical Formula

It requires 2 steps:

1. Computation of NPV
2. Computation of EAC

   Convert PV into annuity payment - divide NPV by PVA interest factor

Step 3: Solve (cont.)

$$\text{Net Present Value or } NPV = \text{Cash Flow for Year 0 } (CF_0) + \frac{\text{Cash Flow for Year 1 } (CF_1)}{\left(1 + \text{Discount Rate } (k)\right)^1} + \frac{\text{Cash Flow for Year 2 } (CF_2)}{\left(1 + \text{Discount Rate } (k)\right)^2} + \cdots + \frac{\text{Cash Flow for Year } n \text{ } (CF_n)}{\left(1 + \text{Discount Rate } (k)\right)^n}$$

Cost of making the investment = Initial cash flow, this is typically a cash outflow taking on a negative value.

Present value of the investment's cash inflows = Present value of the project's future cash inflows.

NPV = -\$50,000 + PV of \$6,000 each year

= -\$50,000 + -\$6,000 (PV of Annuity Factor)

= -\$50,000 + -\$6,000 $\{[1-1/(1.09)^{6}]/0.09\}$

= -\$50,000 + -\$6,000 {4.4859) = **-\$76,915**

Step 3: Solve (cont.)

$$\begin{aligned} EAC &= NPV \div \text{PVA Interest Factor} \\ &= -\$76{,}915 \div 4.4859 \\ &= \mathbf{-\$17{,}145.95} \end{aligned}$$

Step 3: Solve (cont.)

<u>Using a Financial Calculator</u>

Data and Key Input	Display
CF; -50000; ENTER	CFO=-50000
↓ ;-6000; ENTER	CO1=-6000
↓ ;6; ENTER	FO1=6.00
↓ NPV;8; ENTER	i=8
↓ CPT	NPV**=-77,372**

This is the PV of the cash flows

Step 3: Solve (cont.)

The next step is to convert the PV into an annuity payment

Enter

- N = 6
- I/y = 9
- PV = -76915
- FV = 0
- PMT = **-17,145.86**

Thus EAC = $-17,145.86

Step 4: Analyze

EAC indicates the annual cost that is adjusted for time value of money. Here EAC is equal to -$17,145.86.

Internal Rate of Return

The **internal rate of return** (**IRR**) of an investment is the discount rate that results in a zero NPV for the project

- It is analogous to the yield to maturity (YTM) on a bond

Internal Rate of Return

$$\text{Net Present Value} = \text{Cash Flow for Year 0 } (CF_0) + \frac{\text{Cash Flow for Year 1 } (CF_1)}{\left(1 + \text{Internal Rate of Return } (IRR)\right)^1} + \frac{\text{Cash Flow for Year 2 } (CF_2)}{\left(1 + \text{Internal Rate of Return } (IRR)\right)^2} + \cdots + \frac{\text{Cash Flow for Year } n \; (CF_n)}{\left(1 + \text{Internal Rate of Return } (IRR)\right)^n} = 0$$

Internal Rate of Return

Decision Criteria:

- **Decision Criteria:**

Investment projects should be

Accepted if the IRR is above the hurdle rate

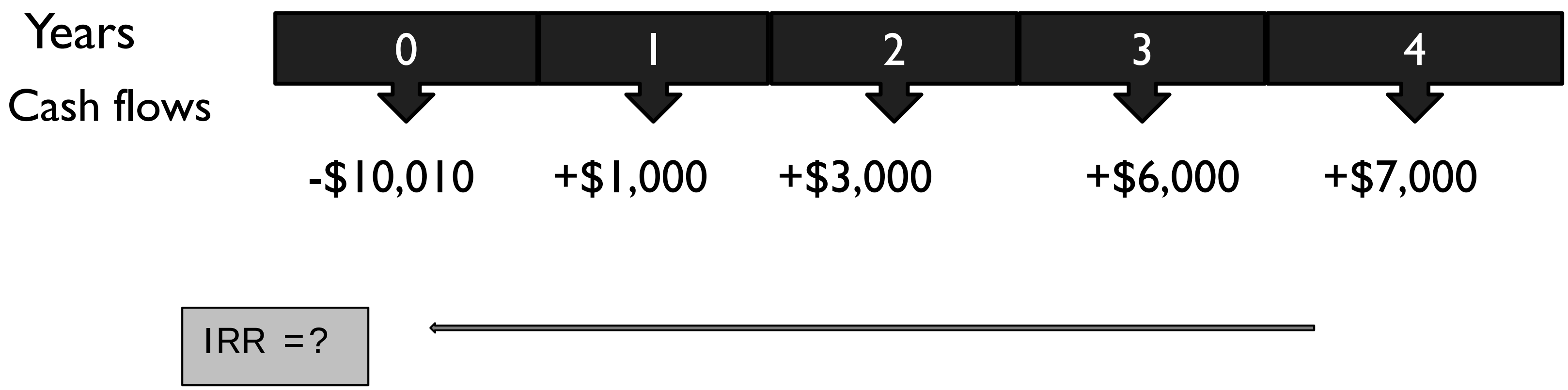
Rejected if the IRR is below the hurdle rate

The Problem

Knowledge Associates is a small consulting firm in Portland, Oregon, and they are considering the purchase of a new copying center for the office that can copy, fax, and scan documents. The new machine costs $10,010 to purchase and is expected to provide cash flow savings over the next four years of $1,000; $3,000; $6,000; and $7,000.

If the discount rate the firm uses to value the cash flows from office equipment purchases is 15%, is this a good investment for the firm?

Step 1: Picture the Problem



Step 2: Decide on a Solution Strategy

- Here we have to calculate the project's IRR. IRR is equal to the discount rate that makes the present value of the future cash flows (in years 1-4) equal to the initial cash outflow of $10,010.

Step 3: Solve

Data and Key Input	Display
CF; -100000; ENTER	CFO=-100000
↓ 1000; ENTER	CO1=1000
↓ ;1; ENTER	FO1=1.00
↓ ;3000; ENTER	C02=3000
↓ ;1; ENTER	FO2=1.00
↓ ;6000; ENTER	C03=6000
↓ ; 1; ENTER	FO3=1.00
↓ ; 7000; ENTER	CO4 = 7000
↓ 1; ENTER	FO4 =1.00
IRR; CPT	IRR = **19%**

Step 4: Analyze

The new copying center requires an initial investment of $10,010 and provides future cash flows that offer a return of 19%. Since the firm has decided 15% as the minimum acceptable return, this is a good investment for the firm.

Complications with IRR: Unconventional Cash Flows

- If the cash flow pattern is non conventional i.e. cash inflow followed by a series of cash outflows (as in the case of a loan), NPV greater than zero indicates that IRR is less than the discount rate used to calculate the NPV.
- NPV leads to the appropriate decision in both conventional and unconventional cash flow pattern.

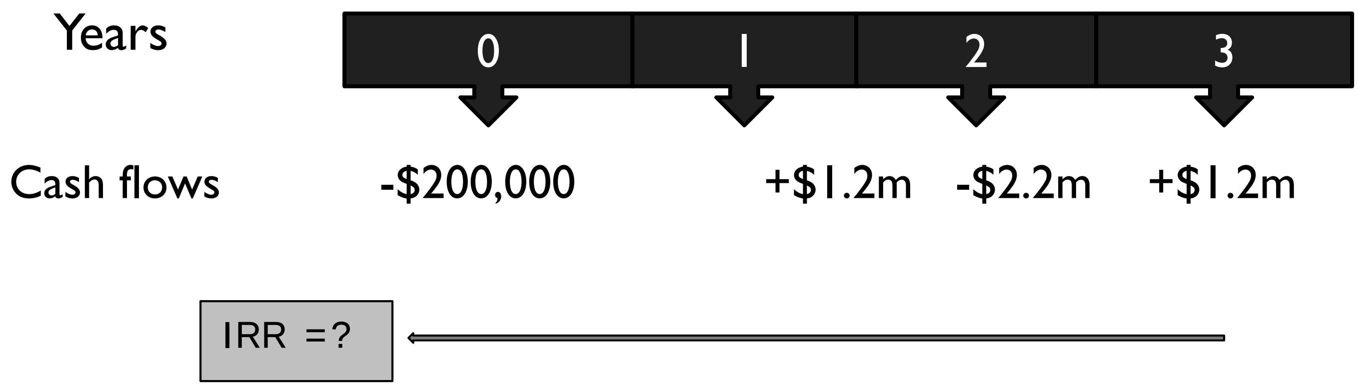
Complications with IRR: Multiple Rates of Return

