Principles of Managerial Finance Solution

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CHAPTER 9

Capital Budgeting Techniques

INSTRUCTOR'S RESOURCES

Overview

This chapter continues the discussion of capital budgeting begun in the preceding chapter (Chapter 8), which established the basic principles of determining relevant cash flows. Both the sophisticated (net present value and the internal rate of return) and unsophisticated (average rate of return and payback period) capital budgeting techniques are presented. Discussion centers on the calculation and evaluation of the NPV and IRR in investment decisions, with and without a capital rationing constraint.

PMF DISK

PMF Tutor

Topics covered for this chapter include net present value, internal rate of return, payback method, and risk-adjusted discount rates (RADRs).

PMF Problem–Solver: Capital Budgeting Techniques

This module allows the student to determine the length of the payback period, the net present value, and internal rate of return for a project.

PMF Templates

Spreadsheet templates are provided for the following problems:

Problem	Topic
9-4	NPV
9-12	IRR–Mutually exclusive projects

Study Guide

The following *Study Guide* examples are suggested for classroom presentation:

Example	Topic
1	Payback
2	Net present value
8	Internal rate of return

ANSWERS TO REVIEW QUESTIONS

9-1 Once the relevant cash flows have been developed, they must be analyzed to determine whether the projects are acceptable or to rank the projects in terms of acceptability in meeting the firm's goal.

9-2 The *payback period* is the exact amount of time required to recover the firm's initial investment in a project. In the case of a mixed stream, the cash inflows are added until their sum equals the initial investment in the project. In the case of an annuity, the payback is calculated by dividing the initial investment by the annual cash inflow.

9-3 The weaknesses of using the payback period are 1) no explicit consideration of shareholders' wealth; 2) failure to take fully into account the time factor of money; and 3) failure to consider returns beyond the payback period and, hence, overall profitability of projects.

9-4 *Net present value* computes the present value of all relevant cash flows associated with a project. For conventional cash flow, NPV takes the present value of all cash inflows over years 1 through n and subtracts from that the initial investment at time zero. The formula for the net present value of a project with conventional cash flows is:

NPV = present value of cash inflows - initial investment

9-5 Acceptance criterion for the net present value method is if NPV > 0, accept; if NPV < 0, reject. If the firm undertakes projects with a positive NPV, the market value of the firm should increase by the amount of the NPV.

9-6 The *internal rate of return* on an investment is the discount rate that would cause the investment to have a net present value of zero. It is found by solving the NPV equation given below for the value of k that equates the present value of cash inflows with the initial investment.

$$NPV = \sum_{t=1}^{n} \frac{CF_t}{(1+k)^t} - I_0$$

9-7 If a project's internal rate of return is greater than the firm's cost of capital, the project should be accepted; otherwise, the project should be rejected. If the project has an acceptable IRR, the value of the firm should increase. Unlike the NPV, the amount of the expected value increase is not known.

9-8 The NPV and IRR always provide consistent accept/reject decisions. These measures, however, may not agree with respect to ranking the projects. The NPV may conflict with the IRR due to different cash flow characteristics of the projects. The greater the difference between timing and magnitude of cash inflows, the more likely it is that rankings will conflict.

9-9 A *net present value profile* is a graphic representation of the net present value of a project at various discount rates. The net present value profile may be used when conflicting rankings of projects exist by depicting each project as a line on the profile and determining the point of intersection. If the intersection occurs at a positive discount rate, any discount rate below the intersection will cause conflicting rankings, whereas any discount rates above the intersection will provide consistent rankings. Conflicts in project rankings using NPV and IRR result from differences in the magnitude and timing of cash flows. Projects with similar-sized investments having low early-year cash inflows tend to be preferred at lower discount rates. At high discount rates, projects with the higher early-year cash inflows are favored, as later-year cash inflows tend to be severely penalized in present value terms.

9-10 The *reinvestment rate assumption* refers to the rate at which reinvestment of intermediate cash flows theoretically may be achieved under the NPV or the IRR methods. The NPV method assumes the intermediate cash flows are reinvested at the discount rate, whereas the IRR method assumes intermediate cash flows are reinvested at the IRR. On a purely theoretical basis, the NPV's reinvestment rate assumption is superior because it provides a more realistic rate, the firm's cost of capital, for reinvestment. The cost of capital is generally a reasonable estimate of the rate at which a firm could reinvest these cash inflows. The IRR, especially one well exceeding the cost of capital, may assume a reinvestment rate the firm cannot achieve. In practice, the IRR is preferred due to the general disposition of business people toward rates of return rather than pure dollar returns.

SOLUTIONS TO PROBLEMS

Note to instructor: In most problems involving the internal rate of return calculation, a financial calculator has been used.

9-1 LG 2: Payback Period

a. \$42,000 ÷ \$7,000 = 6 years

b. The company should accept the project, since 6 < 8.

9-2 LG 2: Payback Comparisons

a. Machine 1: \$14,000 ÷ \$3,000 = 4 years, 8 months
Machine 2: \$21,000 ÷ \$4,000 = 5 years, 3 months

b. Only Machine 1 has a payback faster than 5 years and is acceptable.

c. The firm will accept the first machine because the payback period of 4 years, 8 months is less than the 5-year maximum payback required by Nova Products.

d. Machine 2 has returns which last 20 years while Machine 1 has only seven years of returns. Payback cannot consider this difference; it ignores all cash inflows beyond the payback period.

9-3 LG 2, 3: Choosing Between Two Projects with Acceptable Payback Periods

a.

Project A		
Year	Cash Inflows	Investment Balance
0		-\$100,000
1	\$10,000	-90,000
2	20,000	-70,000
3	30,000	-40,000
4	40,000	0
5	20,000	

Project B		
Year	Cash Inflows	Investment Balance
0		-\$100,000
1	40,000	-60,000
2	30,000	-30,000
3	20,000	-10,000
4	10,000	0
5	20,000	

Both project A and project B have payback periods of exactly 4 years.

b. Based on the minimum payback acceptance criteria of 4 years set by John Shell, both projects should be accepted. However, since they are mutually exclusive projects, John should accept project B.

c. Project B is preferred over A because the larger cash flows are in the early years of the project. The quicker cash inflows occur, the greater their value.

