# CHAPTER 7
# CAPITAL BUDGETING DECISION METHODS
# ANSWERS

## 7-1

a.The capital budget outlines the planned expenditures on fixed assets. Capital budgeting is the whole process of analyzing projects and deciding whether they should be included in the capital budget. This process is of fundamental importance to the success or failure of the firm as the fixed asset investment decisions chart the course of a company for many years into the future.

b. The payback, or payback period, is the number of years it takes a firm to recover its project investment. Payback may be computed with either raw cash flows (regular payback) or discounted cash flows (discounted payback). In either case, payback does not capture a project's entire cash flow stream and is thus not the preferred evaluation method. Note, however, that the payback does measure a project's liquidity, and hence many firms use it as a risk measure.

c. An evaluation technique which looks at a project's contribution to net income rather than its cash flow.

d. Mutually exclusive projects cannot be performed at the same time. We can choose either Project 1 or Project 2, or we can reject both, but we cannot accept both projects. Independent projects can be accepted or rejected individually.

e. The net present value (NPV) and internal rate of return (IRR) techniques are discounted cash flow (DCF) evaluation techniques. These are called DCF methods because they explicitly recognize the time value of money. NPV is the present value of the project's expected future cash flows (both inflows and outflows), discounted at the appropriate cost of capital. NPV is a direct measure of the value of the project to shareholders.

f. IRR is the discount rate that equates the present value of the expected future cash inflows and outflows. IRR measures the rate of return on a project, but it assumes that all cash flows can be reinvested at the IRR rate.

g. The modified internal rate of return (MIRR) assumes that cash flows from all projects are reinvested at the cost of capital as opposed to the project's own IRR. This makes the modified internal rate of return a better indicator of a project's true profitability than the internal rate of return.

h. The profitability index (PI) is the present value of cash inflows divided by the present value of cash outflows. It shows the relative profitability of a particular project.

I. An NPV profile is the plot of a project's NPV versus its cost of capital. The crossover rate is the cost of capital at which the NPV profiles for two projects intersect.

j. A normal capital project is one that has one or more cash outflows (costs) followed by a series of cash inflows. Nonnormal projects are projects that call for a large cash outflow either sometime during or at the end of their lives. A nonnormal project can present three unique difficulties when evaluated by the FIRR criterion: (1) The IRR criterion can lead to an improper decision. (2) The project may have no IRR. (3) The project may have multiple IRRs.

k. The project cost of capital, or discount rate, is the rate used in discounting future cash flows in the NPV method. It is, basically, the cost to the firm of the capital that must be raised in order to invest in the project. The cost of capital depends on the riskiness of the

project, the level of interest rates in the economy, and several other factors.

l. The mathematics of the NPV method imply that project cash flows are reinvested at the cost of capital while the IRR method assumes reinvestment at the IRR. Since project cash flows can be replaced by new external capital which costs k, the proper reinvestment rate assumption is the cost of capital, and thus the best capital budgeting decision rule is NPV.

## 7-2

The NPV is obtained by discounting future cash flows, and the discounting process actually compounds the interest rate over time. Thus, an increase in the discount rate has a much greater impact on a cash flow in Year 5 than on a cash flow in Year 1.

## 7-3

This question is related to Question 7-2 and the same rationale applies. With regard to the second part of the question, the answer is no; the IRR rankings are constant and independent of the firm's cost of capital.

## 7-4

Yes. If PI is greater than 1.0, then by definition the present value of the inflows is greater than the present value of the costs; thus, the NPV is positive. We also know that if the NPV is positive, then the IRR must be greater than k, because the NPV is zero if the IRR is used as the cost of capital.

## 7-5

The NPV and IRR methods both involve compound interest, and the mathematics of discounting requires an assumption about reinvestment rates. The NPV method assumes reinvestment at the cost of capital, while the IRR method assumes reinvestment at the IRR. MIRR is a modified version of IRR which assumes reinvestment at the cost of capital.

# SOLUTIONS

## 7-1

Using a financial calculator:

$NPV_S$ = \$814.33; $NPV_L$ = \$1,675.34.
$IRR_S$ = 15.24%; $IRR_L$ = 14.67%.