Although any project can have only one NPV, a single project can, under certain circumstances, have more than one IRR

The Problem

McClary Custom Printers is considering whether to purchase a printer. The printer costs $200,000 to purchase, and McClary expects it can earn an additional $1.2 million in cash flows in the printer's first year of use. However, there is a problem with purchasing the printer today because it will require a very large expenditure in year 2, such that year 2's cash flow is expected to be -$2.2million. Finally, in year 3, the printer investment is expected to produce a cash flow of $1.2 million. Use the IRR to evaluate whether the printer purchase will be worthwhile.

Step 1: Picture the Problem



Step 2: Decide on a Solution Strategy

- To solve the problem, we can construct an NPV profile that reports the NPV at several discount rates.
- We will use discount rates of 0% to 200%, in increments of 50%, to compute the NPV.

Step 3: Solve

- The NPV profile on next slide is based on various discount rates. For example, NPV at discount rate of 50% is computed as follows:
- NPV = -$200,000 + $1,200,000/(1.5)^1 + -2,200,000/(1.5)^2 + $1,200,000/(1.5)^3

  = -$22,222.22

Step 3: Solve

Discount Rate	NPV
0%	$0
50%	-$22,222.22
100%	$0
150%	$4,800
200%	$0

Step 4: Analyze

- There are three IRRs for this project 0%, 100% and 200%. At all of these rates, NPV is equal to zero.
- However, NPV will be a better decision tool to use under this situation as it is not subject to multiple answers like IRR.

Using the IRR with Mutually Exclusive Investments

Figure 11.1 shows that if we use NPV, project AA+ is better while if we use IRR, project BBR is better. How to select under such circumstances?

- Use NPV as it will give the correct ranking for the projects.

Figure 11.1 Ranking Mutually Exclusive Investments: NPV vs. IRR

(Panel A) Expected Cash Flows

Cash Flows		
Year	**AA+**	**BBR**
0	$(500,000)	$(500,000)
1	100,000	400,000
2	200,000	300,000
3	300,000	200,000
4	400,000	200,000
5	500,000	100,000
NPV	$412,730	$370,241
IRR	38%	52%

- Both alternatives have positive NPVs and IRRs that exceed Apex's 15% required rate of return.
- However, the projects are ranked differently using NPV or IRR: AA+ has the higher NPV while BBR has a higher IRR.
- The ranking difference is due to the effect of discounting and the difference in the patterns of the cash flows for the two projects.
- AA+ cash flows increase over time while BBR's decrease.
- Higher discount rates have a disproportionate effect on present values as we see in Panel B.

Figure 11.1 Ranking Mutually Exclusive Investments: NPV vs. IRR (cont.)