9-4 LG 3: NPV

PV_n = PMT x ($PVIFA_{14\%,20\ yrs}$)

a. PV_n = \$2,000 x 6.623 **b.** PV_n = \$3,000 x 6.623

PV_n = \$13,246	PV_n = \$19,869
NPV = PV_n - Initial investment	NPV = PV_n - Initial investment
NPV = \$13,246 - \$10,000	NPV = \$19,869 - \$25,000
NPV = \$3,246	NPV = -\$ 5,131
Calculator solution: \$3,246.26	Calculator solution: - \$5,130.61
Accept	Reject

c. PV_n = \$5,000 x 6.623
PV_n = \$33,115

NPV = PV_n - Initial investment
NPV = \$33,115 - \$30,000
NPV = \$3,115
Calculator solution: \$3,115.65
Accept

9-5 LG 3: NPV for Varying Cost of Capital

PV_n = PMT x ($PVIFA_{k\%,8\ yrs.}$)

a. 10 %	**b. 12 %**
PV_n = \$5,000 x (5.335)	PV_n = \$5,000 x (4.968)
PV_n = \$26,675	PV_n = \$24,840
NPV = PV_n - Initial investment	NPV = PV_n - Initial investment
NPV = \$26,675 - \$24,000	NPV = \$24,840 - \$24,000
NPV = \$2,675	NPV = \$840
Calculator solution: \$2,674.63	Calculator solution: \$838.19
Accept; positive NPV	Accept; positive NPV

c. 14%

PV_n = \$5,000 x (4.639)
PV_n = \$23,195
NPV = PV_n - Initial investment
NPV = \$23,195 - \$24,000
NPV = - \$805
Calculator solution: - \$805.68
Reject; negative NPV

9-6 LG 2: NPV–Independent Projects

Project A

PV_n = PMT x ($PVIFA_{14\%,10\ yrs.}$)
PV_n = \$4,000 x (5.216)
PV_n = \$20,864

NPV = \$20,864 - \$26,000
NPV = - \$5,136
Calculator solution: - \$5,135.54
Reject

Project B-PV of Cash Inflows

Year	CF	$PVIF_{14\%,n}$	PV
1	$100,000	.877	$ 87,700
2	120,000	.769	92,280
3	140,000	.675	94,500
4	160,000	.592	94,720
5	180,000	.519	93,420
6	200,000	.456	91,200
			$553,820

NPV = PV of cash inflows - Initial investment = $553,820 - $500,000
NPV = $53,820
Calculator solution: $53,887.93
Accept

Project C-PV of Cash Inflows

Year	CF	$PVIF_{14\%,n}$	PV
1	$20,000	.877	$ 17,540
2	19,000	.769	14,611
3	18,000	.675	12,150
4	17,000	.592	10,064
5	16,000	.519	8,304
6	15,000	.456	6,840
7	14,000	.400	5,600
8	13,000	.351	4,563
9	12,000	.308	3,696
10	11,000	.270	2,970
			$86,338

NPV = PV of cash inflows - Initial investment = $86,338 - $170,000
NPV = - $83,662
Calculator solution: - $83,668.24
Reject

Project D

PV_n = PMT x ($PVIFA_{14\%,8\ yrs.}$)
PV_n = $230,000 x 4.639
PV_n = $1,066,970

NPV = PV_n - Initial investment
NPV = $1,066,970 - $950,000
NPV = $116,970
Calculator solution: $116,938.70
Accept

Project E-PV of Cash Inflows

Year	CF	$PVIF_{14\%,n}$	PV
4	$20,000	.592	$ 11,840

5	30,000	.519	15,570
6	0		0
7	50,000	.400	20,000
8	60,000	.351	21,060
9	70,000	.308	21,560
			$90,030

NPV = PV of cash inflows - Initial investment
NPV = $90,030 - $80,000
NPV = $10,030
Calculator solution: $9,963.62
Accept

9-7 LG 3: NPV

a. PVA = $385,000 x ($PVIFA_{9\%,5}$)
PVA = $385,000 x (3.890)
PVA = $1,497,650
Calculator solution: $1,497,515.74

The immediate payment of $1,500,000 is not preferred because it has a higher present value than does the annuity.

b. $$PMT = \frac{PVA}{PVIFA_{9\%,5}} = \frac{\$1{,}500{,}000}{3.890} = \$385{,}604$$
Calculator solution: $385,638.69

c. PVA_{due} = $385,000 x ($PVIFA_{9\%,4}$ + 1)
PVA_{due} = $385,000 x (3.24 + 1)
PVA_{due} = $385,000 x (4.24)
PVA_{due} = $1,632,400
Changing the annuity to a beginning-of-the-period annuity due would cause Simes Innovations to prefer the $1,500,000 one-time payment since the PV of the annuity due is greater than the lump sum.

d. No, the cash flows from the project will not influence the decision on how to fund the project. The investment and financing decisions are separate.

9-8 LG 3: NPV and Maximum Return

PV_n = PMT x ($PVIFA_{k\%,n}$)

a. PV_n = $4,000 x ($PVIFA_{10\%,4}$)
PV_n = $4,000 x (3.170)
PV_n = $12,680

NPV = PV_n - Initial investment
NPV = $12,680 - $13,000
NPV = -$320
Calculator solution: -$320.54
Reject this project due to its negative NPV.

b. $13,000 = $4,000 x $(PVIFA_{k\%,n})$
$13,000 ÷ $4,000 = $(PVIFA_{k\%,4})$
3.25 = $PVIFA_{9\%,4}$
Calculator solution: 8.86%

9% is the maximum required return that the firm could have for the project to be acceptable. Since the firm's required return is 10% the cost of capital is greater than the expected return and the project is rejected.

9-9 LG 3: NPV–Mutually Exclusive Projects

PV_n = PMT x $(PVIFA_{k\%,n})$

a. & b.

Press — **PV of cash inflows; NPV**

A

PV_n = PMT x $(PVIFA_{15\%,8\ yrs.})$
PV_n = $18,000 x 4.487
PV_n = $80,766

NPV = PV_n - Initial investment
NPV = $80,766 - $85,000
NPV = - $4,234
Calculator solution: -$4,228.21
Reject

B

Year	CF	$PVIF_{15\%,n}$	PV
1	$12,000	.870	$10,440
2	14,000	.756	10,584
3	16,000	.658	10,528
4	18,000	.572	10,296
5	20,000	.497	9,940
6	25,000	.432	10,800
			$62,588

NPV = $62,588 - $60,000
NPV = $2,588
Calculator solution: $2,584.33
Accept

C

Year	CF	$PVIF_{15\%,n}$	PV
1	$50,000	.870	$ 43,500
2	30,000	.756	22,680
3	20,000	.658	13,160
4	20,000	.572	11,440
5	20,000	.497	9,940
6	30,000	.432	12,960
7	40,000	.376	15,040
8	50,000	.327	16,350
			$145,070

NPV = \$145,070 - \$130,000
NPV = \$15,070
Calculator solution: \$15,043.88
Accept

c. Ranking - using NPV as criterion

Rank	Press	NPV
1	C	\$15,070
2	B	2,588
3	A	- 4,234

9-10 LG 2, 3: Payback and NPV

a.