MIRR:

$$\text{PV costs}_S = \$10{,}000.$$

$$\text{FV inflows}_S = \$19{,}058.54.$$

$$\text{MIRR}_S = 13.77\%.$$

$$\text{PV costs}_L = \$25{,}000.$$

$$\text{FV inflows}_L = \$47{,}011.07.$$

$$\text{MIRR}_L = 13.46\%.$$

0

$$PI_S = \frac{\$3{,}000(PVIFA_{12\%,5})}{\$10{,}000} = 1.081.$$

$$PI_L = \frac{\$7{,}400(PVIFA_{12\%,5})}{\$25{,}000} = 1.067.$$

Thus, $NPV_L > NPV_S$, $IRR_S > IRR_L$, $MIRR_S > MIRR_L$, and $PI_S > PI_L$. The scale difference between Projects S and L result in IRR, MIRR, and PI favoring S over L. However, NPV favors Project L, and hence L should be chosen.

## 7-2

a.

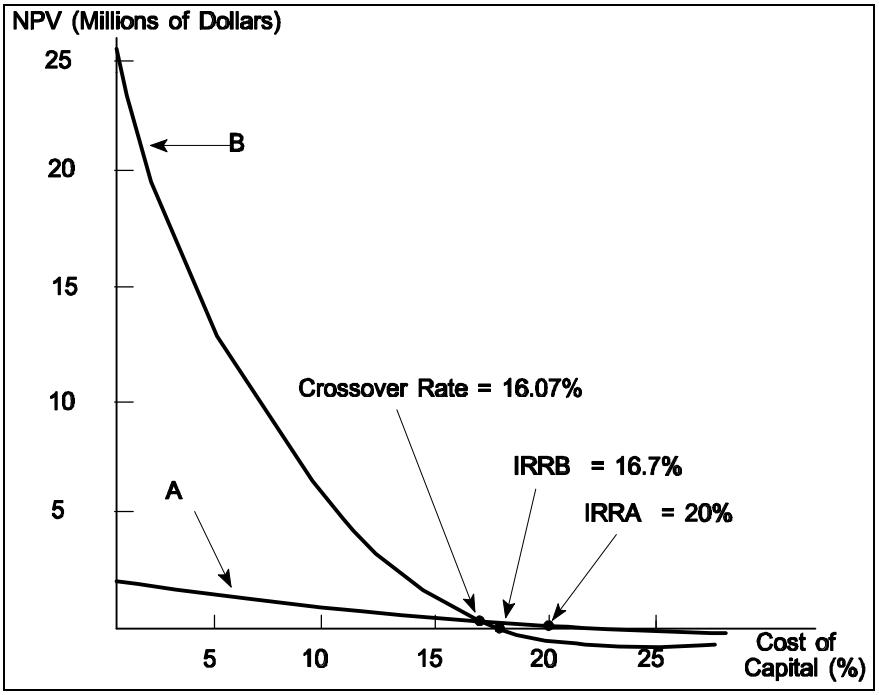
| Year | Plan B | Plan A | Incremental Cash Flow (B - A) |
|---|---|---|---|
| 0 | ($10,000,000) | ($10,000,000) | $ 0 |
| 1 | 1,750,000 | 12,000,000 | (10,250,000) |
| 2-20 | 1,750,000 | 0 | 1,750,000 |

If the firm goes with Plan B, it will forgo $10,250,000 in Year 1, but will receive $1,750,000 per year in Years 2-20.

b. If the firm could invest the incremental $10,250,000 at a return of 16.07%, it would receive cash flows of $1,750,000. If we set up an amortization schedule, we would find that payments of $1,750,000 per year for 19 years would amortize a loan of $10,250,000 at 16.0665%.

c. Yes, assuming (1) equal risk among projects, and (2) that the cost of capital is a constant and does not vary with the amount of capital raised.

d. See graph. If the cost of capital is less than 16.07%, then Plan B should be accepted; if k > 16.07%, then A is preferred.




