

## CAPITAL BUDGETING TECHNIQUES (CHAPTER 9)

Capital budgeting refers to the process used to make decisions concerning investments in the long-term assets of the firm. The general idea is that a firm's capital, which is comprised of its long-term funds, is primarily invested in long-term assets that will enable the firm to generate revenues several years in the future. Often the amount of capital available to a firm is limited; thus the firm must budget how such funds are invested.

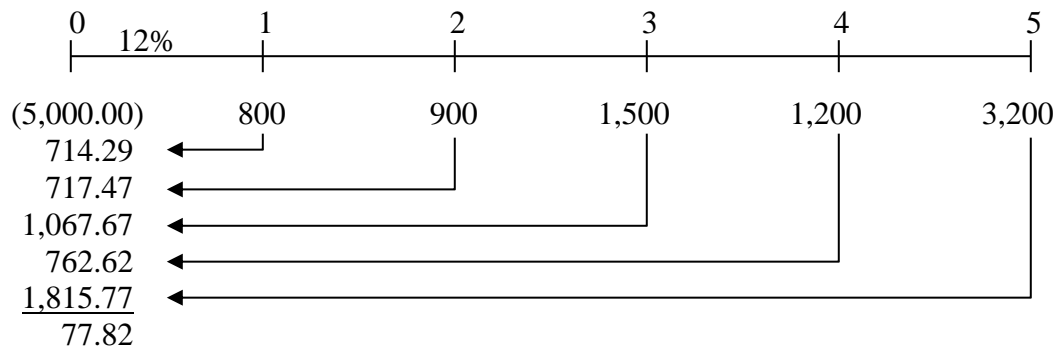
- Importance of Capital Budgeting—because capital budgeting decisions impact the firm for several years, they must be carefully planned. A bad decision can have a significant effect on the firm's future operations. In addition, the timing of the decisions is important. Many capital budgeting projects take years to implement. If firms do not plan accordingly, they might find that the timing of the capital budgeting decision is too late, which could prove costly with respect to lost revenues, especially in highly competitive industries. Decisions that are made too early can also be problematic because capital budgeting projects generally require large investments, thus early decisions might generate unnecessary costs for the firm.
- Generating Ideas for Capital Budgeting—ideas for capital budgeting projects usually are generated by employees, customers, suppliers, and so forth, and are based on the needs and experiences of the firm and of these groups. For example, a sales representative might hear from his or her customers that there is a need for products with particular characteristics that the firm's existing products do not possess. The sales representative presents the idea to management, who in turn evaluates the viability of the idea by consulting with engineers, production personnel, and perhaps by conducting a feasibility study. After the idea is confirmed to be viable in the sense it is saleable to customers, the financial manager must conduct a capital budgeting analysis to ensure the project will be beneficial to the firm with respect to its value.
- Project Classifications—capital budgeting projects usually are classified using the following terms:
  - Replacement decision—a decision concerning whether an existing asset should be replaced by a newer version of the same machine or even a different type of machine that performs the same function as the existing machine. Such replacements are generally made to maintain existing levels of operations, although profitability might change due to changes in expenses (that is, the new machine might be either more expensive or cheaper to operate than the existing machine).
  - Expansion decision—a decision concerning whether the firm should increase operations by adding new products, additional machines, and so forth. Such decisions should increase revenues through expanded operations.
  - Independent project—the acceptance of an independent project does not affect the acceptance of any other project—that is, the decision to purchase an independent project does not affect the decisions to purchase other assets. For example, suppose you have a large sum of money in the bank that you would like to spend on yourself, say, \$150,000. You decide you are going to buy a car that costs about \$30,000 and a new stereo system for your house that costs less than

\$5,000. The decision to buy the car does not affect the decision to buy the stereo—they are independent decisions.