Project	Payback Period		
A	\$40,000 ÷ \$13,000	=	3.08 years
B	3 + (\$10,000 ÷ \$16,000)	=	3.63 years
C	2 + (\$5,000 ÷ \$13,000)	=	2.38 years

Project C, with the shortest payback period, is preferred.

b. Project

A

PV_n = \$13,000 x 3.274
PV_n = \$42,562

PV = \$42,562 - \$40,000
NPV = \$2,562
Calculator solution: \$2,565.82

B

Year	CF	$PVIF_{16\%,n}$	PV
1	\$ 7,000	.862	6,034
2	10,000	.743	7,430
3	13,000	.641	8,333
4	16,000	.552	8,832
5	19,000	.476	9,044
			\$39,673

NPV = \$39,673 - \$40,000
NPV = - \$327
Calculator solution: - \$322.53

C

Year	CF	$PVIF_{16\%,n}$	PV
1	\$19,000	.862	\$16,378
2	16,000	.743	11,888
3	13,000	.641	8,333
4	10,000	.552	5,520
5	7,000	.476	3,332
			\$45,451

NPV = $45,451 - $40,000
NPV = $ 5,451
Calculator solution: $5,454.17
Project C is preferred using the NPV as a decision criterion.

c. At a cost of 16%, Project C has the highest NPV. Because of Project C's cash flow characteristics, high early-year cash inflows, it has the lowest payback period and the highest NPV.

9-11 LG 4: Internal Rate of Return

IRR is found by solving:

$$\$0 = \sum_{t=1}^{n} \left[\frac{CF_t}{(1+IRR)^t} \right] - \text{Initial Investment}$$

It can be computed to the nearest whole percent by the estimation method as shown for Project A below or by using a financial calculator. (Subsequent IRR problems have been solved with a financial calculator and rounded to the nearest whole percent.)

Project A

Average Annuity = ($20,000 + $25,000 + 30,000 + $35,000 + $40,000) ÷ 5
Average Annuity = $150,000 ÷ 5
Average Annuity = $30,000

$PVIFA_{k\%,5yrs.}$ = $90,000 ÷ $30,000 = 3.000
$PVIFA_{19\%,5\ yrs.}$ = 3.0576
$PVIFA_{20\%,5\ yrs.}$ = 2.991

However, try 17% and 18% since cash flows are greater in later years.

Year$_t$	CF_t (1)	$PVIF_{17\%,t}$ (2)	PV@17% [(1) x (2)] (3)	$PVIF_{18\%,t}$ (4)	PV@18% [(1) x (4)] (5)
1	$20,000	.855	$17,100	.847	$16,940
2	25,000	.731	18,275	.718	17,950
3	30,000	.624	18,720	.609	18,270
4	35,000	.534	18,690	.516	18,060
5	40,000	.456	18,240	.437	17,480
			$91,025		$88,700
	Initial investment		- 90,000		- 90,000
	NPV		$ 1,025		- $ 1,300

NPV at 17% is closer to $0, so IRR is 17%. If the firm's cost of capital is below 17%, the project would be acceptable.

Calculator solution: 17.43%

Project B

PV_n = PMT x ($PVIFA_{k\%,4\ yrs.}$)

\$490,000 = \$150,000 x ($PVIFA_{k\%,4\ yrs.}$)

\$490,000 ÷ \$150,000 = ($PVIFA_{k\%,4\ yrs.}$)

3.27 = $PVIFA_{k\%,4}$

8% < IRR < 9%

Calculator solution: IRR = 8.62%

The firm's maximum cost of capital for project acceptability would be 8% (8.62%).

Project C

PV_n = PMT x ($PVIFA_{k\%,5\ yrs.}$)

\$20,000 = \$7,500 x ($PVIFA_{k\%,5\ yrs.}$)

\$20,000 ÷ \$7,500 = ($PVIFA_{k\%,5\ yrs.}$)

2.67 = $PVIFA_{k\%,5\ yrs.}$

25% < IRR < 26%

Calculator solution: IRR = 25.41%

The firm's maximum cost of capital for project acceptability would be 25% (25.41%).

Project D

$$\$0 = \frac{\$120,000}{(1+\text{IRR})^1} + \frac{\$100,000}{(1+\text{IRR})^2} + \frac{\$80,000}{(1+\text{IRR})^3} + \frac{\$60,000}{(1+\text{IRR})^4} - \$240,000$$

IRR = 21%; Calculator solution: IRR = 21.16%

9-12 LG 4: IRR–Mutually Exclusive Projects

a. and b.

Project X

$$\$0 = \frac{\$100,000}{(1+\text{IRR})^1} + \frac{\$120,000}{(1+\text{IRR})^2} + \frac{\$150,000}{(1+\text{IRR})^3} + \frac{\$190,000}{(1+\text{IRR})^4} + \frac{\$250,000}{(1+\text{IRR})^5} - \$500,000$$

IRR = 16%; since IRR > cost of capital, accept.

Calculator solution: 15.67%

Project Y

$$\$0 = \frac{\$140,000}{(1+\text{IRR})^1} + \frac{\$120,000}{(1+\text{IRR})^2} + \frac{\$95,000}{(1+\text{IRR})^3} + \frac{\$70,000}{(1+\text{IRR})^4} + \frac{\$50,000}{(1+\text{IRR})^5} - \$325,000$$

IRR = 17%; since IRR > cost of capital, accept.

Calculator solution: 17.29%

c. Project Y, with the higher IRR, is preferred, although both are acceptable.

