

Chapter 10

The Basics of Capital Budgeting: Evaluating Cash Flows

ANSWERS TO END-OF-CHAPTER QUESTIONS

- 10-1 a. 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. The payback, or payback period, is the number of years it takes a firm to recover its project investment. Payback may be calculated 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.
- b. 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.
- c. 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. The internal rate of return (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.
- d. 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. The profitability index is found by dividing the project's PV of future cash flows by its initial cost. A profitability index greater than 1 is equivalent to a positive NPV project.
- e. 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.

- f. Capital projects with non-normal cash flows have a large cash outflow either sometime during or at the end of their lives. A common problem encountered when evaluating projects with non-normal cash flows is multiple IRRs. A project has normal cash flows if one or more cash outflows (costs) are followed by a series of cash inflows.
 - g. The hurdle rate is the project cost of capital, or discount rate. It is the rate used in discounting future cash flows in the NPV method, and it is the rate that is compared to the IRR. 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 r , the proper reinvestment rate assumption is the cost of capital, and thus the best capital budget decision rule is NPV.
 - h. Not all projects maximize their NPV if operated over their engineering lives and therefore it may be best to terminate a project prior to its potential life. The economic life is the number of years a project should be operated to maximize its NPV, and is often less than the maximum potential life. Capital rationing occurs when management places a constraint on the size of the firm's capital budget during a particular period.
- 10-2 Projects requiring greater investment or that have greater risk should be given more detailed analysis in the capital budgeting process.
- 10-3 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.
- 10-4 This question is related to Question 10-3 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.
- 10-5 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.
- 10-6 Generally, the failure to employ common life analysis in such situations will bias the NPV against the shorter project because it "gets no credit" for profits beyond its initial life, even though it could possibly be "renewed" and thus provide additional NPV.

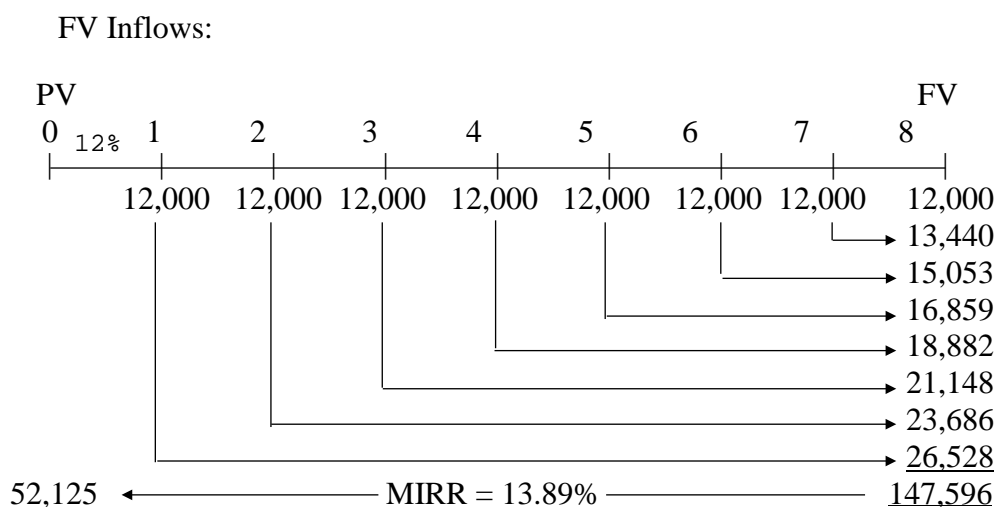
SOLUTIONS TO END-OF-CHAPTER PROBLEMS

10-1
$$\begin{aligned} \text{NPV} &= -\$52,125 + \$12,000[(1/D)-(1/(I*(1+I)^N)] \\ &= -\$52,125 + \$12,000[(1/0.12)-(1/(0.12*(1+0.12)^8)] \\ &= \$7,486.68. \end{aligned}$$

Financial calculator: Input the appropriate cash flows into the cash flow register, input $I = 12$, and then solve for $\text{NPV} = \$7,486.68$.

10-2 Financial calculator: Input the appropriate cash flows into the cash flow register and then solve for $\text{IRR} = 16\%$.

10-3 MIRR: $\text{PV Costs} = \$52,125$.



Financial calculator: Obtain the FVA by inputting $N = 8$, $I/YR = 12$, $PV = 0$, $PMT = 12000$, and then solve for $\text{FV} = \$147,596$. The MIRR can be obtained by inputting $N = 8$, $PV = -52125$, $PMT = 0$, $\text{FV} = 147596$, and then solving for $I = 13.89\%$.

$$\begin{aligned}
 10-4 \quad PV &= \$12,000[(1/I)-(1/(I*(1+I)^N)] \\
 &= \$12,000[(1/0.12)-(1/(0.12*(1+0.12)^8)] \\
 &= \$59,611.68.
 \end{aligned}$$

Financial calculator: Find present value of future cash flows by inputting $N = 8$, $I/YR = 12$, $PMT = -12000$, $FV = 0$, then solve for $PV = \$59,611.68$.

$$\begin{aligned}
 PI &= PV \text{ of future cash flows} / \text{Initial cost} \\
 &= \$59,611.68 / \$52,125 = 1.14.
 \end{aligned}$$

10-5

Year	CF	Cumulative CF
0	-52,125	-52,125
1	12,000	-40,125
2	12,000	-28,125
3	12,000	-16,125
4	12,000	-4,125
5	12,000	7,875
6	12,000	19,875
7	12,000	31,875
8	12,000	43,875

The cumulative cash flows turn positive in Year 5, so the payback will be 4 plus the part of Year 5 that is required to return the investment:

$$\text{Payback} = 4 + (\$4,125 / \$12,000) = 4.34 \text{ years.}$$

Because the future cash flows are identical, we can also find the payback period by dividing the cost by the cash flow: $\$52,125 / \$12,000 = 4.34$ years.

10-6 The project's discounted payback period is calculated as follows:

<u>Period</u>	<u>Annual Cash Flows</u>	<u>Discounted @ 12% Cash Flows</u>	<u>Cumulative</u>
0	\$(52,125)	\$(52,125.00)	\$(52,125.00)
1	12,000	10,714.80	(41,410.20)
2	12,000	9,566.40	(31,843.80)
3	12,000	8,541.60	(23,302.20)
4	12,000	7,626.00	(15,676.20)
5	12,000	6,808.80	(8,867.40)
6	12,000	6,079.20	(2,788.20)
7	12,000	5,427.60	2,639.40
8	12,000	4,846.80	7,486.20

The discounted payback period is $6 + \frac{\$2,788.20}{\$5,427.60}$ years, or 6.51 years.

10-7 a. Project A:

Using a financial calculator, enter the following:

$$CF_0 = -15000000$$

$$CF_1 = 5000000$$

$$CF_2 = 10000000$$

$$CF_3 = 20000000$$

$$I = 10; NPV = \$12,836,213.$$

$$\text{Change } I = 10 \text{ to } I = 5; NPV = \$16,108,952.$$

$$\text{Change } I = 5 \text{ to } I = 15; NPV = \$10,059,587.$$

Project B:

Using a financial calculator, enter the following:

$$CF_0 = -15000000$$

$$CF_1 = 20000000$$

$$CF_2 = 10000000$$

$$CF_3 = 6000000$$

$$I = 10; NPV = \$15,954,170.$$

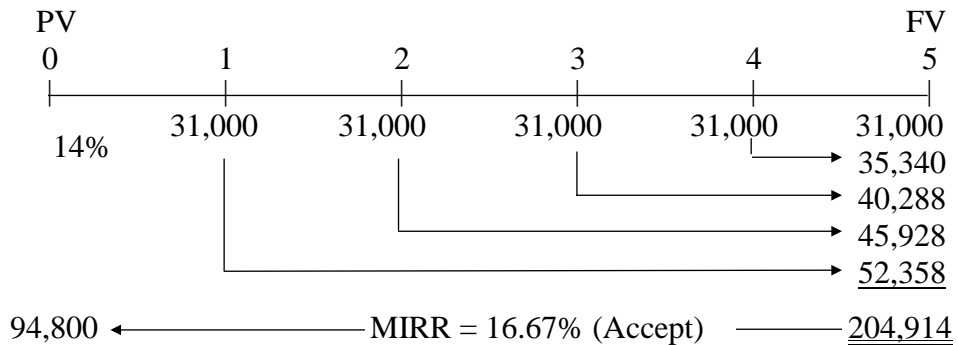
$$\text{Change } I = 10 \text{ to } I = 5; NPV = \$18,300,939.$$

$$\text{Change } I = 5 \text{ to } I = 15; NPV = \$13,897,838.$$

Financial calculator: Input the appropriate cash flows into the cash flow register and then solve for IRR = 19%.

MIRR: PV Costs = \$94,800.

FV Inflows:



Financial calculator: Obtain the FVA by inputting $N = 5$, $I = 14$, $PV = 0$, $PMT = 31000$, and then solve for $FV = \$204,914$. The MIRR can be obtained by inputting $N = 5$, $PV = -94800$, $PMT = 0$, $FV = 204913$, and then solving for $I = 16.67\%$.

10-9 *Electric-powered:*

$$\begin{aligned} \text{NPV}_E &= -\$22,000 + \$6,290 [(1/i)-(1/(i*(1+i)^n))] \\ &= -\$22,000 + \$6,290 [(1/0.12)-(1/(0.12*(1+0.12)^6))] \\ &= -\$22,000 + \$6,290(4.1114) \\ &= -\$22,000 + \$25,861 \\ &= \$3,861. \end{aligned}$$

Financial calculator: Input the appropriate cash flows into the cash flow register, input I = 12, and then solve for NPV = \$3,861.