(Panel B) NPV Profiles

NPV Profiles		
Discount Rate	**AA+**	**BBR**
0%	$1,000,000	$700,000
5%	$ 756,639	$568,722
10%	$ 565,259	$460,528
15%	$ 412,730	$370,241
20%	$ 289,673	$294,046
25%	$ 189,280	$229,088
30%	$ 106,532	$173,199
35%	$ 37,680	$124,709
40%	$ (20,111)	$ 82,317
45%	$ (69,011)	$ 44,998
50%	$ (110,700)	$ 11,934
55%	$ (146,489)	$ (17,531)
60%	$ (177,414)	$ (43,930)
65%	$ (204,298)	$ (67,701)

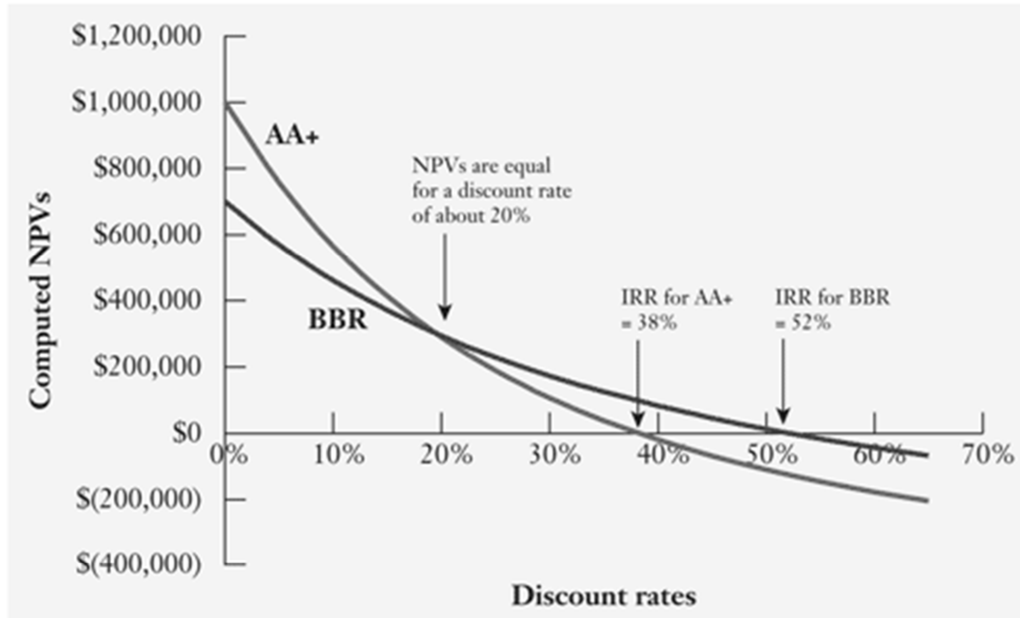


Figure 11.1 Ranking Mutually Exclusive Investments: NPV vs. IRR

(Panel C) Estimating the Break-Even Discount Rate

Year	Cash Flows AA+	Cash Flows BBR	Differential Cash Flows BBR − AA+
0	$(500,000)	$(500,000)	$ 0
1	100,000	400,000	$ 300,000
2	200,000	300,000	$ 100,000
3	300,000	200,000	$(100,000)
4	400,000	200,000	$(200,000)
5	500,000	100,000	$(400,000)

IRR of the Differential Cash Flows = 19.5%

- Using a 19.5% discount rate the two projects have exactly the same NPV.
- For discount rates lower than this break-even 19.5% rate, AA+ has the higher NPV whereas for higher discount rates BBR has the higher NPV.
- Trust NPV. Given the discount rate appropriate for valuing project cash flows, NPV gives the correct ranking of projects!