9-13 LG 4: IRR, Investment Life, and Cash Inflows

a. PV_n = PMT x ($PVIFA_{k\%,n}$)

$\$61,450 = \$10,000 \times (PVIFA_{k\%,10\ yrs.})$
$\$61,450 \div \$10,000 = PVIFA_{k\%,10\ Yrs.}$
$6.145 = PVIFA_{k\%,10\ yrs.}$
$k = IRR = 10\%$ (calculator solution: 10.0%)
The IRR < cost of capital; reject the project.

b. $PV_n = PMT \times (PVIFA_{\%,n})$
$\$61,450 = \$10,000 \times (PVIFA_{15\%,n})$
$\$61,450 \div \$10,000 = PVIFA_{15\%,n}$
$6.145 = PVIFA_{15\%,n}$
18 yrs. < n < 19 yrs.
Calculator solution: 18.23 years

The project would have to run a little over 8 more years to make the project acceptable with the 15% cost of capital.

c. $PV_n = PMT \times (PVIFA_{15\%,10})$
$\$61,450 = PMT \times (5.019)$
$\$61,450 \div 5.019 = PMT$
$12,243.48 = PMT
Calculator solution: $12,244.04

9-14 LG 3, 4: NPV and IRR

a. $PV_n = PMT \times (PVIFA_{10\%,7\ yrs.})$
$PV_n = \$4,000 \times (4.868)$
$PV_n = \$19,472$

$NPV = PV_n$ - Initial investment
NPV = $19,472 - $18,250
NPV = $1,222
Calculator solution: $1,223.68

b. $PV_n = PMT \times (PVIFA_{k\%,n})$
$\$18,250 = \$4,000 \times (PVIFA_{k\%,7yrs.})$
$\$18,250 \div \$4,000 = (PVIFA_{k\%,7\ yrs.})$
$4.563 = PVIFA_{k\%,7\ yrs.}$
IRR = 12%
Calculator solution: 12.01%

c. The project should be accepted since the NPV > 0 and the IRR > the cost of capital.

9-15 LG 3: NPV, with Rankings

a. $NPV_A = \$20,000(PVIFA_{15\%,3}) - \$50,000$
$NPV_A = \$20,000(2.283) - \$50,000$
$NPV_A = \$45,660 - \$50,000 = - \$4,340$
Calculator solution: - $4,335.50
Reject

NPV_B = \$35,000($PVIF_{15\%,1}$) + \$50,000($PVIFA_{15\%,2}$)($PVIF_{15\%,1}$) - \$100,000
NPV_B = \$35,000(.870) + \$50,000(1.626)(.870) - \$100,000
NPV_B = \$30,450 + \$70,731- \$100,000 = \$1,181
Calculator solution: \$1,117.78
Accept

NPV_C = \$20,000($PVIF_{15\%,1}$) + \$40,000($PVIF_{15\%,2}$) + \$60,000($PVIF_{15\%,3}$) - \$80,000
NPV_C = \$20,000(.870) + \$40,000(.756) + \$60,000(.658) - \$80,000
NPV_C = \$17,400 + \$30,240 + 39,480 - \$80,000 = \$7,120
Calculator solution: \$7,088.02
Accept

NPV_D = \$100,000($PVIF_{15\%,1}$) + \$80,000($PVIF_{15\%,2}$) + \$60,000($PVIF_{15\%,3}$)
- \$180,000
NPV_D = \$100,000(.870) + \$80,000(.756) + \$60,000(.658) - \$180,000
NPV_D = \$87,000 + \$60,480 + 39,480 - \$180,000 = \$6,960
Calculator solution: \$6,898.99
Accept

b.

Rank	Press	NPV
1	C	\$7,120
2	D	6,960
3	B	1,181

c. Using the calculator the IRRs of the projects are:

Project	IRR
A	9.70%
B	15.63%
C	19.44%
D	17.51%

Since the lowest IRR is 9.7% all of the projects would be acceptable if the cost of capital was approximately 10%.

NOTE: Since project A was the only reject project from the 4 projects, all that was needed to find the minimum acceptable cost of capital was to find the IRR of A.

9-16 LG 2, 3, 4: All Techniques, Conflicting Rankings

a.

Project A				Project B		
Year	Cash Inflows	Investment Balance		Year	Cash Inflows	Investment Balance
0		-\$150,000		0		-\$150,000

1	$45,000	-105,000		1	$75,000	-75,000
2	45,000	-60,000		2	60,000	-15,000
3	45,000	-15,000		3	30,000	+15,000
4	45,000	+30,000		4	30,000	0
5	45,000				30,000	
6	45,000				30,000	

$$\text{Payback}_A = \frac{\$150,000}{\$45,000} = 3.33 \text{ years} = 3 \text{ years } 4 \text{ months}$$

$$\text{Payback}_B = 2 \text{ years} + \frac{\$15,000}{\$30,000} \text{ years} = 2.5 \text{ years} = 2 \text{ years } 6 \text{ months}$$

b. NPV_A = $45,000($PVIFA_{0\%,6}$) - $150,000
NPV_A = $45,000(6) - $150,000
NPV_A = $270,000 - $150,000 = $120,000
Calculator solution: $120,000

NPV_B = $75,000($PVIF_{0\%,1}$) + $60,000($PVIF_{0\%,2}$) + $30,000($PVIFA_{0\%,4}$)($PVIF_{0\%,2}$) -$150,000
NPV_B = $75,000 + $60,000 + $30,000(4) - $150,000
NPV_B = $75,000 + $60,000 + $120,000 - $150,000 = $105,000
Calculator solution: $105,000

c. NPV_A = $45,000($PVIFA_{9\%,6}$) - $150,000
NPV_A = $45,000(4.486) - $150,000
NPV_A = $201,870 - $150,000 = $51,870
Calculator solution: $51,886.34

NPV_B = $75,000($PVIF_{9\%,1}$) + $60,000($PVIF_{9\%,2}$) + $30,000($PVIFA_{9\%,4}$)($PVIF_{9\%,2}$) -$150,000
NPV_B = $75,000(.917) + $60,000(.842) + $30,000(3.24)(.842) - $150,000
NPV_B = $68,775 + $50,520 + $81,842 - $150,000 = $51,137
Calculator solution: $51,112.36

d. Using a financial calculator:
IRR_A = 19.91%
IRR_B = 22.71%

e.

	Rank		
Project	Payback	NPV	IRR
A	2	1	2
B	1	2	1

The project that should be selected is A. The conflict between NPV and IRR is due partially to the reinvestment rate assumption. The assumed reinvestment rate of project B is 22.71%, the project's IRR. The reinvestment rate assumption of A is 9%, the firm's cost of capital. On a practical level project B will probably be selected due to management's preference for making decisions based on percentage returns, and their desire to receive a return of cash quickly.

9-17 LG 2, 3: Payback, NPV, and IRR

a. Payback period

3 + ($20,000 ÷ $35,000) = 3.57 years

b. PV of cash inflows

Year	CF	$PVIF_{12\%,n}$	PV
1	$20,000	.893	$ 17,860
2	25,000	.797	19,925
3	30,000	.712	21,360
4	35,000	.636	22,260
5	40,000	.567	22,680
			$104,085

NPV = PV of cash inflows - Initial investment
NPV = $104,085 - $95,000
NPV = $9,085
Calculator solution: $9,080.61

c.

$$\$0 = \frac{\$20,000}{(1+\text{IRR})^1} + \frac{\$25,000}{(1+\text{IRR})^2} + \frac{\$30,000}{(1+\text{IRR})^3} + \frac{\$35,000}{(1+\text{IRR})^4} + \frac{\$40,000}{(1+\text{IRR})^5} - \$95,000$$

IRR = 15%
Calculator solution: 15.36%

d. NPV = $9,085; since NPV > 0; accept
IRR = 15%; since IRR > 12% cost of capital; accept

The project should be implemented since it meets the decision criteria for both NPV and IRR.