- Mutually exclusive projects—in this case, the decision to invest in one project affects other projects because only one project can be purchased. For example, if in the above example you decided you were going to buy only one automobile, but you were looking at two different types of cars, one is a Chevrolet and the other is a Ford. Once you make the decision to buy the Chevrolet, you have also decided you are not going to buy the Ford.
- Similarities between Capital Budgeting and Asset Valuation—to make a capital budgeting decision, we need to compare the cost of the project to the value the project will provide the firm. To determine the value of an asset, we must compute the present value of the cash flows the asset is expected to generate over its life. The process to compute the value of a capital asset is the same as was discussed in the sections of the notes that covered the valuation of financial assets (i.e., bonds and stocks). Once the value of the asset is determined, the firm can decide whether to invest in the asset by comparing its computed value to how much the asset costs to purchase. Following this decision-making procedure helps ensure the firm will maximize its value—that is, if an asset has a value to the firm that is greater than its cost, the firm’s value will be increased if the firm purchases the asset.
- Capital Budgeting Evaluation Techniques—in this section, the basic techniques that are used to make capital budgeting decisions are described. To illustrate the techniques, let’s assume a firm is considering investing in a project that has the following cash flows:

Year (t)	Expected After-Tax Net Cash Flows, $\hat{CF}_t$
0	\$(5,000)
1	800
2	900
3	1,500
4	1,200
5	3,200

$\hat{CF}_0 = \$(5,000)$  represents the net cost, or initial investment, that is required to purchase the asset—the parentheses indicate that the cash flow is negative. If the firm’s required rate of return is 12 percent, the cash flow timeline for the asset is:



- Net present value (NPV)—to determine the NPV of a project, you need to compute the present value of all the future cash flows associated with the project, sum them up, and then subtract (or add a negative amount for) the initial investment of the project. The resulting value represents the amount by which the firm’s value will increase, on a present value basis, if the firm invests in the project. For example, if the NPV of a project is \$1,000, then the value of the firm should increase by \$1,000 today. Thus, a project is acceptable if its NPV is positive. In other words,

Accept the project if:  $NPV > 0$

The NPV computation is:

$$\begin{aligned}
 NPV &= \frac{CF_0}{(1+r)^0} + \frac{\hat{CF}_1}{(1+r)^1} + \frac{\hat{CF}_2}{(1+r)^2} + \dots + \frac{\hat{CF}_n}{(1+r)^n} \\
 &= CF_0 + \frac{\hat{CF}_1}{(1+r)^1} + \frac{\hat{CF}_2}{(1+r)^2} + \dots + \frac{\hat{CF}_n}{(1+r)^n} = \sum_{t=0}^n \frac{\hat{CF}_t}{(1+r)^t}
 \end{aligned}$$

The NPV for the project in our example is:

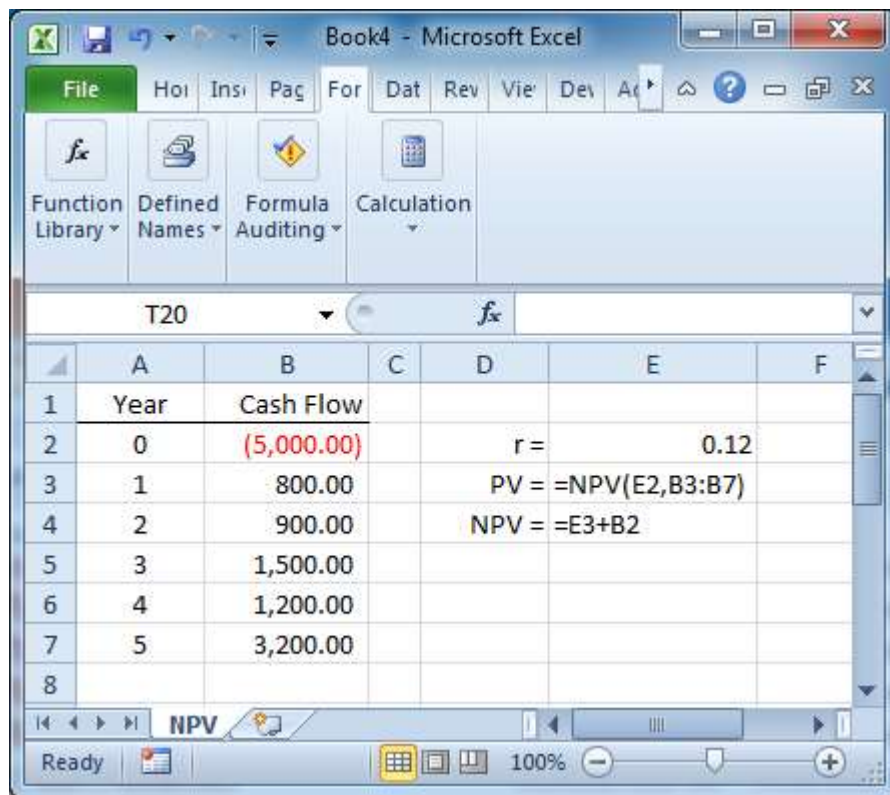
$$\begin{aligned}
 NPV &= -\$5,000 + \frac{\$800}{(1.12)^1} + \frac{\$900}{(1.12)^2} + \frac{\$1,500}{(1.12)^3} + \frac{\$1,200}{(1.12)^4} + \frac{\$3,200}{(1.12)^5} \\
 &= -\$5,000 + \$800(0.89286) + \$900(0.79719) + \$1,500(0.71178) \\
 &\quad + \$1,200(0.63552) + \$3,200(0.56743) \\
 &= \$77.82
 \end{aligned}$$

The result of this computation is the same as that given in the cash flow timeline diagram. According to the acceptance criterion, the project in our example should be purchased. Remember that if the firm accepts a project with a positive NPV its value should increase, and vice versa. Therefore, if a project has a negative NPV it would not be acceptable because such a

project would decrease the value of the firm.

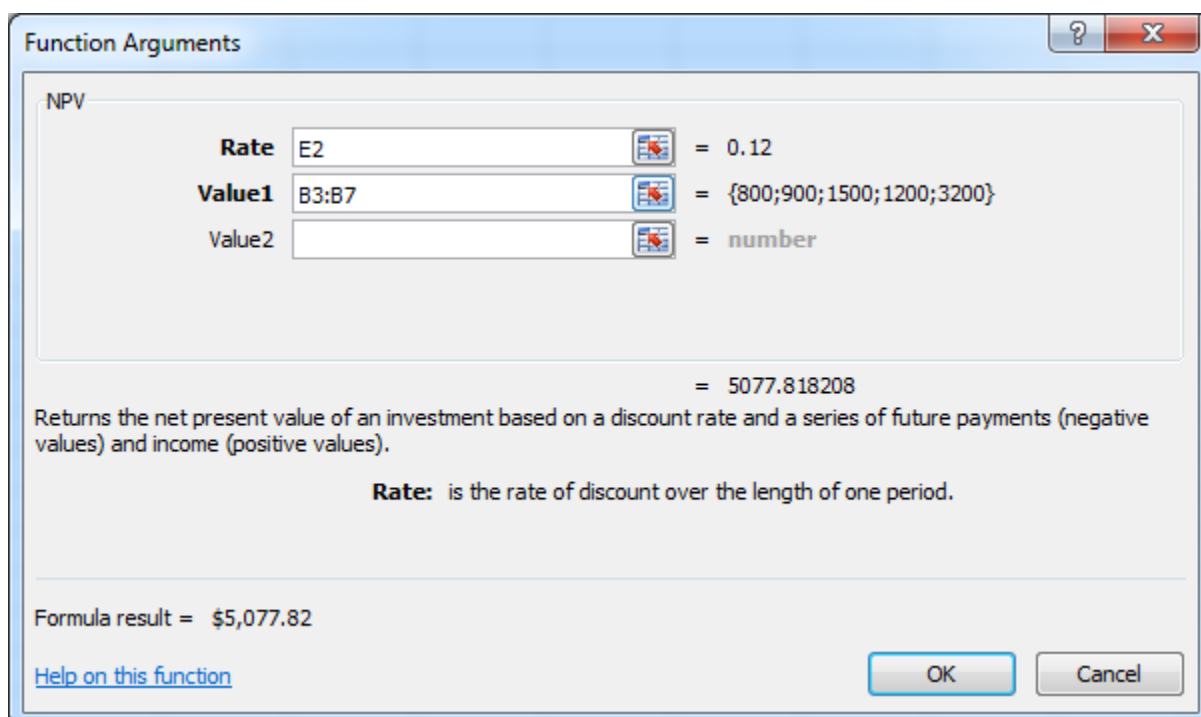
The easiest way to compute the NPV for a project is to use the cash flow register on your calculator. Refer to the instructions that came with your calculator to determine how to use the CF register. If you have a Texas Instruments BAII PLUS, you can use the steps given in the Time Value of Money section of the notes. The inputs should be  $CF_0 = -5,000$ ,  $CF_1 = 800$ ,  $CF_2 = 900$ ,  $CF_3 = 1,500$ ,  $CF_4 = 1,200$ ,  $CF_5 = 3,200$ , and  $I = 12$ . Press the NPV key (and CPT) to find  $NPV = 77.82$ .