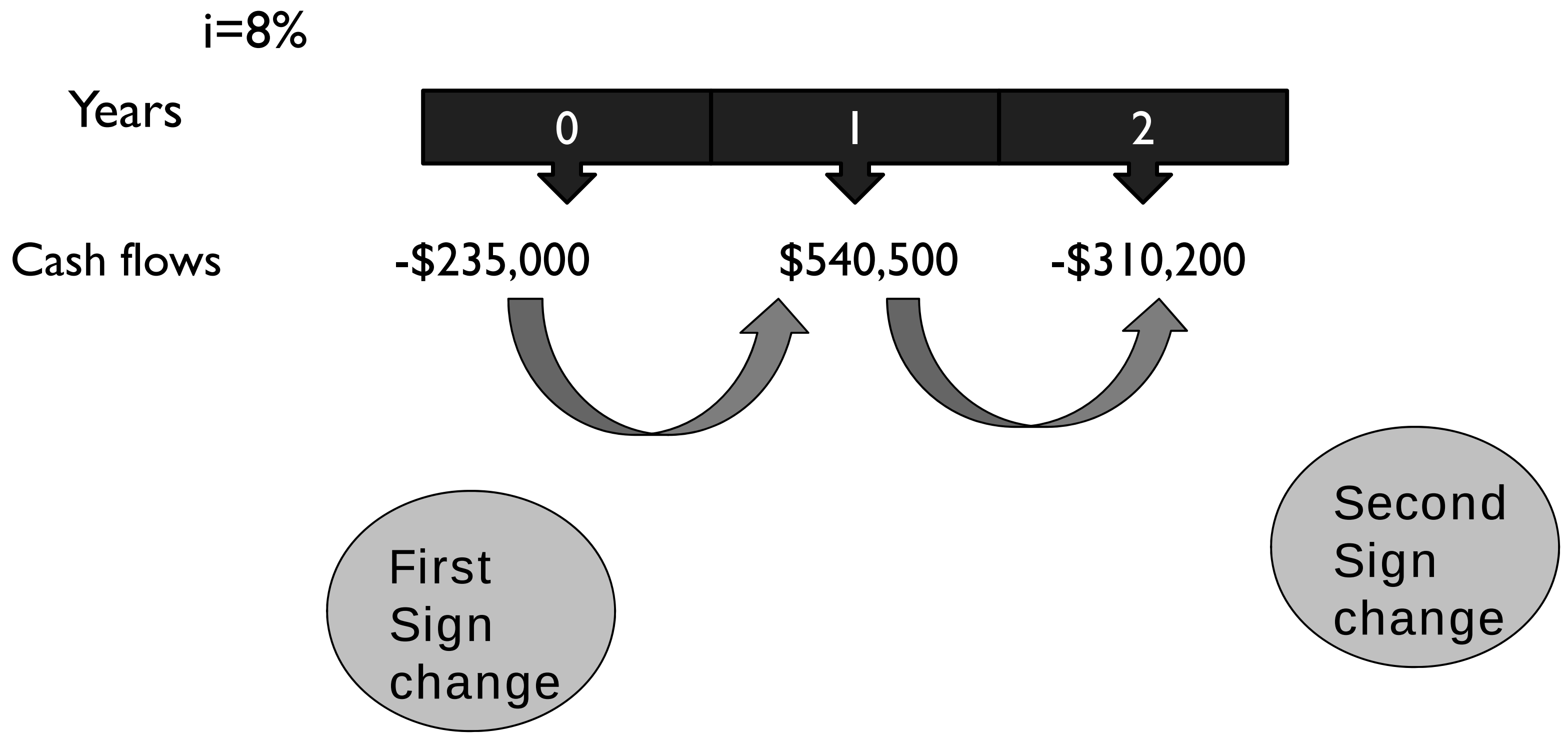
Modified Internal Rate of Return

Modified Internal Rate of Return (MIRR) eliminates the problem of multiple IRRs. MIRR rearranges the project cash flows such that there is only one change in the sign of the cash flows over the life of the project. There are two steps to computing MIRR.

Modified Internal Rate of Return

1. Modify the project's cash flow stream by discounting the negative future cash flows back to the present using the discount rate. The present value of these future negative cash flows is then added to the initial outlay to form a modified project cash flow stream
2. MIRR = IRR (modified cash flow stream).

Step 1: Picture the Problem



Step 2: Decide on a Solution Strategy

- If we use IRR, we will get multiple IRRs as there are two sign changes in cash flow stream.

- We can use MIRR by doing the following:
  - First, discount the year 2 negative cash flows back to year 0 using the 8% discount rate.
  - Second, calculate the MIRR of the resulting cash flows for years 0 and 1.