9-18 LG 3, 4, 5: NPV, IRR, and NPV Profiles

a. and b.

Project A

PV of cash inflows:

Year	CF	$PVIF_{12\%,n}$	PV
1	$25,000	.893	$ 22,325
2	35,000	.797	27,895
3	45,000	.712	32,040
4	50,000	.636	31,800
5	55,000	.567	31,185
			$145,245

NPV = PV of cash inflows - Initial investment
NPV = $145,245 - $130,000
NPV = $15,245

Calculator solution: $15,237.71

Based on the NPV the project is acceptable since the NPV is greater than zero.

$$\$0 = \frac{\$25,000}{(1+\text{IRR})^1} + \frac{\$35,000}{(1+\text{IRR})^2} + \frac{\$45,000}{(1+\text{IRR})^3} + \frac{\$50,000}{(1+\text{IRR})^4} + \frac{\$55,000}{(1+\text{IRR})^5} - \$130,000$$

IRR = 16%
Calculator solution: 16.06%

Based on the IRR the project is acceptable since the IRR of 16% is greater than the 12% cost of capital.

Project B
PV of cash inflows:

Year	CF	$PVIF_{12\%,n}$	PV
1	$40,000	.893	$ 35,720
2	35,000	.797	27,895
3	30,000	.712	21,360
4	10,000	.636	6,360
5	5,000	.567	2,835
			$ 94,170

NPV = $94,170 - $85,000
NPV = $9,170
Calculator solution: $9,161.79

Based on the NPV the project is acceptable since the NPV is greater than zero.

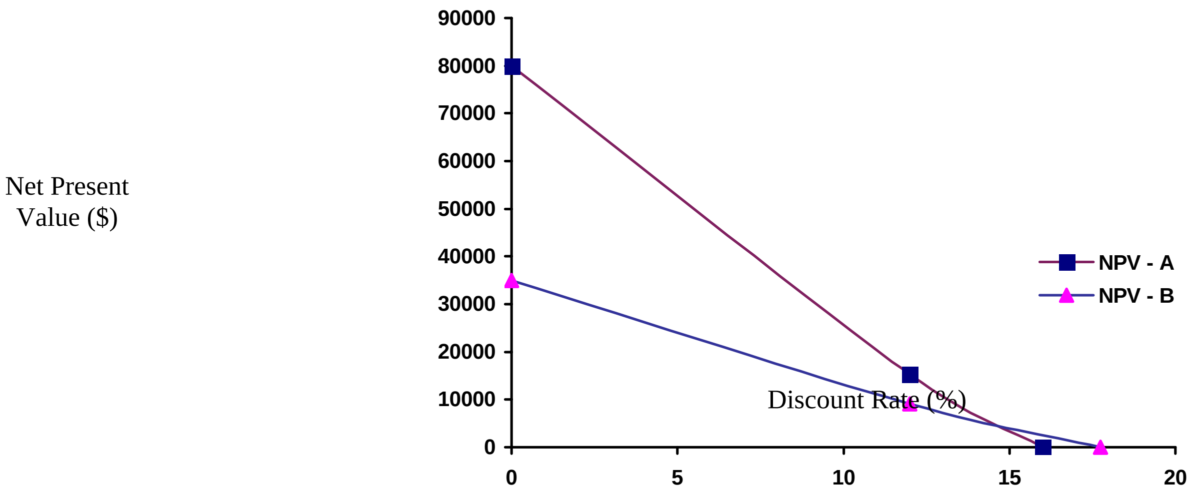
$$\$0 = \frac{\$40,000}{(1+\text{IRR})^1} + \frac{\$35,000}{(1+\text{IRR})^2} + \frac{\$30,000}{(1+\text{IRR})^3} + \frac{\$10,000}{(1+\text{IRR})^4} + \frac{\$5,000}{(1+\text{IRR})^5} - \$85,000$$

IRR = 18%
Calculator solution: 17.75%

Based on the IRR the project is acceptable since the IRR of 16% is greater than the 12% cost of capital.

c.

Net Present Value Profile



Data for NPV Profiles

Discount Rate	NPV A	NPV B
0%	$ 80,000	$ 35,000
12%	$ 15,245	-
15%	-	$ 9,170
16%	0	-
18%	-	0

d. The net present value profile indicates that there are conflicting rankings at a discount rate lower than the intersection point of the two profiles (approximately 15%). The conflict in rankings is caused by the relative cash flow pattern of the two projects. At discount rates above approximately 15%, Project B is preferable; below approximately 15%, Project A is better.

e. Project A has an increasing cash flow from year 1 through year 5, whereas Project B has a decreasing cash flow from year 1 through year 5. Cash flows moving in opposite directions often cause conflicting rankings.

9-19 LG 2, 3, 4, 5, 6: All Techniques–Mutually Exclusive Investment Decision

	Project A	Project B	Project C
Cash inflows (years 1 - 5)	$20,000	$31,500	$32,500
a. Payback*	3 years	3.2 years	3.4 years
b. NPV*	$10,340	$10,786	$ 4,303
c. IRR*	20%	17%	15%

* Supporting calculations shown below:

a. Payback Period:

Project A:	$60,000	÷	$20,000	=	3 years
Project B:	$100,000	÷	$31,500	=	3.2 years
Project C:	$110,000	÷	$32,500	=	3.4 years

b. NPV
Project A

c. IRR
Project, A

PV_n =PMT x ($PVIFA_{13\%,5\ Yrs.}$)
PV_n = \$20,000 x 3.517
PV_n = 70,340

NPV = \$70,340 - \$60,000
NPV = \$10,340
Calculator solution: \$10,344.63

NPV at 19% = \$1,152.70
NPV at 20% = - \$ 187.76
Since NPV is closer to zero at 20%, IRR = 20%
Calculator solution: 19.86%

Project B
PV_n = \$31,500.00 x 3.517
PV_n = \$110,785.50

NPV = \$110,785.50 - \$100,000
NPV = \$10,785.50
Calculator solution: \$10,792.78