Financial calculator: Input the appropriate cash flows into the cash flow register and then solve for IRR = 18%.

Gas-powered:

$$\begin{aligned} \text{NPV}_G &= -\$17,500 + \$5,000 [(1/i)-(1/(i*(1+i)^n))] \\ &= -\$17,500 + \$5,000 [(1/0.12)-(1/(0.12*(1+0.12)^6))] \\ &= -\$17,500 + \$5,000(4.1114) \\ &= -\$17,500 + \$20,557 \\ &= \$3,057. \end{aligned}$$

Financial calculator: Input the appropriate cash flows into the cash flow register, input I = 12, and then solve for NPV = \$3,057.

Financial calculator: Input the appropriate cash flows into the cash flow register and then solve for IRR = 17.97% \approx 18%.

The firm should purchase the electric-powered forklift because it has a higher NPV than the gas-powered forklift. The company gets a high rate of return (18% > r = 12%) on a larger investment.

10-10 Financial calculator solution, NPV:

Project A

Inputs	5	10		7000	0
	<input type="text" value="N"/>	<input type="text" value="I"/>	<input type="text" value="PV"/>	<input type="text" value="PMT"/>	<input type="text" value="FV"/>

Output = -26,535.51

$$NPV_A = \$26,535.51 - \$22,000 = \$4,535.51.$$

Project B

Inputs	5	10		20000	0
	<input type="text" value="N"/>	<input type="text" value="I"/>	<input type="text" value="PV"/>	<input type="text" value="PMT"/>	<input type="text" value="FV"/>

Output = -75,815.74

$$NPV_B = \$75,815.74 - \$70,000 = \$5,815.74.$$

Financial calculator solution, IRR:

Project A: $CF_0 = -22000$, $CF_1 = 7000$, $N_j = 5$, $IRR_A = ?$ $IRR_A = 17.78\%$.

Project B: $CF_0 = -70000$, $CF_1 = 20000$, $N_j = 5$, $IRR_B = ?$ $IRR_B = 13.20\%$.

Financial calculator solution, MIRR:

Project A

Inputs	5	10	0	7000	
	<input type="text" value="N"/>	<input type="text" value="I"/>	<input type="text" value="PV"/>	<input type="text" value="PMT"/>	<input type="text" value="FV"/>

Output = -42,735.70

$$PV\ costs_A = \$22,000.$$

$$FV\ inflows_A = \$42,735.70.$$

Inputs	5		-22000	0	42,735.70
	<input type="text" value="N"/>	<input type="text" value="I"/>	<input type="text" value="PV"/>	<input type="text" value="PMT"/>	<input type="text" value="FV"/>

Output = 14.20

$$MIRR_A = 14.20\%.$$

Project B

Inputs	5	10	0	20000	
	<input type="text" value="N"/>	<input type="text" value="I"/>	<input type="text" value="PV"/>	<input type="text" value="PMT"/>	<input type="text" value="FV"/>
Output	=				122,102

PV costs_B = \$70,000.
 FV inflows_B = \$122,102.

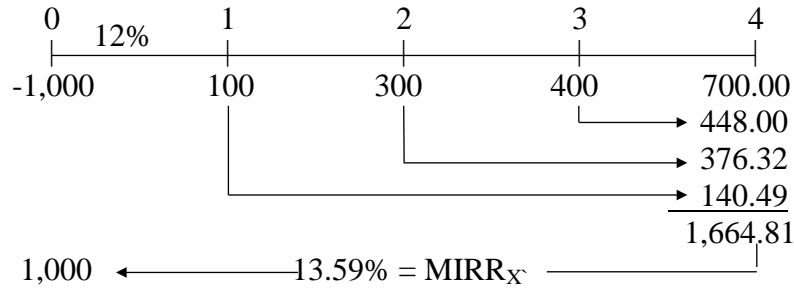
Inputs	5		-70000	0	122,102
	<input type="text" value="N"/>	<input type="text" value="I"/>	<input type="text" value="PV"/>	<input type="text" value="PMT"/>	<input type="text" value="FV"/>
Output		= 11.77			

MIRR_b = 11.77%.

$$PI_A = \frac{\$26,535.51}{\$22,000} = 1.206. \quad PI_B = \frac{\$75,815.74}{\$70,000} = 1.083.$$

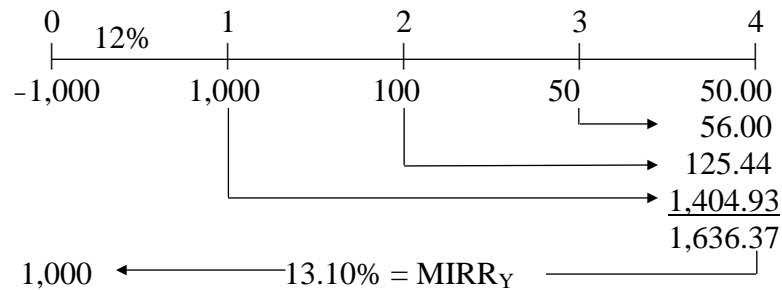
Thus, NPV_B > NPV_A; IRR_A > IRR_B; MIRR_A > MIRR_B; and PI_A > PI_B. The scale difference between Projects A and B result in the IRR, MIRR, and PI favouring A over B. However, NPV favours Project B, and therefore B should be chosen.

10-11 Project X:



$$\$1,000 = \$1,664.81 / (1 + \text{MIRR}_X)^4.$$

Project Y:



$$\$1,000 = \$1,636.37 / (1 + \text{MIRR}_Y)^4.$$

Thus, since $\text{MIRR}_X > \text{MIRR}_Y$, Project X should be chosen.

Alternative step: You could calculate NPVs, see that Project X has the higher NPV, and just calculate MIRR_X .

$$\text{NPV}_X = \$58.02 \text{ and } \text{NPV}_Y = \$39.94.$$

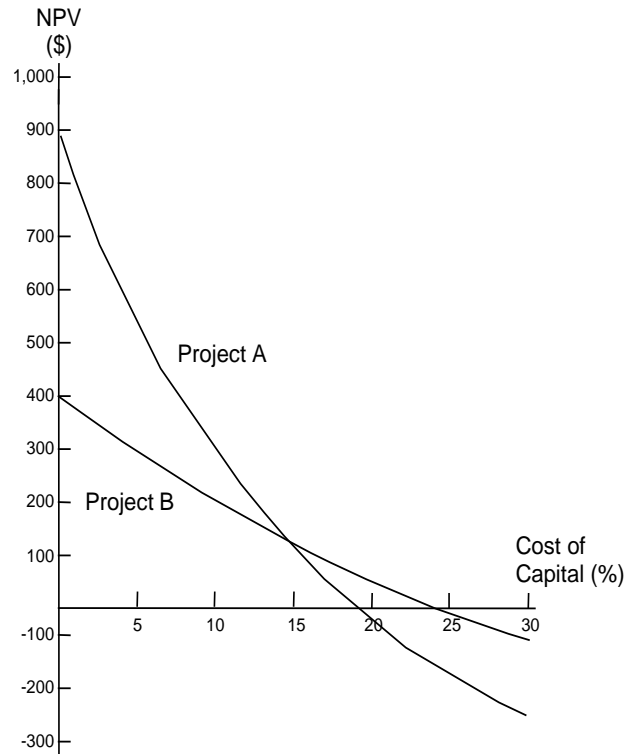
- 10-12 a. Purchase price \$ 900,000
 Installation 165,000
 Initial outlay \$1,065,000

$$\text{CF}_0 = -1065000; \text{CF}_{1-5} = 350000; I = 14; \text{NPV} = ?$$

$$\text{NPV} = \$136,578; \text{IRR} = 19.22\%.$$

- b. Ignoring environmental concerns, the project should be undertaken because its NPV is positive and its IRR is greater than the firm's cost of capital.
- c. Environmental effects could be added by estimating penalties or any other cash outflows that might be imposed on the firm to help return the land to its previous state (if possible). These outflows could be so large as to cause the project to have a negative NPV—in which case the project should not be undertaken.

10-13 a.



r	NPV _A	NPV _B
0.0%	\$890	\$399
10.0	283	179
12.0	200	146
18.1	0	62
20.0	(49)	41
24.0	(138)	0
30.0	(238)	(51)

- b. At $r = 10\%$, Project A has the greater NPV, specifically \$283.34 as compared to Project B's NPV of \$178.60. Thus, Project A would be selected. At $r = 17\%$, Project B has an NPV of \$75.95 which is higher than Project A's NPV of \$31.05. Thus, choose Project B if $r = 17\%$.

c. Here is the MIRR for Project A when $r = 10\%$:

$$\begin{aligned} \text{PV costs} &= \$300 + \$387/(1.10)^1 + \$193/(1.10)^2 \\ &\quad + \$100/(1.10)^3 + \$180/(1.10)^7 = \$978.82. \end{aligned}$$

$$\text{TV inflows} = \$600(1.10)^3 + \$600(1.10)^2 + \$850(1.10)^1 = \$2,459.60.$$

Now, MIRR is that discount rate which forces the TV of \$2,459.60 in 7 years to equal \$978.82:

$$\$978.82 = \$2,459.60/(1+\text{MIRR})^7.$$

$$\text{MIRR}_A = 14.07\%.$$

$$\text{Similarly, } \text{MIRR}_B = 15.89\%.$$

At $r = 17\%$,

$$\text{MIRR}_A = 17.57\%.$$

$$\text{MIRR}_B = 19.91\%.$$

d. To find the crossover rate, construct a Project Δ which is the difference in the two projects' cash flows:

<u>Year</u>	<u>Project $\Delta =$ CF_A - CF_B</u>
0	\$105
1	(521)
2	(327)
3	(234)
4	466
5	466
6	716
7	(180)

$$\text{IRR}_\Delta = \text{Crossover rate} = 14.53\%.$$

Projects A and B are mutually exclusive, thus, only one of the projects can be chosen. As long as the cost of capital is greater than the crossover rate, both the NPV and IRR methods will lead to the same project selection. However, if the cost of capital is less than the crossover rate the two methods lead to different project selections—a conflict exists. When a conflict exists, the NPV method must be used.