## 7-3

a. Using a financial calculator, we get:

$NPV_A$ = \$18,108,510; $NPV_B$ = \$13,946,117.
$IRR_A$ = 15.03%; $IRR_B$ = 22.26%.

b. If Linke takes Plan A rather than B, its cash flows will be (in millions of dollars):

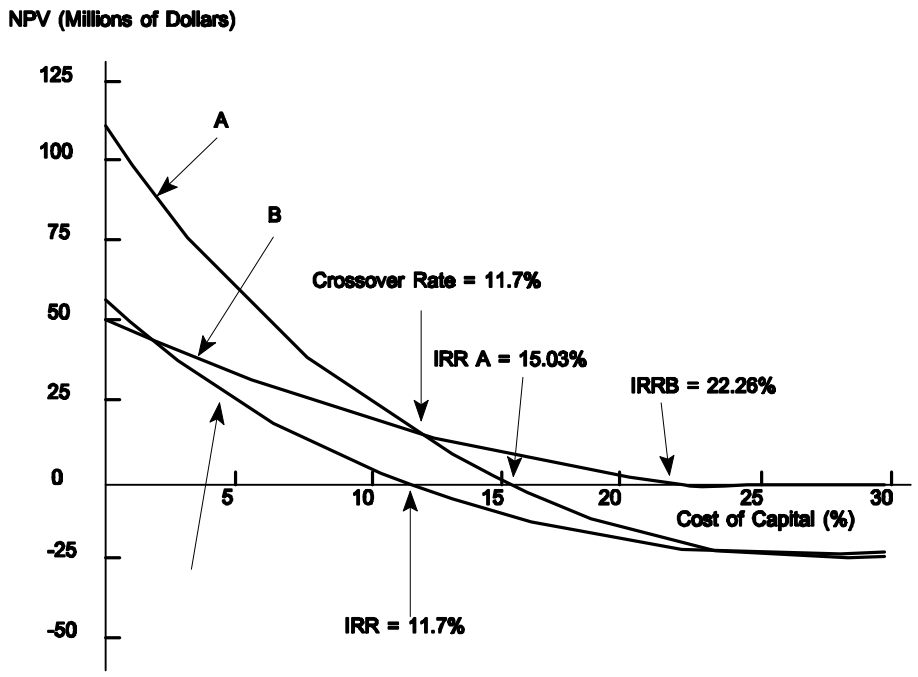
| Year | Cash Flows from A | Cash Flows from B | Project $\Delta$ Cash Flows |
|---|---|---|---|
| 0 | ($50) | ($15.0) | ($35.0) |
| 1 | 8 | 3.4 | 4.6 |
| 2 | 8 | 3.4 | 4.6 |
| . | . | . | . |
| . | . | . | . |
| . | . | . | . |
| 20 | 8 | 3.4 | 4.6 |

So, Project $\Delta$ has a "cost" of \$35,000,000 and "inflows" of \$4,600,000 per year for 20 years.

$NPV_\Delta$ = \$4,162,393; $IRR_\Delta$ = 11.71%.

Since $IRR_\Delta > k$, and since $NPV_\Delta > 0$, we should accept $\Delta$. This means accept the larger project (Project A). In addition, when dealing with mutually exclusive projects, we use the NPV method for choosing the best project.

c.




d. The NPV method implicitly assumes that the opportunity exists to reinvest the cash flows generated by a project at the cost of capital, while use of the IRR method implies the opportunity to reinvest at the IRR. If the firm's cost of capital is constant at 10 percent, all projects with an NPV > 0 will be accepted by the firm. As cash flows come in from these projects, the firm will either pay them out to investors, or use them as a substitute for outside capital which costs 10 percent. Thus, since these cash flows are expected to save the firm 10 percent, this is their opportunity cost reinvestment rate.

The IRR method assumes reinvestment at the internal rate of return itself, which is an incorrect assumption, given a constant expected future cost of capital, and ready access to capital markets.

## 7-4

a. *Payback:* To determine the payback, construct the cumulative cash flows for each project:

| | Cumulative Cash Flows | |
|---|---|---|
| Year | Project X | Project Y |
| 0 | ($10,000) | ($10,000) |
| 1 | (3,500) | (6,500) |
| 2 | (500) | (3,000) |
| 3 | 2,500 | 500 |
| 4 | 3,500 | 4,000 |

$Payback_X$ = 2 + $500/$3,000 = 2.17 years.
$Payback_Y$ = 2 + $3,000/$3,500 = 2.86 years.