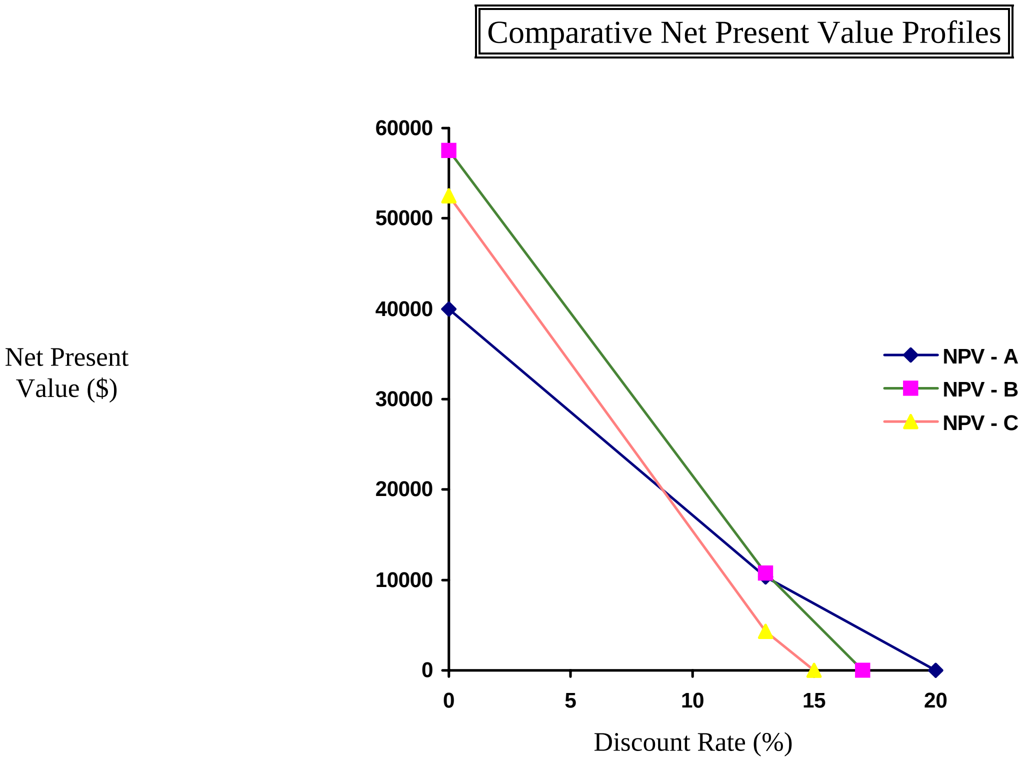
Project B
NPV at 17% = \$779.40
NPV at 18% = -\$1,494.11
Since NPV is closer to zero at 17%, IRR = 17%
Calculator solution: 17.34%

Project C
PV_n = \$32,500.00 x 3.517
PV_n = \$114,302.50

NPV = \$114,302.50 - \$110,000
NPV = \$4,302.50
Calculator solution: \$4,310.02

Project C
NPV at 14% = \$1,575.13
NPV at 15% = - \$1,054.96
Since NPV is closer to zero at 15%, IRR = 15%
Calculator solution: 14.59%

d.



Data for NPV Profiles

Discount Rate	NPV A	NPV B	NPV C
0%	$ 40,000	$ 57,500	$ 52,500
13%	$ 10,340	10,786	4,303
15%	-	-	0
17%	-	0	-
20%	0	-	-

The difference in the magnitude of the cash flow for each project causes the NPV to compare favorably or unfavorably, depending on the discount rate.

e. Even though A ranks higher in Payback and IRR, financial theorists would argue that B is superior since it has the highest NPV. Adopting B adds $445.50 more to the value of the firm than does A.

9-20 LG 2, 3, 4, 5, 6: All Techniques with NPV Profile–Mutually Exclusive Projects

a. **Project A**

Payback period

Year 1 + Year 2 + Year 3	=	$60,000
Year 4	=	$20,000

Initial investment	=	$80,000

Payback = 3 years + ($20,000 ÷ 30,000)
Payback = 3.67 years

Project B
Payback period
$50,000 ÷ $15,000 = 3.33 years

b. **Project A**
PV of cash inflows

Year	CF	$PVIF_{13\%,n}$	PV
1	$15,000	.885	$ 13,275
2	20,000	.783	15,660
3	25,000	.693	17,325
4	30,000	.613	18,390
5	35,000	.543	19,005
			$83,655

NPV = PV of cash inflows - Initial investment
NPV = $83,655 - $80,000
NPV = $3,655
Calculator solution: $3,659.68

Project B
NPV = PV of cash inflows - Initial investment
PV_n = PMT x ($PVIFA_{13\%,n}$)
PV_n = $15,000 x 3.517
PV_n = $52,755
NPV = $52,755 - $50,000
= $2,755
Calculator solution: $2,758.47

c. **Project A**

$$\$0 = \frac{\$15{,}000}{(1+\text{IRR})^1} + \frac{\$20{,}000}{(1+\text{IRR})^2} + \frac{\$25{,}000}{(1+\text{IRR})^3} + \frac{\$30{,}000}{(1+\text{IRR})^4} + \frac{\$35{,}000}{(1+\text{IRR})^5} - \$80{,}000$$

IRR = 15%
Calculator solution: 14.61%

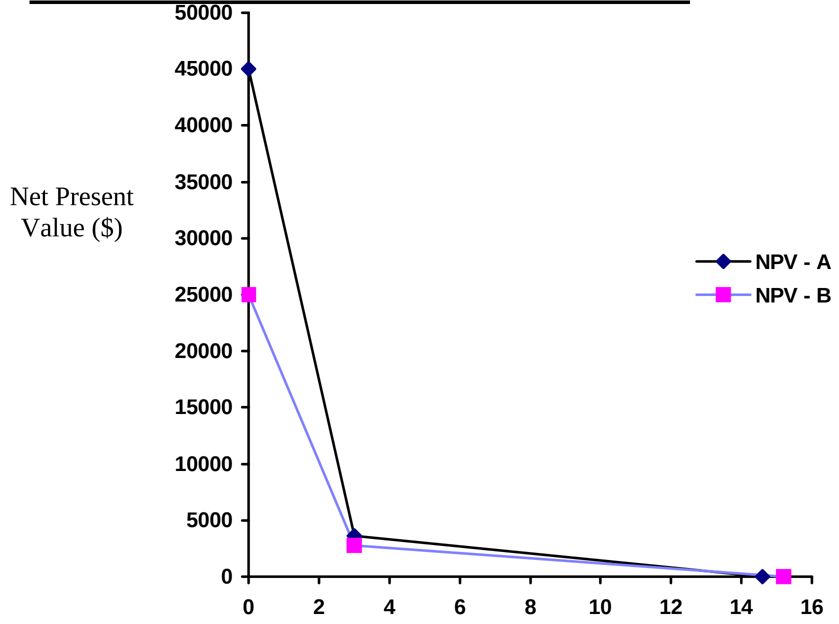
Project B
$0 = $15,000 x (PVIFA $_{k\%,5}$) - $50,000
IRR = 15%

Calculator solution: 15.24%

d.