10-14 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

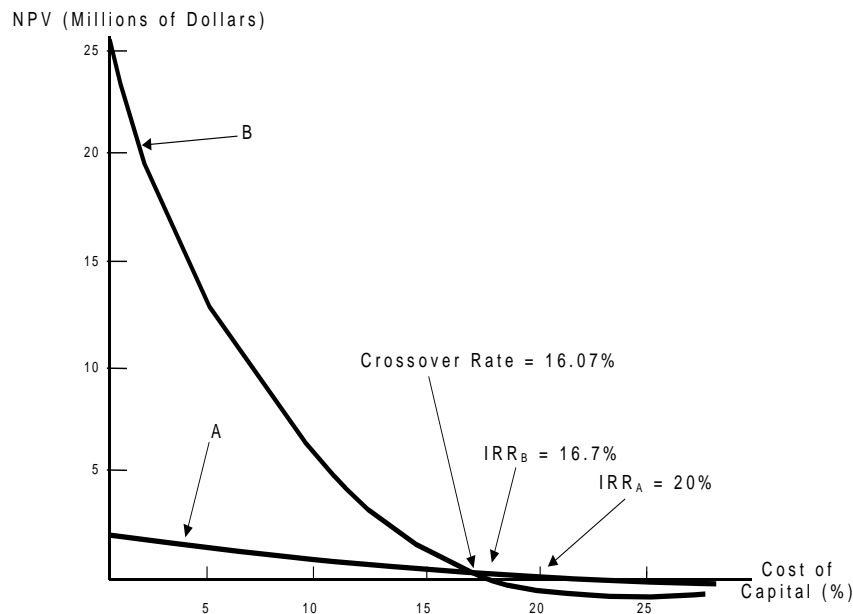
If the firm goes with Plan B, it will forgo \$10,250,000 in Year 1, but will receive \$1,750,000 per year in Years 2-20.

- 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%.

Financial calculator solution:

Inputs	19		-10250000	1750000	0
	N	I	PV	PMT	FV
Output	= 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 $r > 16.07\%$, then Plan A is preferred.



10-15 a. Financial calculator solution:

Plan A

Inputs	20	10		8000000	0
	<input type="text" value="N"/>	<input type="text" value="I"/>	<input type="text" value="PV"/>	<input type="text" value="PMT"/>	<input type="text" value="FV"/>

Output = -68,108,510

$$NPV_A = \$68,108,510 - \$50,000,000 = \$18,108,510.$$

Plan B

Inputs	20	10		3400000	0
	<input type="text" value="N"/>	<input type="text" value="I"/>	<input type="text" value="PV"/>	<input type="text" value="PMT"/>	<input type="text" value="FV"/>

Output = -28,946,117

$$NPV_B = \$28,946,117 - \$15,000,000 = \$13,946,117.$$

Plan A

Inputs	20		-50000000	8000000	0
	<input type="text" value="N"/>	<input type="text" value="I"/>	<input type="text" value="PV"/>	<input type="text" value="PMT"/>	<input type="text" value="FV"/>

Output = 15.03

$$IRR_A = 15.03\%.$$

Plan B

Inputs	20		-15000000	3400000	0
	<input type="text" value="N"/>	<input type="text" value="I"/>	<input type="text" value="PV"/>	<input type="text" value="PMT"/>	<input type="text" value="FV"/>

Output = 22.26

$$IRR_B = 22.26\%.$$

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

<u>Year</u>	<u>Cash Flows from A</u>	<u>Cash Flows from B</u>	<u>Project Δ Cash Flows</u>
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 Δ has a “cost” of \$35,000,000 and “inflows” of \$4,600,000 per year for 20 years.

Inputs	20	10		4600000	0
	N	I	PV	PMT	FV
Output	= -39,162,393				

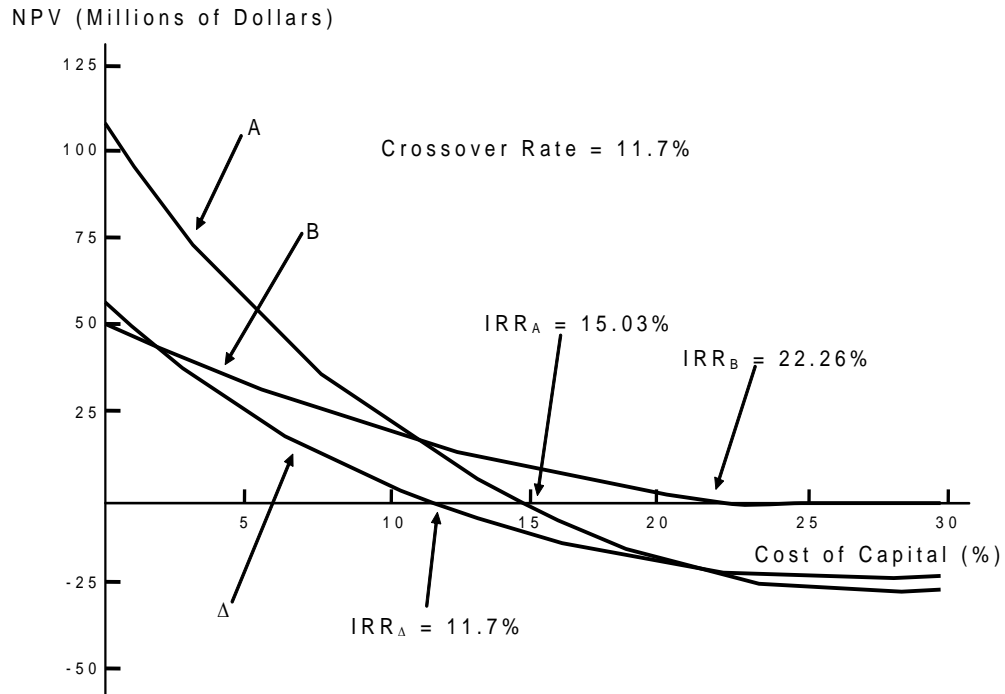
$$NPV_{\Delta} = \$39,162,393 - \$35,000,000 = \$4,162,393.$$

Inputs	2		-35000000	4600000	0
	N	I	PV	PMT	FV
Output	= 11.71				

$$IRR_{\Delta} = 11.71\%.$$

Since $IRR_{\Delta} > r$, we should accept Δ. 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.

10-16 The EAA of ship A is found by first finding the PV: $N = 7$, $I/YR = 12$, $PMT = 17$, $FV = 0$; solve for $PV = -77.58$. The NPV is $\$77.58 - \$60 = \$17.58$ million. We convert this to an equivalent annual annuity by inputting: $N = 7$, $I/YR = 12$, $PV = -17.58$, $FV = 0$, and solve for $PMT = EAA = \$3.85$ million.

For ship B, the NPV = 24.42. We convert this to an equivalent annual annuity by inputting: $N = 14$, $I/YR = 12$, $PV = -24.42$, $FV = 0$, and solve for $PMT = EAA = \$3.68$ million.

Ship A has the higher equivalent annual annuity, and should be accepted.

10-17 The EAA of machine A is found by first finding the PV: $N = 4$, $I/YR = 10$, $PMT = 4$, $FV = 0$; solve for $PV = -12.679$. The NPV is $\$12.679 - \$10 = \$2.679$ million. We convert this to an equivalent annual annuity by inputting: $N = 4$, $I/YR = 10$, $PV = -2.679$, $FV = 0$, and solve for $PMT = EAA = 0.845 \approx \0.85 million.

For machine B, the $NPV = 3.672$. We convert this to an equivalent annual annuity by inputting: $N = 8$, $I/YR = 10$, $PV = -3.672$, $FV = 0$, and solve for $PMT = EAA = 0.688 \approx \0.69 million. Accept machine A.

10-18 The EAA of machine 190-3 is found by converting its NPV to an equivalent annual annuity by inputting: $N = 3$, $I/YR = 14$, $PV = -11,981.99$, $FV = 0$, and solve for $PMT = EAA = 5,161.019 \approx \$5,161.02$.