You can also use a spreadsheet to compute NPV. Using Excel, you could set up the spreadsheet as follows:



	A	B	C	D	E	F
1	Year	Cash Flow				
2	0	(5,000.00)		r =	0.12	
3	1	800.00		PV =	=NPV(E2,B3:B7)	
4	2	900.00		NPV =	=E3+B2	
5	3	1,500.00				
6	4	1,200.00				
7	5	3,200.00				
8						

To solve for the present value of the future cash flows, put the cursor in cell **E3** and click on the “Financial” function named NPV. In the box that appears, input the following cell locations:



The range **B3:B7** contains the values of the cash flows for Year 1 through Year 5 because the NPV function programmed into the spreadsheet computes the present value of the *future* cash flows *only*. When you click “OK” you will see the result of the computation, which is \$5,077.82, appear in cell **E3**. But, because this result represents only the present value of the future cash flows, you need to add  $CF_0$  to the result to determine the NPV. In this case, the computation is completed in cell **E4**, where  $CF_0$  is added to the result of the NPV computation that appears in cell **E3**. Cell **E4** should now show the correct answer for the NPV, which is \$77.82.

- Internal rate of return (IRR)—if a project has a positive NPV, then it generates a return that is greater than the cost of the funds that are used to purchase the project. A project’s IRR is defined as the rate of return the firm would earn, on average, if it purchases the project. To determine the IRR, you must compute the rate of return that causes the project’s NPV to equal zero, which is also the point where the present value of the future cash flows equals the initial investment. In other words:

$$NPV = CF_0 + \frac{\hat{CF}_1}{(1+IRR)^1} + \frac{\hat{CF}_2}{(1+IRR)^2} + \dots + \frac{\hat{CF}_n}{(1+IRR)^n} = 0$$

or

$$CF_0 = \frac{\hat{CF}_1}{(1+IRR)^1} + \frac{\hat{CF}_2}{(1+IRR)^2} + \dots + \frac{\hat{CF}_n}{(1+IRR)^n}$$

If this computation seems familiar, it should be, because the computation for IRR is the same as the computation for the yield to maturity (YTM) on a bond, which was discussed in the section of the notes titled Bonds—Characteristics and Valuation.