*Net Present Value:*

$$NPV_X = -\$10{,}000 + \frac{\$6{,}500}{(1.12)^1} + \frac{\$3{,}000}{(1.12)^2} + \frac{\$3{,}000}{(1.12)^3} + \frac{\$1{,}000}{(1.12)^4} = \$966.01.0$$

$$NPV_Y = -\$10{,}000 + \frac{\$3{,}500}{(1.12)^1} + \frac{\$3{,}500}{(1.12)^2} + \frac{\$3{,}500}{(1.12)^3} + \frac{\$3{,}500}{(1.12)^4} = \$630.72.0$$

*Internal Rate of Return (IRR):* To solve for the IRR find the discount rates which equate each NPV to zero:

$IRR_X$ = 18.0%.
$IRR_Y$ = 15.0%.

*Modified IRR (MIRR):* To obtain each project's MIRR, begin by finding each project's terminal value (TV) of cash inflows:

$TV_X = \$6{,}500(1.12)^3 + \$3{,}000(1.12)^2 + \$3{,}000(1.12)^1 + \$1{,}000 = \$17{,}255.23.$
$TV_Y = \$3{,}500(1.12)^3 + \$3{,}500(1.12)^2 + \$3{,}500(1.12)^1 + \$3{,}500 = \$16{,}727.65.$

Now, each project's MIRR is that discount rate which equates the PV of the TV to each project's cost, $10,000:

$MIRR_X$ = 14.6%.
$MIRR_Y$ = 13.7%.

*Profitability Index (PI):*

$PI_X$ = PV benefits/PV costs = $10,966.01/$10,000 = 1.10.
$PI_Y$ = $10,630.72/$10,000 = 1.06.

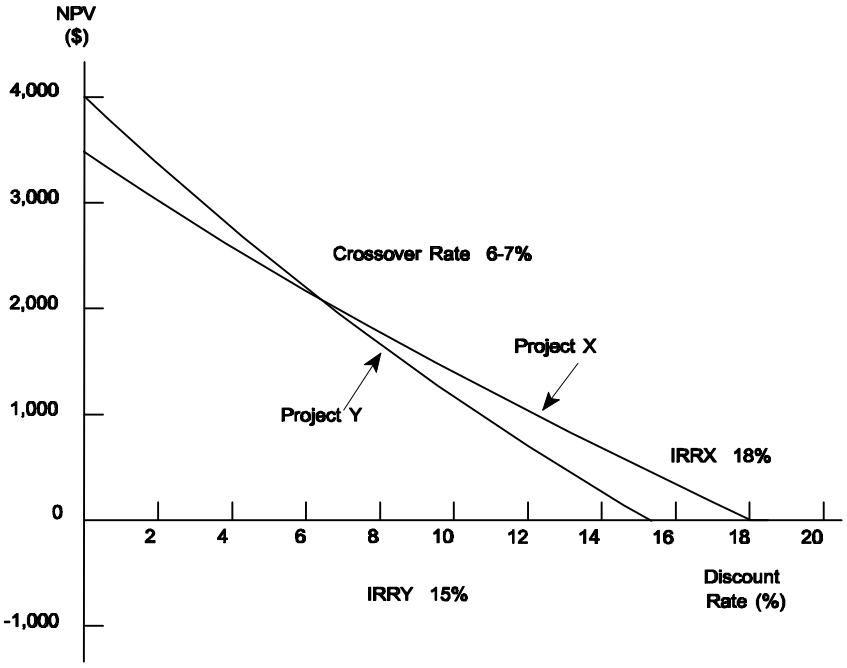
b. The following table summarizes the project rankings by each method:

| | Ranks Higher |
|---|---|
| Payback | X |
| NPV | X |
| IRR | X |
| MIRR | X |
| PI | X |

Note that all methods rank Project X over Project Y. Additionally, both projects are acceptable under the NPV, IRR, and PI criteria. Thus, both projects should be accepted if they are independent.

c. Choose the project with the highest NPV at k = 12%, or Project X. Note that both projects have four-year lives--if Project X and Project Y had different lives and were repeatable, a different procedure would be required. This is discussed in Chapter 8.

d. To determine the effects of changing the cost of capital, plot the NPV profiles of each project:




| Discount Rate | $NPV_X$ | $NPV_Y$ |
|---|---|---|
| 0% | $3,500 | $4,000 |
| 4 | 2,546 | 2,705 |
| 8 | 1,707 | 1,592 |
| 12 | 966 | 630 |
| 16 | 307 | (206) |