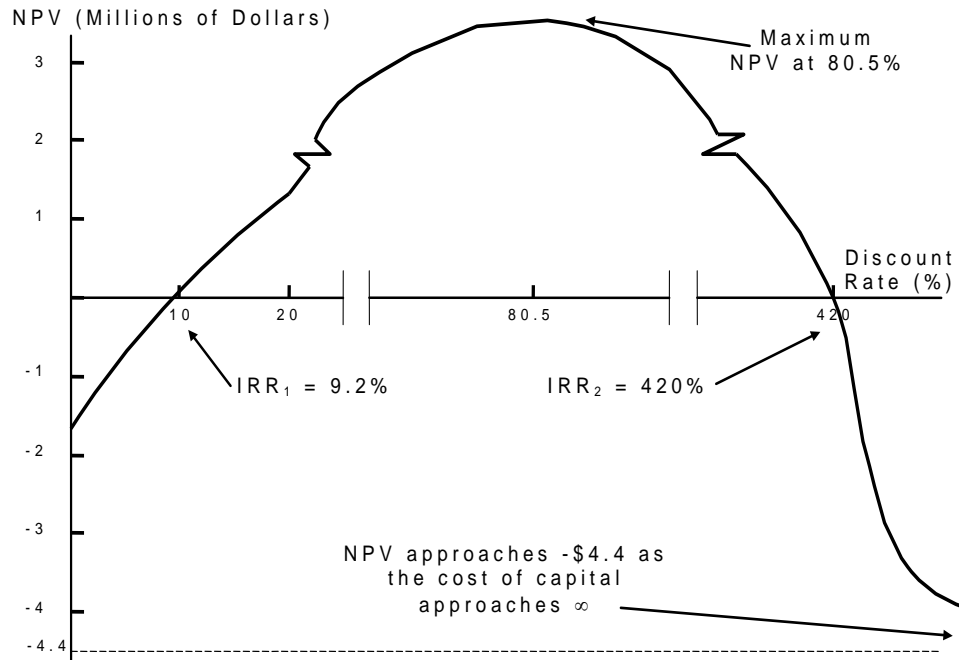
The EAA of machine 360-6 is found by converting its NPV to an equivalent annual annuity by inputting: $N = 6$, $I/YR = 14$, $PV = -22,256.02$, $FV = 0$, and solve for $PMT = EAA = 5,723.302 \approx \$5,723.30$.

Both new machines have positive NPVs, hence the old machine should be replaced. Choose Model 360-6.

10-19 a. The project's expected cash flows are as follows (in millions of dollars):

<u>Time</u>	<u>Net Cash Flow</u>
0	\$(4.4)
1	27.7
2	(25.0)

We can construct the following NPV profile:



<u>Discount Rate</u>	<u>NPV</u>
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)

The table above was constructed using a financial calculator with the following inputs: $CF_0 = -4400000$, $CF_1 = 27700000$, $CF_2 = -25000000$, and $I =$ discount rate to solve for the NPV.

- b. If $r = 8\%$, reject the project since $NPV < 0$. But if $r = 14\%$, 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.
- d. Here is the MIRR for the project when $r = 8\%$:

$$PV \text{ costs} = \$4,400,000 + \$25,000,000/(1.08)^2 = \$25,833,470.51.$$

$$TV \text{ inflows} = \$27,700,000(1.08)^1 = \$29,916,000.00.$$

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

$$\$25,833,470.51 = \$29,916,000(PVIF_{r,2}).$$

Inputs	2		-25833470.51	0	29916000
	N	I	PV	PMT	FV
Output		= 7.61			
		MIRR = 7.61%.			

At $r = 14\%$,

Inputs	2		-23636688.21	0	31578000
	N	I	PV	PMT	FV
Output		= 15.58			
		MIRR = 15.58%.			

$$PV \text{ costs} = \$4,400,000 + \$25,000,000/(1.14)^2 = \$23,636,688.21.$$

$$TV \text{ inflows} = \$27,700,000(1.14)^1 = \$31,578,000.$$

Now, MIRR is that discount rate which forces the PV of the TV of \$31,578,000 over 2 years to equal \$23,636,688.21:

$$\$23,636,688.21 = \$31,578,000(PVIF_{r,2}).$$

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

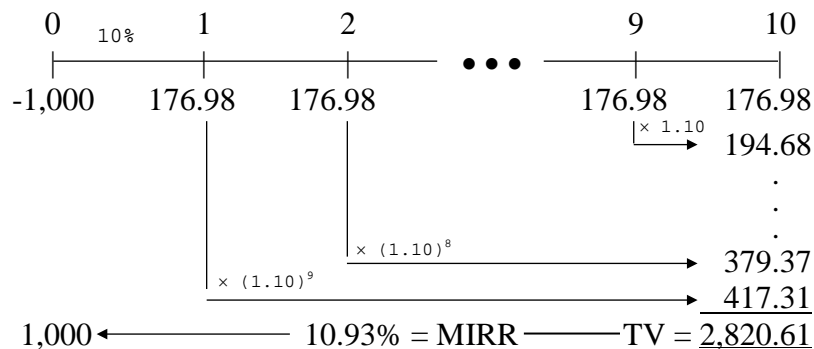
10-20 Step 1: Determine the PMT:



The IRR is the discount rate at which the NPV of a project equals zero. Since we know the project's initial investment, its IRR, the length of time that the cash flows occur, and that each cash flow is the same, then we can determine the project's cash flows by setting it up as a 10-year annuity. With a financial calculator, input $N = 10$, $I/YR = 12$, $PV = -1000$, and $FV = 0$ to obtain $PMT = \$176.98$.

Step 2: Since we've been given the WACC, once we have the project's cash flows we can now determine the project's MIRR.

Calculate the project's MIRR:



FV of inflows: With a financial calculator, input $N = 10$, $I/YR = 10$, $PV = 0$, and $PMT = -176.98$ to obtain $FV = \$2,820.61$. Then input $N = 10$, $PV = -1000$, $PMT = 0$, and $FV = 2820.61$ to obtain $I/YR = MIRR = 10.93\%$.

10-21 The PV of costs for the conveyor system is (\$496,401), while the PV of costs for the forklift system is (\$461,171). Thus, the forklift system is expected to be (\$496,401) - (\$461,171) = \$35,230 less costly than the conveyor system, and hence the forklift trucks should be used.

Financial calculator solution:

Input: $CF_0 = -250000$, $CF_1 = -65000$, $N_j = 5$, $I = 10$, $NPV_C = ?$
 $NPV_C = -496401$.

Input: $CF_0 = -120000$, $CF_1 = -90000$, $N_j = 5$, $I = 10$, $NPV_F = ?$ $NPV_F = -461171$.

10-22 a. Payback A (cash flows in thousands):

<u>Period</u>	<u>Annual Cash Flows</u>	<u>Cumulative</u>
0	\$(25,000)	\$(25,000)
1	5,000	(20,000)
2	10,000	(10,000)
3	15,000	5,000
4	20,000	25,000

$$\text{Payback}_A = 2 + \$10,000/\$15,000 = 2.67 \text{ years.}$$

Payback B (cash flows in thousands):

<u>Period</u>	<u>Annual Cash Flows</u>	<u>Cumulative</u>
0	\$(25,000)	\$(25,000)
1	20,000	(5,000)
2	10,000	5,000
3	8,000	13,000
4	6,000	19,000

$$\text{Payback}_B = 1 + \$5,000/\$10,000 = 1.50 \text{ years.}$$

b. Discounted payback A (cash flows in thousands):

<u>Period</u>	<u>Annual Cash Flows</u>	<u>Discounted @ 10% Cash Flows</u>	<u>Cumulative</u>
0	\$(25,000)	\$(25,000.00)	\$(25,000.00)
1	5,000	4,545.45	(20,454.55)
2	10,000	8,264.46	(12,190.09)
3	15,000	11,269.72	(920.37)
4	20,000	13,660.27	12,739.90

Discounted Payback_A = 3 + \$920.37/\$13,660.27 = 3.07 years.

Discounted payback B (cash flows in thousands):

<u>Period</u>	<u>Annual Cash Flows</u>	<u>Discounted @ 10% Cash Flows</u>	<u>Cumulative</u>
0	\$(25,000)	\$(25,000.00)	\$(25,000.00)
1	20,000	18,181.82	(6,818.18)
2	10,000	8,264.46	1,446.28
3	8,000	6,010.52	7,456.80
4	6,000	4,098.08	11,554.88

Discounted Payback_B = 1 + \$6,818.18/\$8,264.46 = 1.83 years.

- c. NPV_A = \$12,739,908; IRR_A = 27.27%.
 NPV_B = \$11,554,880; IRR_B = 36.15%.

Both projects have positive NPVs, so both projects should be undertaken.

- d. At a discount rate of 5%, NPV_A = \$18,243,813.
 At a discount rate of 5%, NPV_B = \$14,964,829.

At a discount rate of 5%, Project A has the higher NPV; consequently, it should be accepted.

- e. At a discount rate of 15%, NPV_A = \$8,207,071.
 At a discount rate of 15%, NPV_B = \$8,643,390.

At a discount rate of 15%, Project B has the higher NPV; consequently, it should be accepted.

f.

Year	Project $\Delta =$ <u>CE_A - CE_B</u>
0	\$ 0
1	(15)
2	0
3	7
4	14

$IRR_{\Delta} = \text{Crossover rate} = 13.5254\% \approx 13.53\%$.

g. Use 3 steps to calculate $MIRR_A$ @ $r = 10\%$:

Step 1: Calculate the NPV of the uneven cash flow stream, so its FV can then be calculated. With a financial calculator, enter the cash flow stream into the cash flow registers, then enter $I = 10$, and solve for $NPV = \$37,739,908$.

Step 2: Calculate the FV of the cash flow stream as follows:

Enter $N = 4$, $I = 10$, $PV = -37739908$, and $PMT = 0$ to solve for $FV = \$55,255,000$.

Step 3: Calculate $MIRR_A$ as follows:

Enter $N = 4$, $PV = -25000000$, $PMT = 0$, and $FV = 55255000$ to solve for $I = 21.93\%$.