Step 3:Solve

Discount the year 2 negative cash flows to year 0.

Years	0	1	2
Cash flows	-$235,000	$540,500	-$310,200
	-$265,947		
	-$500,947		

Step 3: Solve (cont.)

The modified cash flow stream is as follows:

Years	0	1	2
Cash flows	-$500,947	$540,500	-$0

- Calculating the IRR for the above modified cash flows produces MIRR equal to 7.9%

Step 4: Analyze

We were able to compute IRR by eliminating the second sign change and thus modifying the cash flows.

MIRR is not the same as IRR as modified cash flows are discounted based on the discount rate used to calculate NPV (which is not the same as IRR).

Profitability Index

The **profitability index (PI)** is a cost-benefit ratio equal to the present value of an investment's future cash flows divided by its initial cost.

Decision Criteria:

- If PI is greater than one, the NPV will be positive and the investment should be accepted
- When PI is less than one, which indicates a bad investment, NPV will be negative and the project should be rejected.

Profitability Index

Potential problems with PI:

Project A has PI = 1.3

Project B has PI = 1.1

This suggests should choose Project A

Suppose investments are $10MM,for A, $100MM for B

Which has larger NPV?

The Problem

PNG Pharmaceuticals is considering an investment in a new automated materials handling system that is expected to reduce its drug manufacturing costs by eliminating much of the waste currently involved in its specialty drug division. The new system will require an initial investment of $50,000 and is expected to provide cash savings over the next six-year period as shown on next slide.

The Problem

Year	Expected Cash Flow
0	-$50,000
1	$15,000
2	$8,000
3	$10,000
4	$12,000
5	$14,000
6	$16,000

Step 1: Picture the Problem

k=10%

Years	0	1	2	3	4	5	6
Cash flows (in $, thousands)	-$50	+$15	+$8	+$10	+$12	+$14	+$16

PI =?

Step 2: Decide on a Solution Strategy

The PI for a project is equal to the present value of the project's expected cash flows for years 1-6 divided by the initial outlay.

PI = PV of expected cash flows ÷ -Initial outlay

Step 3: Solve

Step 1: Computing PV of Cash Inflows

Year	Expected Cash flow	Present Value at 10% discount rate
1	$15,000	$13,636.36
2	$8,000	$6,611.57
3	$10,000	$7,513.14
4	$12,000	$8,196.16
5	$14,000	$8,692.90
6	$16,000	$9,031.58
NPV of Expected Cash flows, Years 1-6		$53,681.72

Step 3: Solve

Step 2: Compute the PI

PI = PV of expected $CF_{1\text{-}6}$ ÷ Initial Outlay

= $53,681.72 ÷ $50,000

= **1.073**

Step 4: Analyze

- PNG Pharmaceuticals requires an initial investment of \$50,000 and provides future cash flows that have a present value of \$53,681.72. Thus, PI is equal to 1.073.

- It is an acceptable project since PI is greater than one.

Payback Period

- The **Payback period** for an investment opportunity is the number of years needed to recover the initial cash outlay required to make the investment.

- Decision Criteria: Accept the project if the payback period is less than a pre-specified maximum number of years.

Limitations of Payback Period

1. It ignores the time value of money
2. It ignores cash flows that are generated by the project beyond the end of the payback period.
3. It utilizes an arbitrary cutoff criterion.

Table 11-1 Limitations of the Payback Period Criterion

	Project Long		Project Short	
	Cash Flows		Cash Flows	
	Annual	Cumulative	Annual	Cumulative
Initial cash outlay	$(100,000)	$(100,000)	$(100,000)	$(100,000)
Year 1	70,000	(30,000)	50,000	(50,000)
Year 2	**30,000**	**0**	**50,000**	**0**
Year 3	30,000	30,000	0	0
Year 4	25,000	55,000	0	0
Year 5	10,000	65,000	0	0

Payback equals two years for both projects because it takes two years to recover the cost of the initial outlay from the cash inflows. However, Project Long looks a lot better because it continues to provide cash inflows after the payback year!