Net Present Value Profile

Data for NPV Profiles



Discount Rate	NPV A	NPV B
0%	$ 45,000	$ 25,000
13%	$ 3,655	$ 2,755
14.6%	0	-
15.2%	-	0

Intersection - approximately 14%
If cost of capital is above 14%, conflicting rankings occur.
The calculator solution is 13.87%.

e. Both projects are acceptable. Both have positive NPVs and equivalent IRR's that are greater than the cost of capital. Although Project B has a slightly higher IRR, the rates are very close. Since Project A has a higher NPV, and also has the shortest payback, accept Project A.

9-21 LG 2, 3, 4: Integrative–Complete Investment Decision

a. Initial investment:

Installed cost of new press =		
Cost of new press		$2,200,000
- After-tax proceeds from sale of old asset		
Proceeds from sale of existing press	(1,200,000)	
+ Taxes on sale of existing press *	480,000	
Total after-tax proceeds from sale		(720,000)
Initial investment		$1,480,000

* Book value = $0
$1,200,000 - $1,000,000 = $200,000 capital gain

$1,000,000 - $0 = $1,000,000 recaptured depreciation

$200,000 capital gain x (.40)	=	$ 80,000	
$1,000,000 recaptured depreciation x (.40)	=	$400,000	
	=	$480,000	tax liability

b.

Calculation of Operating Cash Flows

Year	Revenues	Expenses	Depreciation	Net Profits before Taxes	Taxes	Net Profits after Taxes	Cash Flow
1	$1,600,000	$800,000	$440,000	$360,000	$144,000	$216,000	$656,000
2	1,600,000	800,000	704,000	96,000	38,400	57,600	761,600
3	1,600,000	800,000	418,000	382,000	152,800	229,200	647,200
4	1,600,000	800,000	264,000	536,000	214,400	321,600	585,600
5	1,600,000	800,000	264,000	536,000	214,400	321,600	585,600
6	0	0	110,000	-110,000	-44,000	-66,000	44,000

c. Payback period = 2 years + ($62,400 ÷ $647,200) = 2.1 years

d. PV of cash inflows:

Year	CF	$PVIF_{11\%,n}$	PV
1	$656,000	.901	$591,056
2	761,600	.812	618,419
3	647,200	.731	473,103
4	585,600	.659	385,910
5	585,600	.593	347,261
6	44,000	.535	23,540
			$2,439,289

NPV = PV of cash inflows - Initial investment
NPV = $2,439,289 - $1,480,000
NPV = $959,289
Calculator solution: $959,152

$$\$0 = \frac{\$656,000}{(1+\text{IRR})^1} + \frac{\$761,600}{(1+\text{IRR})^2} + \frac{\$647,200}{(1+\text{IRR})^3} + \frac{\$585,600}{(1+\text{IRR})^4} + \frac{\$585,600}{(1+\text{IRR})^5} + \frac{\$44,000}{(1+\text{IRR})^6} - \$1,480,000$$

IRR = 35%
Calculator solution: 35.04%

e. The NPV is a positive $959,289 and the IRR of 35% is well above the cost of capital of 11%. Based on both decision criteria, the project should be accepted.

9-22 LG 3, 4, 5: Integrative–Investment Decision

a. Initial investment:

Installed cost of new asset =		
Cost of the new machine	$1,200,000	
+ Installation costs	150,000	
Total cost of new machine		$1,350,000
- After-tax proceeds from sale of old asset =		
Proceeds from sale of existing machine	(185,000)	
- Tax on sale of existing machine*	(79,600)	
Total after-tax proceeds from sale		(264,600)
+ Increase in net working capital		25,000
Initial investment		$1,110,400

* Book value = $384,000

Calculation of Operating Cash Flows

New Machine

Year	Reduction in Operating Costs	Depreciation	Net Profits Before Taxes	Taxes	Net Profits After Taxes	Cash Flow
1	$350,000	$270,000	$ 80,000	$32,000	$ 48,000	$318,000
2	350,000	432,000	- 82,000	- 32,800	- 49,200	382,800
3	350,000	256,500	93,500	37,400	56,100	312,600
4	350,000	162,000	188,000	75,200	112,800	274,800
5	350,000	162,000	188,000	75,200	112,800	274,800
6	0	67,500	- 67,500	- 27,000	- 40,500	27,000

Existing Machine

Year	Depreciation	Net Profits Before Taxes	Taxes	Net Profits After Taxes	Cash Flow
1	$152,000	- $152,000	- $60,800	- $91,200	$60,800
2	96,000	- 96,000	- 38,400	- 57,600	38,400
3	96,000	- 96,000	- 38,400	- 57,600	38,400
4	40,000	- 40,000	- 16,000	- 24,000	16,000
5	0	0	0	0	0
6	0	0	0	0	0

Incremental Operating Cash Flows

Year	New Machine	Existing Machine	Incremental Cash Flow
1	$318,000	$60,800	$257,200
2	382,800	38,400	344,400
3	312,600	38,400	274,200
4	274,800	16,000	258,800
5	274,800	0	274,800
6	27,000	0	27,000

Terminal cash flow:			
After-tax proceeds from sale of new asset =			
	Proceeds from sale of new asset	$200,000	
-	Tax on sale of new asset *	(53,000)	
	Total proceeds-sale of new asset		$147,000
-	After-tax proceeds from sale of old asset		0
+	Change in net working capital		25,000
Terminal cash flow			$172,000

* Book value of new machine at the end of year 5 is $67,500
200,000 - $67,500 = $132,500 recaptured depreciation
132,500 x.40 = $53,000 tax liability

b.

Year	CF	$PVIF_{9\%,n}$	PV
1	$257,200	.917	$ 235,852
2	344,400	.842	289,985
3	274,200	.772	211,682
4	258,800	.708	183,230
5	274,800	.650	178,620
Terminal value	172,000	.650	111,800
			$1,211,169

NPV = PV of cash inflows - Initial investment
NPV = $1,211,169 - $1,110,400
NPV = $100,769
Calculator solution: $100,900

c.

$$\$0 = \frac{\$257,200}{(1+\text{IRR})^1} + \frac{\$344,400}{(1+\text{IRR})^2} + \frac{\$274,200}{(1+\text{IRR})^3} + \frac{\$258,800}{(1+\text{IRR})^4} + \frac{\$446,800}{(1+\text{IRR})^5} - \$1,110,400$$

IRR = 12.2%
Calculator solution: 12.24%

d. Since the NPV > 0 and the IRR > cost of capital, the new machine should be purchased.

e. 12.24%. The criterion is that the IRR must equal or exceed the cost of capital; therefore, 12.24% is the lowest acceptable IRR.