Use 3 steps to calculate $MIRR_B$ @ $r = 10\%$:

Step 1: Calculate the NPV of the uneven cash flow stream, so its FV can then be calculated. With a financial calculator, enter the cash flow stream into the cash flow registers, then enter $I = 10$, and solve for $NPV = \$36,554,880$.

Step 2: Calculate the FV of the cash flow stream as follows:

Enter $N = 4$, $I = 10$, $PV = -36554880$, and $PMT = 0$ to solve for $FV = \$53,520,000$.

Step 3: Calculate $MIRR_B$ as follows:

Enter $N = 4$, $PV = -25000000$, $PMT = 0$, and $FV = 53520000$ to solve for $I = 20.96\%$.

According to the MIRR approach, if the 2 projects were mutually exclusive, Project A would be chosen because it has the higher MIRR. This is consistent with the NPV approach.

10-23 a. NPV of termination after Year t:

$$NPV_0 = -\$22,500 + \$22,500 = 0.$$

Using a financial calculator input the following: $CF_0 = -22500$, $CF_1 = 23750$, and $I = 10$ to solve for $NPV_1 = -\$909.09 \approx -\909 .

Using a financial calculator input the following: $CF_0 = -22500$, $CF_1 = 6250$, $CF_2 = 20250$, and $I = 10$ to solve for $NPV_2 = -\$82.64 \approx -\83 .

Using a financial calculator input the following: $CF_0 = -22500$, $CF_1 = 6250$, $N_j = 2$, $CF_3 = 17250$, and $I = 10$ to solve for $NPV_3 = \$1,307.29 \approx \$1,307$.

Using a financial calculator input the following: $CF_0 = -22500$, $CF_1 = 6250$, $N_j = 3$, $CF_4 = 11250$, and $I = 10$ to solve for $NPV_4 = \$726.73 \approx \727 .

Using a financial calculator input the following: $CF_0 = -22500$, $CF_1 = 6250$, $N_j = 5$, and $I = 10$ to solve for $NPV_5 = \$1,192.42 \approx \$1,192$.

The firm should operate the truck for 3 years, $NPV_3 = \$1,307$.

b. No. Proceeds from selling the asset could only raise NPV and IRR. The value of the firm is maximized by terminating the project after Year 3.

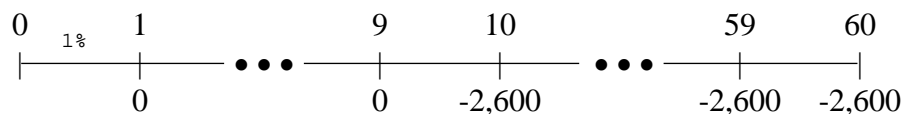
10-24 Facts: 5 years remaining on lease; rent = \$2,000/month; 60 payments left, payment at end of month.

New lease terms: \$0/month for 9 months; \$2,600/month for 51 months.

WACC = 12% annual (1% per month).



PV cost of old lease: $N = 60$; $I/YR = 1$; $PMT = -2000$; $FV = 0$; $PV = ?$ $PV = -\$89,910.08$.

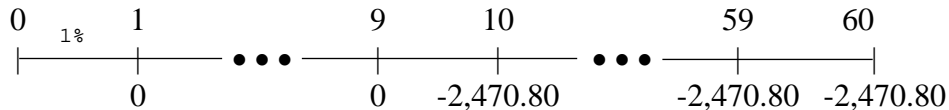


PV cost of new lease: $CF_0 = 0$, $CF_{1-9} = 0$; $CF_{10-60} = -2600$; $I/YR = 1$
 $NPV = -\$94,611.45$.

Sharon should not accept the new lease because the present value of its cost is $\$94,611.45 - \$89,910.08 = \$4,701.37$ greater than the old lease.

- b. At $t = 9$ the FV of the original lease's cost = $-\$89,910.08(1.01)^9 = -\$98,333.33$. Since lease payments for months 0-9 would be zero, we can calculate the lease payments during the remaining 51 months as follows: $N = 51$; $I/YR = 1$; $PV = 98333.33$; and $FV = 0$. Solve for $PMT = -\$2,470.80$.

Check:



PV cost of new lease: $CF_0 = 0$; $CF_{1-9} = 0$; $CF_{10-60} = -2470.80$; $I/YR = 1$.
 NPV = $-\$89,909.99$.

Except for rounding; the PV cost of this lease equals the PV cost of the old lease.

c. Period	Old Lease	New Lease	Δ Lease
0	0	0	0
1-9	-2,000	0	-2,000
10-60	-2,000	-2,600	600

$CF_0 = 0$; $CF_{1-9} = -2000$; $CF_{10-60} = 600$; $IRR = ?$ $IRR = 1.9113\%$. This is the periodic rate. To obtain the nominal cost of capital, multiply by 12: $12(0.019113) = 22.94\%$.

Check: Old lease terms:

$N = 60$; $I/YR = 1.9113$; $PMT = -2000$; $FV = 0$; $PV = ?$ $PV = -\$71,039.17$.

New lease terms:

$CF_0 = 0$; $CF_{1-9} = 0$; $CF_{10-60} = -2600$; $I/YR = 1.9113$; $NPV = ?$ $NPV = -\$71,038.98$.

Except for rounding differences; the costs are the same.

SOLUTION TO SPREADSHEET PROBLEM

10-25 The detailed solution for the spreadsheet problem is in the file *Ch 10 Build a Model Solution.xlsx* and is available on the textbook's website.

MINI CASE

You have just graduated with a business degree from a large university, and one of your favourite courses was “Today’s Entrepreneurs.” In fact, you enjoyed it so much you have decided you want to “be your own boss.” While you were studying, your grandfather died and left you \$1 million to do with as you please. You are not an inventor, and you do not have a trade skill that you can market; however, you have decided that you would like to purchase at least one established franchise in the fast foods area, maybe two (if profitable). The problem is that you have never been one to stay with any project for too long, so you figure that your time frame is 3 years. After 3 years you will go on to something else.

You have narrowed your selection down to two choices: (1) Franchise L Lisa’s Soups, Salads, & Stuff and (2) Franchise S, Sam’s Fabulous Fried Chicken. The net cash flows shown below include the price you would receive for selling the franchise in Year 3 and the forecast of how each franchise will do over the 3-year period. Franchise L’s cash flows will start off slowly but will increase rather quickly as people become more health conscious, while Franchise S’s cash flows will start off high but will trail off as other chicken competitors enter the marketplace and as people become more health conscious and avoid fried foods. Franchise L serves breakfast and lunch, while Franchise S serves only dinner, so it is possible for you to invest in both franchises. You see these franchises as perfect complements to each another: You could attract both the lunch and dinner crowds and the health-conscious and not so health-conscious crowds without the franchises directly competing against each another.

Here are the net cash flows (in thousands of dollars):

<u>Year</u>	<u>Expected Net Cash Flow</u>	
	<u>Franchise L</u>	<u>Franchise S</u>
0	\$(100)	\$(100)
1	10	70
2	60	50
3	80	20

Depreciation, salvage values, net working capital requirements, and tax effects are all included in these cash flows.

You also have made subjective risk assessments of each franchise, and concluded that both franchises have risk characteristics that require a return of 10%. You must now determine whether one or both of the projects should be accepted.

a. What is capital budgeting?

Answer: Capital budgeting is the process of analyzing additions to fixed assets. Capital budgeting is important because, more than anything else, fixed asset investment decisions chart a company's course for the future. Conceptually, the capital budgeting process is identical to the decision process used by individuals making investment decisions. These steps are involved:

1. Estimate the cash flows—interest and maturity value or dividends in the case of bonds and stocks, operating cash flows in the case of capital projects.
2. Assess the riskiness of the cash flows.
3. Determine the appropriate discount rate, based on the riskiness of the cash flows and the general level of interest rates. This is called the project cost of capital in capital budgeting.
4. Evaluate the cash flows.

b. What is the difference between independent and mutually exclusive projects?

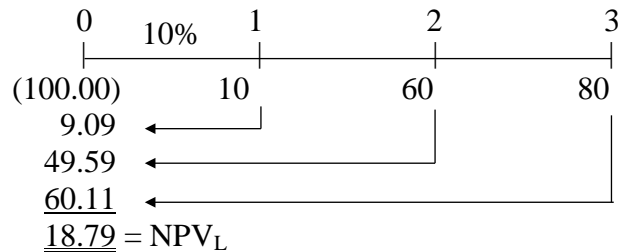
Answer: Projects are independent if the cash flows of one are not affected by the acceptance of the other. Conversely, two projects are mutually exclusive if acceptance of one impacts adversely the cash flows of the other; that is, at most one of two or more such projects may be accepted. Put another way, when projects are mutually exclusive it means that they do the same job. For example, a forklift truck versus a conveyor system to move materials, or a bridge versus a ferry boat.

c. 1. Define the term *net present value (NPV)*. What is each franchise's NPV?

Answer: The net present value (NPV) is simply the sum of the present values of a project's cash flows:

$$NPV = \sum_{t=0}^n \frac{CF_t}{(1+r)^t}$$

Franchise L's NPV is \$18.79:



NPVs are easy to determine using a calculator with an NPV function. Enter the cash flows sequentially, with outflows entered as negatives; enter the cost of capital; and then press the NPV button to obtain the project's NPV, \$18.78 (note the penny rounding difference). The NPV of franchise S is NPV_S = \$19.98.

c. 2. What is the rationale behind the NPV method? According to NPV, which franchise or franchises should be accepted if they are independent? Mutually exclusive?