Discounted Payback Period

- Discounted payback period approach is similar except that it uses discounted cash flows to calculate the payback period.

- Decision Criteria: Accept the project if its discounted payback period is less than the pre-specified number of years.

Table 11.2 Discounted Payback Period Example (Discount Rate 17 percent)

Project Long

	Annual Cash Flows	Cumulative Cash Flows	Discounted Cash Flows	Cumulative Discounted Cash Flows
Initial cash outlay	$(100,000)	$(100,000)	$(100,000)	$(100,000)
Year 1	70,000	(30,000)	59,829	(40,171)
Year 2	**30,000**	**0**	**21,915**	**(18,256)**
Year 3	30,000	30,000	18,731	476
Year 4	25,000	55,000	13,341	13,817
Year 5	10,000	65,000	4,561	18,378

Discounted Payback equals 2.97 years for Project Long! Three years of discounted cash flows sum to a positive $476. However, since we need to sum to 0 we do not need a full three years of discounted cash flows (we need $18,256/$18,731 = .97 of Year 3's cash inflow).

Project Short

	Annual Cash Flows	Cumulative Cash Flows	Discounted Cash Flows	Cumulative Discounted Cash Flows
Initial cash outlay	$(100,000)	$(100,000)	$(100,000)	$(100,000)
Year 1	50,000	(50,000)	42,735	(57,265)
Year 2	**50,000**	**0**	**36,526**	**(20,739)**
Year 3	–	–	–	(20,739)
Year 4	–	–	–	(20,739)
Year 5	–	–	–	(20,739)

Discounted payback is *never* achieved for Project Short! The discounted cash flows never cumulate to equal zero.