The crossover point occurs at about 6-7 percent. To find this rate exactly, create a Project $\Delta$, which is the difference in cash flows between Projects X and Y:

| Year | Project X - Project Y = Project $\Delta$ Net Cash Flows |
|---|---|
| 0 | $ 0 |
| 1 | 3,000 |
| 2 | (500) |
| 3 | (500) |
| 4 | (2,500) |

Then find the IRR of Project $\Delta$.

$$IRR_{\Delta} = \text{Crossover rate} = 6.2\%.$$

Thus, if the firm's cost of capital is less than 6.2 percent, a conflict exists since $NPV_Y > NPV_X$, but $IRR_X > IRR_Y$. Note, however, that when k = 5.0%, $MIRR_X$ =10.64%, and $MIRR_Y$ = 10.83%; hence, the modified IRR ranks the projects correctly, even to the left of the crossover point.

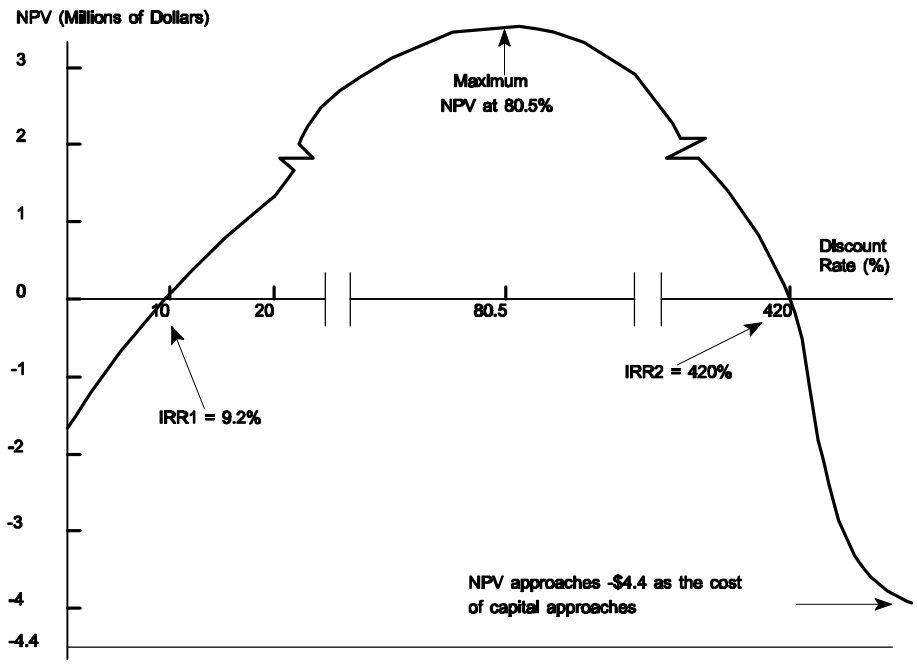
e. The basic cause of the conflict is differing reinvestment rate assumptions between NPV and IRR. The conflict occurs in this situation because the projects differ in their cash flow timing.

## 7-5

a.The project's expected cash flows are as follows (in millions of dollars):

| Time | Net Cash Flow |
|---|---|
| 0 | ($ 4.4) |
| 1 | 27.7 |
| 2 | (25.0) |

We can construct the following NPV profile:




| Discount Rate | NPV |
|---|---|
| 0% | ($1,700,000) |
| 9 | (29,156) |
| 10 | 120,661 |
| 50 | 2,955,556 |
| 100 | 3,200,000 |
| 200 | 2,055,556 |
| 300 | 962,500 |
| 400 | 140,000 |
| 410 | 70,204 |
| 420 | 2,367 |
| 430 | (63,581) |

b. If k = 8%, reject the project since NPV < 0. But if k = 14%, accept the project because NPV > 0.

c. Other possible projects with multiple rates of return could be nuclear power plants where disposal of radioactive wastes is required at the end of the project's life, or leveraged leases where the borrowed funds are repaid at the end of the lease life. (See Chapter 17 for more information on leases.

d. Here is the MIRR for the project when k = 8%:

PV costs = $\$4,400,000 + \$25,000,000/(1.08)^2 = \$25,833,470.51$.
TV inflows = $\$27,700,000(1.08)^1 = \$29,916,000.00$.