Answer: The rationale behind the NPV method is straightforward: if a project has NPV = \$0, then the project generates exactly enough cash flows (1) to recover the cost of the investment and (2) to enable investors to earn their required rates of return (the opportunity cost of capital). If NPV = \$0, then in a financial (but not an accounting) sense, the project breaks even. If the NPV is positive, then more than enough cash flow is generated, and conversely if NPV is negative.

Consider franchise L's cash inflows, which total \$150. They are sufficient (1) to return the \$100 initial investment, (2) to provide investors with their 10 percent aggregate opportunity cost of capital, and (3) to still have \$18.79 left over on a present value basis. This \$18.79 excess PV belongs to the shareholders—the debtholders' claims are fixed, so the shareholders' wealth will be increased by \$18.79 if franchise L is accepted. Similarly, shareholders gain \$19.98 in value if franchise S is accepted.

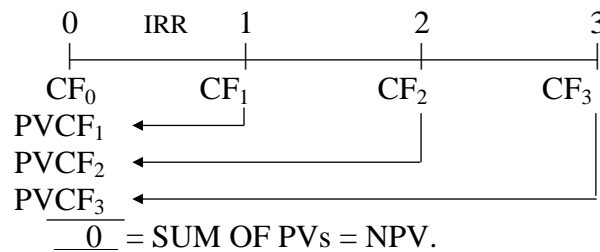
If franchises L and S are independent, then both should be accepted, because they both add to shareholders' wealth, hence to the stock price. If the franchises are mutually exclusive, then franchise S should be chosen over L, because S adds more to the value of the firm.

c. 3. How would the NPVs change if the cost of capital changed?

Answer: The NPV of a project is dependent on the cost of capital used. Thus, if the cost of capital changed, the NPV of each project would change. NPV declines as r increases, and NPV rises as r falls.

d. 1. Define the term *internal rate of return (IRR)*. What is each franchise's IRR?

Answer: The internal rate of return (IRR) is that discount rate which forces the NPV of a project to equal zero:

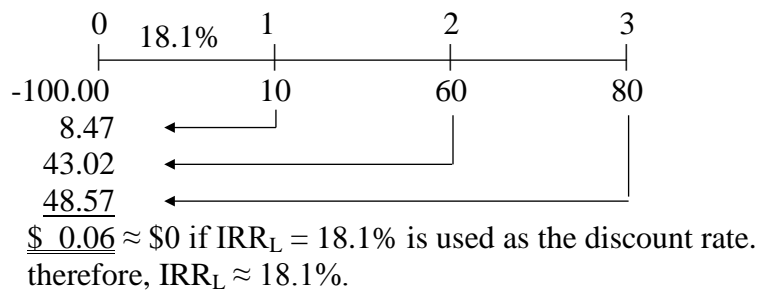


Expressed as an equation, we have:

$$\text{IRR: } \sum_{t=0}^n \frac{CF_t}{(1 + \text{IRR})^t} = \$0 = \text{NPV.}$$

Note that the IRR equation is the same as the NPV equation, except that to find the IRR the equation is solved for the particular discount rate, IRR, that forces the project's NPV to equal zero (the IRR) rather than using the cost of capital (r) in the denominator and finding NPV. Thus, the two approaches differ in only one respect: in the NPV method, a discount rate is specified (the project's cost of capital) and the equation is solved for NPV, while in the IRR method, the NPV is specified to equal zero and the discount rate (IRR) which forces this equality is found.

Franchise L's IRR is 18.1 percent:



A financial calculator is extremely helpful when calculating IRRs. The cash flows are entered sequentially, and then the IRR button is pressed. For franchise S, $IRR_S \approx 23.6\%$. Note that with many calculators, you can enter the cash flows into the cash flow register, also enter $r = i$, and then calculate both NPV and IRR by pressing the appropriate buttons.

d. 2. How is the IRR on a project related to the YTM on a bond?

Answer: The IRR is to a capital project what the YTM is to a bond. It is the expected rate of return on the project, just as the YTM is the promised rate of return on a bond.

d. 3. What is the logic behind the IRR method? According to IRR, which franchises should be accepted if they are independent? Mutually exclusive?

Answer: IRR measures a project's profitability in the rate of return sense: if a project's IRR equals its cost of capital, then its cash flows are just sufficient to provide investors with their required rates of return. An IRR greater than r implies an economic profit, which accrues to the firm's shareholders, while an IRR less than r indicates an economic loss, or a project that will not earn enough to cover its cost of capital.

Projects' IRRs are compared to their costs of capital, or hurdle rates. Since franchises L and S both have a hurdle rate of 10 percent, and since both have IRRs greater than that hurdle rate, both should be accepted if they are independent. However, if they are mutually exclusive, franchise S would be selected, because it has the higher IRR.

d. 4. How would the franchises' IRRs change if the cost of capital changed?

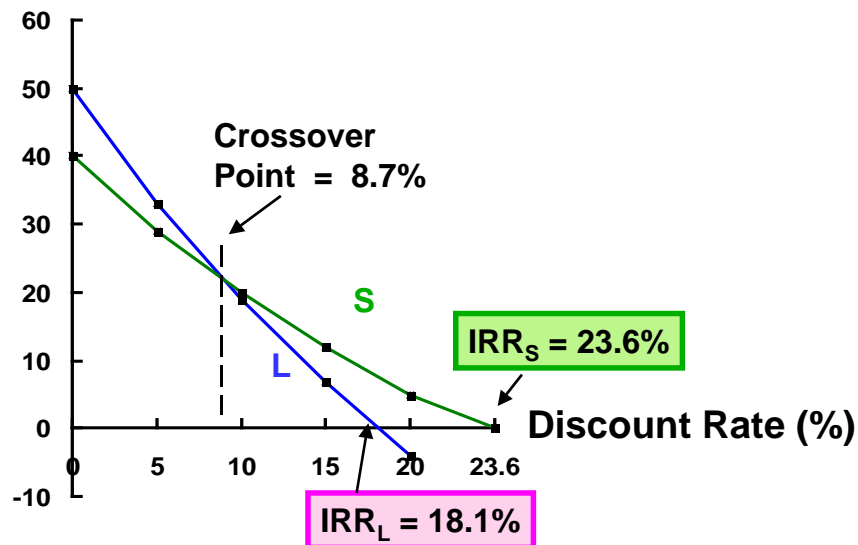
Answer: IRRs are independent of the cost of capital. Therefore, neither IRR_S nor IRR_L would change if r changed. However, the acceptability of the franchises could change—L would be rejected if r were above 18.1%, and S would also be rejected if r were above 23.6%.

e. 1. Draw NPV profiles for Franchises L and S. At what discount rate do the profiles cross?

Answer: The NPV profiles are plotted in the figure below.

Note the following points:

1. The y-intercept is the project's NPV when $r = 0\%$. This is \$50 for L and \$40 for S.
2. The x-intercept is the project's IRR. This is 18.1 percent for L and 23.6 percent for S.
3. NPV profiles are curves rather than straight lines. To see this, note that these profiles approach cost = -\$100 as r approaches infinity.
4. From the figure below, it appears that the crossover point is between 8 and 9 percent. The precise value is approximately 8.7 percent. One can calculate the crossover rate by (1) going back to the data on the problem, finding the cash flow differences for each year, (2) entering those differences into the cash flow register, and (3) pressing the IRR button to get the crossover rate, $8.68\% \approx 8.7\%$.



r	NPV_L	NPV_S
0%	\$50	\$40
5	33	29
10	19	20
15	7	12
20	(4)	5

- e. 2. Look at your NPV profile graph without referring to the actual NPVs and IRRs. Which franchise or franchises should be accepted if they are independent? Mutually exclusive? Explain. Are your answers correct at any cost of capital less than 23.6%?

Answer: The NPV profiles show that the IRR and NPV criteria lead to the same accept/reject decision for any independent project. Consider franchise L. It intersects the x-axis at its IRR, 18.1 percent. According to the IRR rule, L is acceptable if r is less than 18.1 percent. Also, at any r less than 18.1 percent, L's NPV profile will be above the x axis, so its NPV will be greater than \$0. Thus, for any independent project, NPV and IRR lead to the same accept/reject decision.

Now assume that L and S are mutually exclusive. In this case, a conflict might arise. First, note that $IRR_S = 23.6\% > 18.1\%$ = therefore, regardless of the size of r , project S would be ranked higher by the IRR criterion. However, the NPV profiles show that $NPV_L > NPV_S$ if r is less than 8.7 percent. Therefore, for any r below the 8.7% crossover rate, say $r = 7$ percent, the NPV rule says choose L, but the IRR rule says choose S. Thus, if r is less than the crossover rate, a ranking conflict occurs.

- f. 1. What is the underlying cause of ranking conflicts between NPV and IRR?