Table 11.3 Basic Capital-Budgeting Techniques

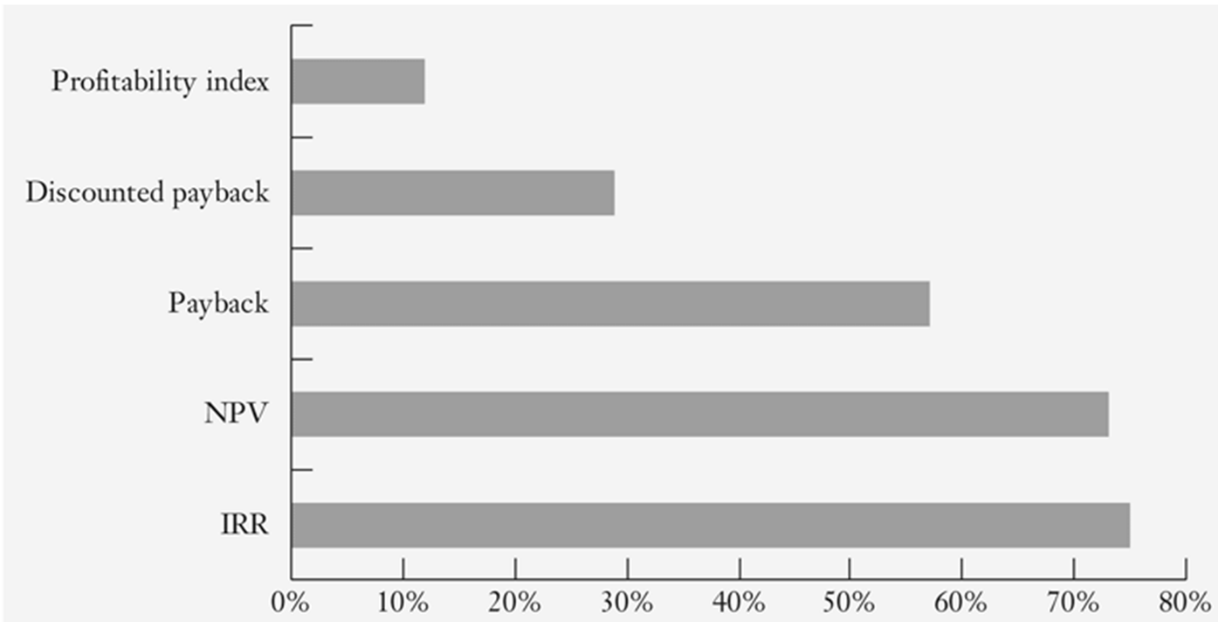
Investment Criterion	Definition	Decision Rule	Advantages	Disadvantages
Net Present Value (NPV)	Present value of expected cash inflows minus the present value of cash outflows.	Accept investments that have a positive NPV.	Theoretically correct in that it measures directly the increase in value that the project is expected to produce. Measures the increase in shareholder wealth expected from undertaking the project being analyzed.	Somewhat complicated to compute (requires an understanding of the time value of money). Not familiar to managers without formal business education.
Equivalent Annual Cost (EAC) or Equivalent Annual Annuity (EAA)	The annual cost that is equivalent in present value to the initial cost and annual cash flows of an investment.	Select the investment alternative that has the lowest annual cost.	Provides a tool that can be used to account for differences in initial cost of purchase, different annual costs of operations, and different productive lives.	Should only be used where the investments being compared are expected to be used indefinitely. For single-use investments, NPV is appropriate.
Profitability Index (PI)	Present value of expected future cash flows divided by the initial cash investment.	When the PI is greater than 1, the NPV will be positive, so the project should be accepted. When PI is less than 1, which indicates a bad investment, NPV will be negative and the project should be rejected.	Theoretically correct in that it measures directly the increase in value that the project is expected to produce. Useful when rank ordering positive-NPV projects where capital is being rationed.	Not as familiar to managers as NPV and does not add any additional information.
Internal Rate of Return (IRR)	The discount rate that makes NPV equal to zero.	Accept the project if the IRR is greater than the required rate of return or discount rate used to calculate the net present value of the project, and reject it otherwise.	Provides a rate-of-return metric, which many managers prefer.	Cannot always be estimated. Sometimes provides multiple rates of return for projects with multiple changes in the sign of their cash flows over time. Can provide conflicting indications to NPV for mutually exclusive projects.
Modified Internal Rate of Return (MIRR)	The discount rate that makes the NPV of the modified cash flow stream equal to zero.	Accept the project if the MIRR is greater than the required rate of return or discount rate used to calculate the net present value of the project, and reject it otherwise.	Always produces a single rate-of-return estimate.	The rate of return produced by the MIRR is not unique to the project because it is influenced by the discount rate used to discount the negative cash flows.
Payback	Time until the initial cash outlay has been recovered.	If the project payback is less than the maximum the firm will accept, the project is acceptable.	Easy to understand and calculate. An indication of risk (how long it takes to recover the investment).	Ignores time value of money. Ignores cash flows beyond the payback period. No rational way to determine the cutoff value for payback.
Discounted Payback	The number of years required to recover the initial investment out of project *discounted* future cash flows.	If the discounted project payback is less than the maximum the firm will accept, the project is acceptable.	Same as payback. Plus, by discounting the cash flows, this measure takes into account the time value of money.	Same as the last two items above. Also, because cash inflows must be discounted, discounted payback is more complicated to compute than payback.

A Glance at Actual Capital Budgeting Practices

- Figure 11.2 provides the results of a survey of the CFOs of large US firms, showing the popularity of various tools.

- The results show that NPV and IRR methods are by far the most widely used methods, although more than half the firms surveyed did use the Payback method.

Figure 11.2 Survey of the Popularity of Capital-Budgeting Methods



Source: John Graham and Campbell Harvey, "How Do CFOs Make Capital Budgeting and Capital Structure Decisions?" *Journal of Applied Corporate Finance*, Vol. 15, No. 1 (Spring 2002), 8–23.