Now, MIRR is that discount rate which forces the PV of $29,916,000 over 2 years to equal $25,833,470.51:

$\$25,833,470.51 = \$29,916,000(PVIF_{k,2})$.
MIRR = 7.61%.

At k = 14%, MIRR = 15.58%.

Yes. The MIRR method leads to the same conclusion as the NPV method. Reject the project if k = 8%, which is greater than the corresponding MIRR of 7.61%, and accept the project if k = 14%, which is less than the corresponding MIRR of 15.58%.

## 7-6

*Determine cash flows:*

t=0: The firm will borrow $2,000,000, but $1,000,000 must be spent on the casino project. Net cash flow = $1 million.

t=1: Repay $2 million loan, plus 10 percent interest ($200,000), plus $700,000 fee: Net cash outflow = $2.9 million.

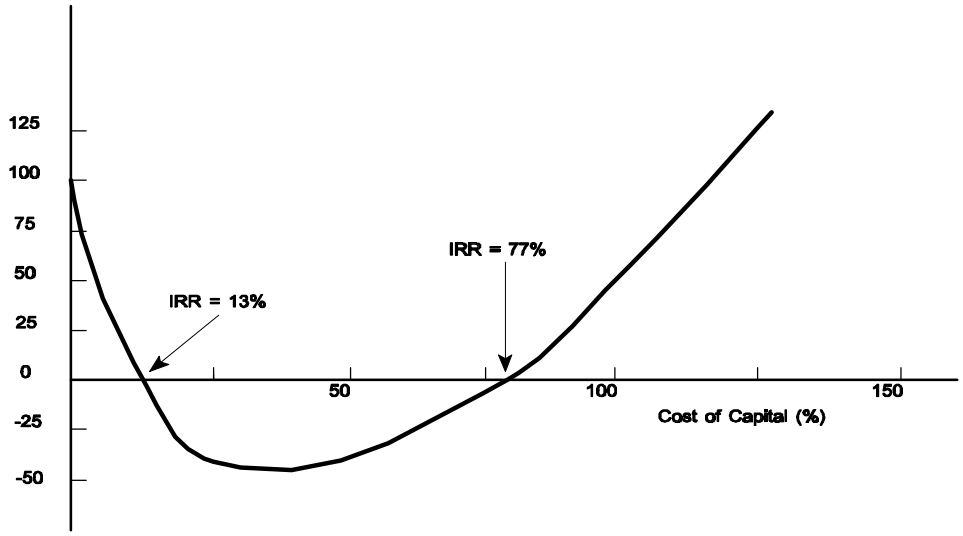
t=2: Receive $2 million from sale of casino.

*Work out NPV profile:*

$$NPV = +\$1,000,000 - \frac{\$2,900,000}{(1+k)^1} + \frac{\$2,000,000}{(1+k)^2}.0$$

Solve at different values of k:

| k | NPV | |
|---|---|---|
| 0% | $100,000 | |
| 10 | 16,529 | |
| 13 | (78) | ≈ 0 |
| 15 | (9,452) | |
| 25 | (40,000) | |
| 35 | (50,754) | |
| 50 | (44,444) | |
| 77 | (32) | ≈ 0 |
| 100 | 50,000 | |




150 160,000

As the graph indicates, the NPV is positive at any k less than 13 percent or greater than 77 percent; within that range, the NPV is negative.

The deal really amounts to a loan plus a construction project. If the firm could borrow at low rates (less than 13 percent), then the project would be profitable because the profit on the sale of the casino ($1 million) would more than cover the interest and fee on the loan. Or, if the firm had such good investment opportunities that the firm could make over 76 percent on the $1 million made available by the deal, it would be profitable. In between, it is not a good project.

## 7-7

a.The IRRs of the two alternatives are undefined. To calculate an IRR, the cash flow stream must include both cash inflows and outflows.

b. The PV of costs for the conveyor system is ($911,067), while the PV of costs for the forklift system is ($838,834). Thus, the forklift system is expected to be ($838,834) - ($911,067) = $72,233 less costly than the conveyor system, and hence the forklift trucks should be used.