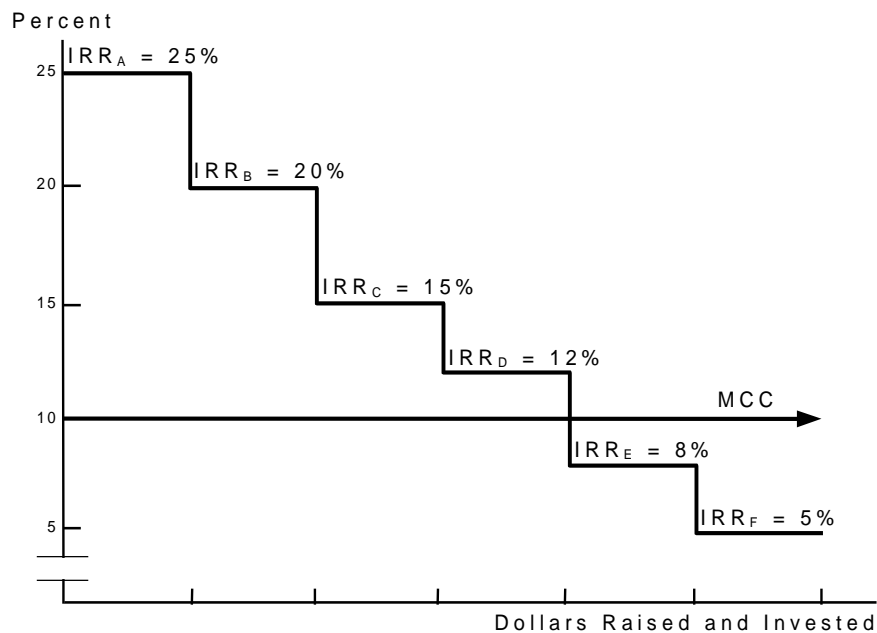
Answer: For normal projects' NPV profiles to cross, one project must have both a higher vertical axis intercept and a steeper slope than the other. A project's vertical axis intercept typically depends on (1) the size of the project and (2) the size and timing pattern of the cash flows—large projects, and ones with large distant cash flows, would generally be expected to have relatively high vertical axis intercepts. The slope of the NPV profile depends entirely on the timing pattern of the cash flows—long-term projects have steeper NPV profiles than short-term ones. Thus, we conclude that NPV profiles can cross in two situations: (1) when mutually exclusive projects differ in scale (or size) and (2) when the projects' cash flows differ in terms of the timing pattern of their cash flows (as for franchises L and S).

- f. 2. What is the “reinvestment rate assumption”, and how does it affect the NPV versus IRR conflict?

Answer: The reinvestment rate assumption is behind the ranking conflicts between projects of different size and/or different timing patterns of cash flows. All DCF methods implicitly assume that cash flows can be reinvested at some rate, regardless of what is actually done with the cash flows. Discounting is the reverse of compounding. Since compounding assumes reinvestment, so does discounting. NPV and IRR are both found by discounting, so they both implicitly assume some discount rate. Inherent in the NPV calculation is the assumption that cash flows can be reinvested at the project's cost of capital, while the IRR calculation assumes reinvestment at the IRR rate.

f. 3. Which method is the best? Why?

Answer: Whether NPV or IRR gives better rankings depends on which has the better reinvestment rate assumption. Normally, the NPV's assumption is better. The reason is as follows: a project's cash inflows are generally used as substitutes for outside capital, that is, projects' cash flows replace outside capital and, hence, save the firm the cost of outside capital. Therefore, in an opportunity cost sense, a project's cash flows are reinvested at the cost of capital. To see this graphically, think of the following situation: assume the firm's cost of capital is a constant 10% within the relevant range of financing considered, and it has projects available as shown in the graph below:



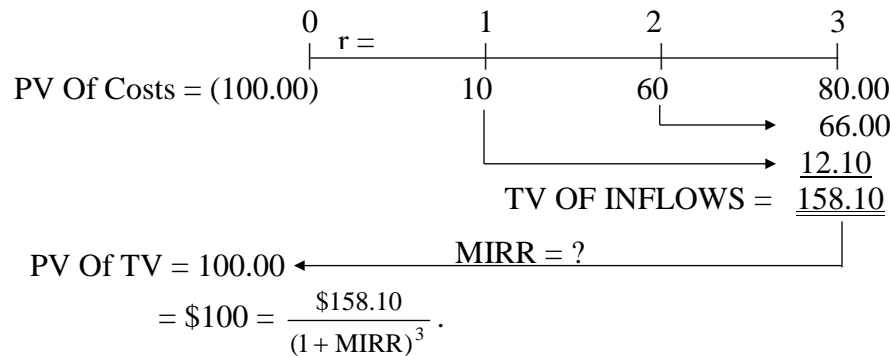
What projects will be accepted, by either NPV or IRR? Projects A, B, C, and D.

If the same situation exists year after year, at what rate of return will cash flows from earlier years' investments be reinvested? Capital budgeting decisions are made in this sequence: (1) the company would say, "we can take on A, B, C, and D and finance them with 10% money, so let's do it." (2) then, it would get cash flows from earlier years' projects. What would it do with those cash flows? It would use them in lieu of raising money that costs 10%, so it would save 10%. Therefore, 10% is the opportunity cost of the cash flows. In effect, cash flows are reinvested at the 10% cost of capital.

Note, however, that NPV and IRR always give the same accept/reject decisions for independent projects, so IRR can be used just as well as NPV when independent projects are being evaluated. The NPV versus IRR conflict arises only if mutually exclusive projects are involved.

g. 1. Define the term *modified IRR (MIRR)*. Find the MIRRs for Franchises L and S.

Answer: MIRR is that discount rate which equates the present value of the terminal value of the inflows, compounded at the cost of capital, to the present value of the costs. Here is the setup for calculating franchise L's modified IRR:



$$\text{PV costs} = \frac{\text{TV}}{(1 + \text{MIRR})^n} = \sum_{t=0}^n \frac{\text{COF}_t}{(1+r)^t} = \frac{\sum_{t=1}^n \text{CIF}_t (1+r)^{n-t}}{(1 + \text{MIRR})^n}.$$

After you calculate the TV, enter N = 3, PV = -100, PMT = 0, FV = 158.1, and then press i to get the answer, $\text{MIRR}_L = 16.5\%$. We could calculate MIRR_S similarly: = 16.9%. Thus, franchise S is ranked higher than L. This result is consistent with the NPV decision.

g. 2. What are the MIRR's advantages and disadvantages vis-a-vis the regular IRR? What are the MIRR's advantages and disadvantages vis-a-vis the NPV?

Answer: MIRR is a better rate of return measure than IRR for two reasons: (1) it correctly assumes reinvestment at the project's cost of capital rather than at its IRR. (2) MIRR avoids the problem of multiple IRRs—there can be only one MIRR for a given project.

MIRR does not always lead to the same decision as NPV when mutually exclusive projects are being considered. In particular, small projects often have a higher MIRR, but a lower NPV, than larger projects. Thus, MIRR is not a perfect substitute for NPV, and NPV remains the single best decision rule. However, MIRR is superior to the regular IRR, and if a rate of return measure is needed, MIRR should be used.

- h.** As a separate project (Project P), you are considering sponsoring a pavilion at the upcoming World's Fair. The pavilion would cost \$800,000, and it is expected to result in \$5 million of incremental cash inflows during its 1 year of operation. However, it would then take another year, and \$5 million of costs, to demolish the site and return it to its original condition. Thus, Project P's expected net cash flows look like this (in millions of dollars):

Year	Net Cash Flows
0	\$(0.8)
1	5.0
2	(5.0)

The project is estimated to be of average risk, so its cost of capital is 10%.

- h.** 1. What are normal and non-normal cash flows?

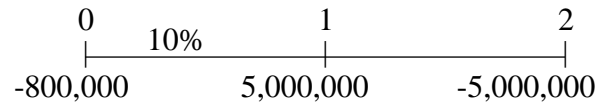
Answer: Normal cash flows begin with a negative cash flow (or a series of negative cash flows), switch to positive cash flows, and then remain positive. They have only one change in sign. (Note: normal cash flows can also start with positive cash flows, switch to negative cash flows, and then remain negative.) Non-normal cash flows have more than one sign change. For example, they may start with negative cash flows, switch to positive, and then switch back to negative.

Projects with normal cash flows have outflows, or costs, in the first year (or years) followed by a series of inflows. Projects with non-normal cash flows have one or more outflows after the inflow stream has begun. Here are some examples:

	<u>Inflow (+) Or Outflow (-) In Year</u>					
	<u>0</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>
Normal	-	+	+	+	+	+
	-	-	+	+	+	+
	-	-	-	+	+	+
Non-normal	-	+	+	+	+	-
	-	+	+	-	+	-
	-	+	+	-	-	-

h. 2. What is Project P's NPV? What is its IRR? Its MIRR?

Answer: Here is the time line for the cash flows, and the NPV:



$$\text{NPV}_P = -\$386,776.86.$$

We can find the NPV by entering the cash flows into the cash flow register, entering $i = 10$, and then pressing the NPV button. However, calculating the IRR presents a problem. With the cash flows in the register, press the IRR button. An HP-10B financial calculator will give the message “error-soln.” This means that project P has multiple IRRs. An HP-17B will ask for a guess. If you guess 10%, the calculator will produce $\text{IRR} = 25\%$. If you guess a high number, such as 200%, it will produce the second IRR, 400% ¹. The MIRR of project P = 5.6%, and is found by computing the discount rate that equates the terminal value (\$5.5 million) to the present value of cost (\$4.93 million).