CHAPTER 9 CASE
Making Norwich Tool's Lathe Investment Decision

The student is faced with a typical capital budgeting situation in Chapter 9's case. Norwich Tool must select one of two lathes that have different initial investments and cash inflow patterns. After calculating both unsophisticated and sophisticated capital budgeting techniques, the student must reevaluate the decision by taking into account the higher risk of one lathe.

a. Payback period

Lathe A:

Years 1 - 4 = $644,000

Payback = 4 years + ($16,000 ÷ $450,000) = 4.04 years

Lathe B:

Years 1 - 3 = $304,000

Payback = 3 years + ($56,000 ÷ $86,000) = 3.65 years

Lathe A will be rejected since the payback is longer than the 4-year maximum accepted, and lathe B is accepted because the project payback period is less than the 4-year payback cutoff.

b. **(1) NPV**

Year	Lathe A Cash Flow	$PVIF_{13\%}$	PV	Lathe B Cash Flow	$PVIF_{13\%,t}$	PV\
1	$128,000	.885	$113,280	$ 88,000	.885	$ 77,880
2	182,000	.783	142,506	120,000	.783	93,960
3	166,000	.693	115,038	96,000	.693	66,528
4	168,000	.613	102,984	86,000	.613	52,718
5	450,000	.543	244,350	207,000	.543	112,401
	PV =		$718,158	PV =		$403,487

NPV_A = $718,158 - $660,000
= $58,158
Calculator solution: $58,132.89

NPV_B = $403,487 - $360,000
= $43,487
Calculator solution: $43,483.25

(2) IRR

Lathe A:

$$\$0 = \frac{\$128{,}000}{(1+\text{IRR})^1} + \frac{\$182{,}000}{(1+\text{IRR})^2} + \frac{\$166{,}000}{(1+\text{IRR})^3} + \frac{\$168{,}000}{(1+\text{IRR})^4} + \frac{\$450{,}000}{(1+\text{IRR})^5} - \$660{,}000$$

IRR = 16%
Calculator solution: 15.95%

Lathe B:

$$\$0 = \frac{\$88{,}000}{(1+\text{IRR})^1} + \frac{\$120{,}000}{(1+\text{IRR})^2} + \frac{\$96{,}000}{(1+\text{IRR})^3} + \frac{\$86{,}000}{(1+\text{IRR})^4} + \frac{\$207{,}000}{(1+\text{IRR})^5} - \$360{,}000$$

IRR = 17%
Calculator solution: 17.34%

Under the NPV rule both lathes are acceptable since the NPVs for A and B is greater than zero. Lathe A ranks ahead of B since it has a larger NPV. The same accept decision applies to both projects with the IRR, since both IRRs are greater than the 13% cost of capital. However, the ranking reverses with the 17% IRR for B being greater than the 16% IRR for lathe A.

c. Summary

	Lathe A	**Lathe B**
Payback period	4.04 years	3.65 years
NPV	$58,158	$43,487
IRR	16%	17%

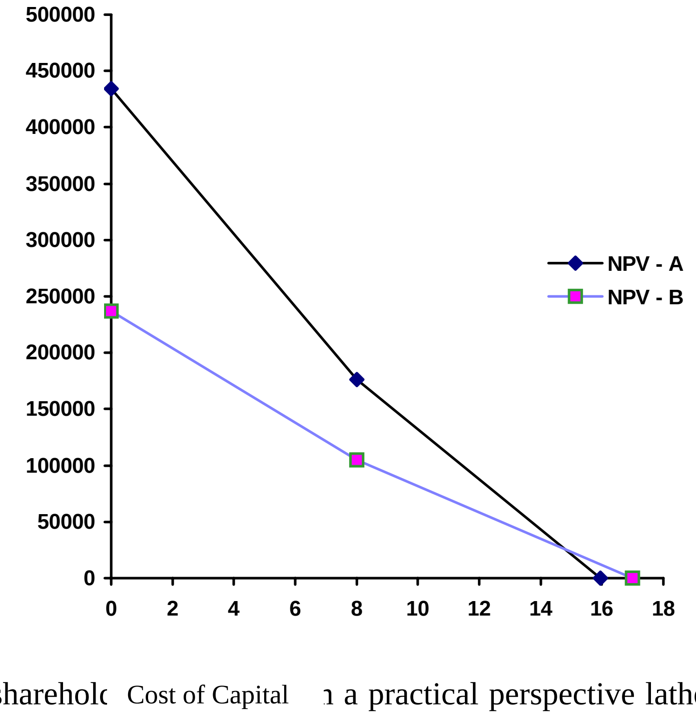
Both projects have positive NPVs and IRRs above the firm's cost of capital. Lathe A, however, exceeds the maximum payback period requirement. Because it is so close to the 4-year maximum and this is an unsophisticated capital budgeting technique, Lathe A should not be eliminated from consideration on this basis alone, particularly since it has a much higher NPV.

If the firm has unlimited funds, it should choose the project with the highest NPV, Lathe A, in order to maximize shareholder value. If the firm is subject to capital rationing, Lathe B, with its shorter payback period and higher IRR, should be chosen. The IRR considers the relative size of the investment, which is important in a capital rationing situation.

d. To create an NPV profile it is best to have at least 3 NPV data points. To create the third point an 8% discount rate was arbitrarily chosen. With the 8% rate the NPV for lathe A is $176,077 and the NPV for lathe B is $104,663

NPV

Lathe B is preferred over lathe A based on the IRR. However, as can be seen in the NPV profile, to the left of the cross-over point of the two lines lathe A is preferred. The underlying cause of this conflict in rankings arises from the reinvestment assumption of NPV versus IRR. NPV assumes the intermediate cash flows are reinvested at the cost of capital, while the IRR has cash flows being reinvested at the IRR. The difference in these two rates and the timing of the cash flows will determine the cross-over point.



e. On a theoretical basis lathe A should be preferred because of its higher NPV and thus its known impact on sharehol a practical perspective lathe B may be selected due to its higher IRR and its faster pa ference results from managers preference for evaluating decisions based on percent returns rather than dollar returns, and on the desire to get a return of cash flows as quickly as possible.