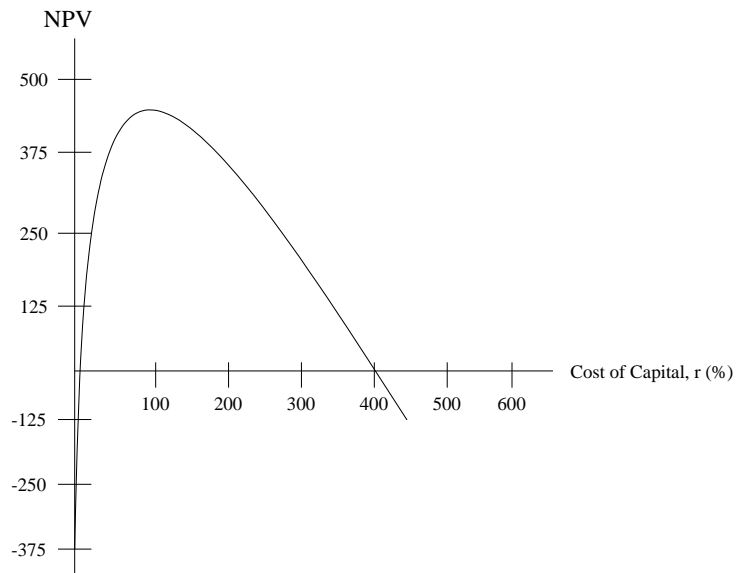
h. 3. Draw Project P's NPV profile. Does Project P have normal or non-normal cash flows? Should this project be accepted?

Answer: You could put the cash flows in your calculator and then enter a series of i values, get an NPV for each, and then plot the points to construct the NPV profile. We used a spreadsheet program to automate the process and then to draw the profile. Note that the profile crosses the x-axis twice, at 25% and at 400%, signifying two IRRs. Which IRR is correct? In one sense, they both are—both cause the project's NPV to equal zero. However, in another sense, both are wrong—neither has any economic or financial significance.

Project P has non-normal cash flows; that is, it has more than one change of signs in the cash flows. Without this non-normal cash flow pattern, we would not have the multiple IRRs.

Since project P's NPV is negative, the project should be rejected, even though both IRRs (25% and 400%) are greater than the project's 10 percent cost of capital. The MIRR of 5.6% also supports the decision that the project should be rejected.

¹ Looking at the figure below, if you guess an IRR to the left of the peak NPV rate, the lower IRR will appear. If you guess $\text{IRR} > \text{peak NPV rate}$, the higher IRR will appear.



i. What does the profitability index (PI) measure? What are the PIs of Franchises S and L?

Answer: The PI is equal to the present value of all future cash flows divided by the initial cost. It measures the “bang for the buck.”

$$PI_S = \$119.98 / \$100 = 1.1998.$$

$$PI_L = \$118.78 / \$100 = 1.1878.$$

j. 1. What is the payback period? Find the regular and discounted paybacks for Franchises L and S.

Answer: The payback period is the expected number of years required to recover a project's cost. We calculate the payback by developing the cumulative cash flows as shown below for project 1 (in thousands of dollars):

<u>Year</u>	<u>Expected NCF</u>	
	<u>Annual</u>	<u>Cumulative</u>
0	\$(100)	\$(100)
1	10	(90)
2	60	(30)
3	80	50

← Payback is between t = 2 and t = 3

0	1	2	3
-100	10	60	80
	-90	-30	+50

Franchise L's \$100 investment has not been recovered at the end of year 2, but it has been more than recovered by the end of year 3. Thus, the recovery period is between 2 and 3 years. If we assume that the cash flows occur evenly over the year, then the investment is recovered $\$30/\$80 = 0.375 \approx 0.4$ into year 3. Therefore, $\text{payback}_L = 2.4$ years. Similarly, $\text{payback}_S = 1.6$ years.

The discounted payback for L (as shown in (j 3)) is 2.7 years. Similarly, discounted $\text{payback}_S = 1.9$ years.

j. 2. What is the rationale for the payback method? According to the payback criterion, which franchise or franchises should be accepted if the firm's maximum acceptable payback is 2 years, and if Franchises L and S are independent? If they are mutually exclusive?

Answer: Payback represents a type of "breakeven" analysis: the payback period tells us when the project will break even in a cash flow sense. With a required payback of 2 years, franchise S is acceptable, but franchise L is not. Whether the two projects are independent or mutually exclusive makes no difference in this case.

j. 3. What is the difference between the regular and discounted payback periods?

Answer: Discounted payback is similar to payback except that discounted rather than raw cash flows are used.

Setup for franchise L's discounted payback, assuming a 10% cost of capital:

<u>Year</u>	<u>Expected Net Cash Flows</u>		<u>Cumulative</u>
	<u>Raw</u>	<u>Discounted</u>	
0	\$(100)	\$(100.00)	\$(100.00)
1	10	9.09	(90.91)
2	60	49.59	(41.32)
3	80	60.11	18.79

Discounted Payback_L = 2 + (\$41.32/\$60.11) = 2.69 = 2.7 years. Similarly, discounted payback_S = 1.9 years.

Versus 2.4 years for the regular payback.

j. 4. What is the main disadvantage of discounted payback? Is the payback method of any real usefulness in capital budgeting decisions?

Answer: Regular payback has two critical deficiencies: (1) it ignores the time value of money, and (2) it ignores the cash flows that occur after the payback period. Discounted payback does consider the time value of money, but it still fails to consider cash flows after the payback period; hence it has a basic flaw. In spite of its deficiency, many firms today still calculate the discounted payback and give some weight to it when making capital budgeting decisions. However, payback is not generally used as the primary decision tool. Rather, it is used as a rough measure of a project's liquidity and riskiness.

k. In an unrelated analysis, you have the opportunity to choose between the following two mutually exclusive projects:

Year	<u>Expected Net Cash Flows</u>	
	<u>Project S</u>	<u>Project L</u>
0	\$(100,000)	\$(100,000)
1	60,000	33,500
2	60,000	33,500
3	--	33,500
4	--	33,500

The projects provide a necessary service, so whichever one is selected is expected to be repeated into the foreseeable future. Both projects have a 10 percent cost of capital.

k. 1. What is each project's initial NPV?

Answer: The NPVs, found with a financial calculator, are calculated as follows:

Input the following: $CF_0 = -100000$, $CF_1 = 60000$, $N_j = 2$, and $I = 10$ to solve for $NPV_S = \$4,132.23 \approx \$4,132$.

Input the following: $CF_0 = -100000$, $CF_1 = 33500$, $N_j = 4$, and $I = 10$ to solve for $NPV_L = \$6,190.49 \approx \$6,190$.

However, if we make our decision based on the raw NPVs, we would be biasing the decision against the shorter project. Since the projects are expected to be replicated, if we initially choose project S, it would be repeated after 2 years. However, the raw NPVs do not reflect the replication cash flows.

k. 2. What is each project's equivalent annual annuity?

Answer: We begin with the NPVs found in the previous step. We then find the annuity payment stream that has the same present value as follows:

For Project S, input the following: $N = 2$, $I/YR = 10$, $PV = -4,132.23$, $FV = 0$, and solve for $PMT = EAA = \$2,380.95$.

For Project L, input the following: $N = 4$, $I/YR = 10$, $PV = -6,190.49$, $FV = 0$, and solve for $PMT = EAA = \$1,952.92$.

Project S is preferred because it has a higher EAA.

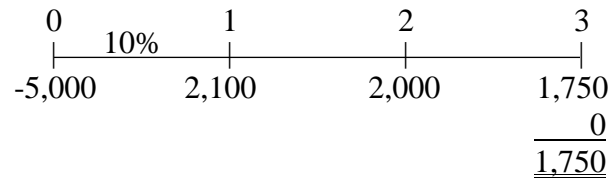
1. You are also considering another project that has a physical life of 3 years; that is, the machinery will be totally worn out after 3 years. However, if the project were terminated prior to the end of 3 years, the machinery would have a positive salvage value. Here are the project's estimated cash flows:

<u>Year</u>	<u>Initial Investment And Operating Cash Flows</u>	<u>End-Of-Year Net Salvage Value</u>
0	(\$5,000)	\$5,000
1	2,100	3,100
2	2,000	2,000
3	1,750	0

Using the 10% cost of capital, what is the project's NPV if it is operated for the full 3 years? Would the NPV change if the company planned to terminate the project at the end of Year 2? At the end of Year 1? What is the project's optimal (economic) life?

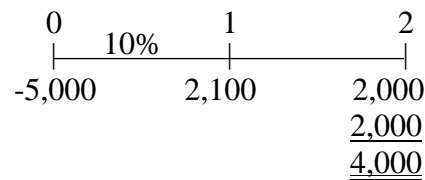
Answer: Here are the time lines for the 3 alternative lives:

No termination:



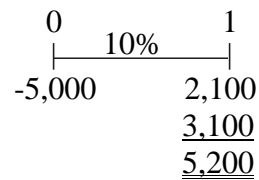
NPV = -\$123.

Terminate after 2 years:



NPV = \$215.

Terminate after 1 year:



NPV = -\$273.

We see (1) that the project is acceptable only if operated for 2 years, and (2) that a project's engineering life does not always equal its economic life.

m. After examining all the potential projects, you discover that there are many more projects this year with positive NPVs than in a normal year. What two problems might this extra-large capital budget cause?

You only have a limited amount of capital to commit to projects. If you have to raise external capital to fund some of these other positive NPV projects, then you may be faced with an increasing cost of capital. This is called an increasing marginal cost of capital schedule, and it also happens to companies when they exhaust their internal sources of funds and have to go to external capital markets for their funding. This increased cost of capital may cause you to reject projects that you might otherwise accept because with your increased cost of capital, some projects may show a negative NPV when they would otherwise have a positive NPV in a normal year.

Another effect of this large capital budget is that you may choose to ration capital—i.e., not fund all of the projects. This is called capital rationing, and companies and investors do this when for whatever reason they put a cap on the funds they are willing to invest in new projects.