The IRR for our project is

$$\text{NPV} = -\$5,000 + \frac{\$800}{(1 + \text{IRR})^1} + \frac{\$900}{(1 + \text{IRR})^2} + \frac{\$1,500}{(1 + \text{IRR})^3} + \frac{\$1,200}{(1 + \text{IRR})^4} + \frac{\$3,200}{(1 + \text{IRR})^5} = 0$$

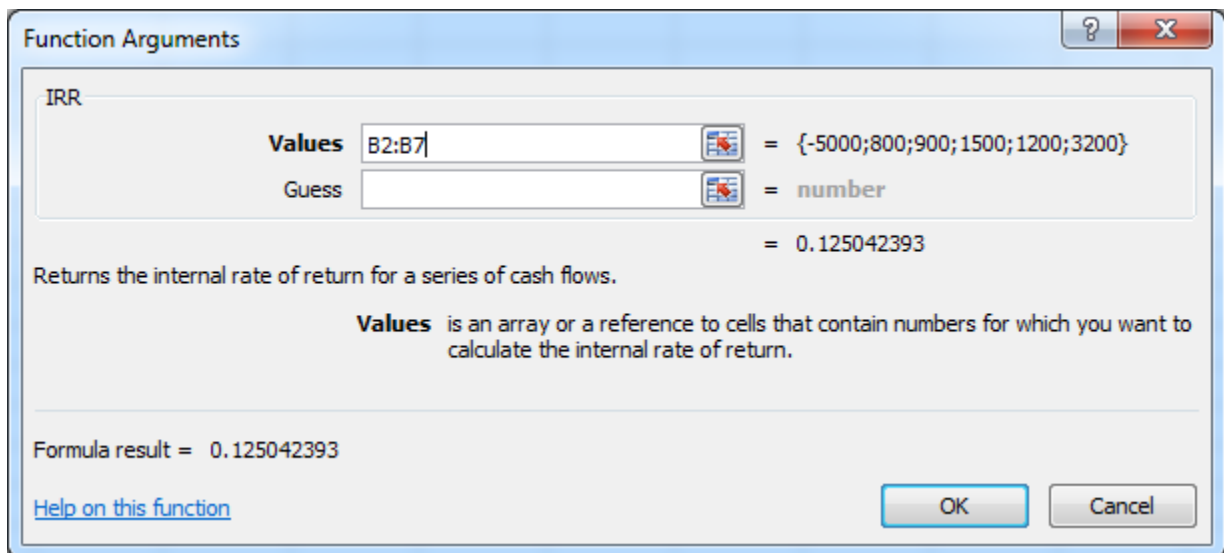
$$-\$5,000 = \frac{\$800}{(1 + \text{IRR})^1} + \frac{\$900}{(1 + \text{IRR})^2} + \frac{\$1,500}{(1 + \text{IRR})^3} + \frac{\$1,200}{(1 + \text{IRR})^4} + \frac{\$3,200}{(1 + \text{IRR})^5}$$

It is not easy to solve for the IRR without a calculator because you have to use the trial-and-error method—that is, plug in various values for IRR until the right side of the equation equals the left side of the equation. With a financial calculator, however, it is very easy to solve for IRR. Follow the same steps you would to compute the NPV, but press the IRR key (and CPT) instead of the NPV key. You should find that IRR= 12.5%.

Using a spreadsheet to compute the IRR for the project, set up the problem as before:

Year	Cash Flow	
0	(5,000.00)	r = 0.12
1	800.00	PV = \$5,077.82
2	900.00	NPV = \$77.82
3	1,500.00	IRR = =IRR(B2:B7)
4	1,200.00	
5	3,200.00	

To solve for the internal rate of return for this project, put the cursor in cell **D5** and click the “Financial” function named IRR. In the box that appears input the following cell locations:



The range **B2:B7** contains the values of all the cash flows for the project, including the initial investment contained in cell **B2**. When you click “OK,” the answer, 12.50%, will appear in cell **D5**.

A project is acceptable using IRR if its IRR is greater than the firm’s required rate of return—that is,  $IRR > r$ . Thus,

Accept the project if:  $IRR > r$  (the firm’s required rate of return)

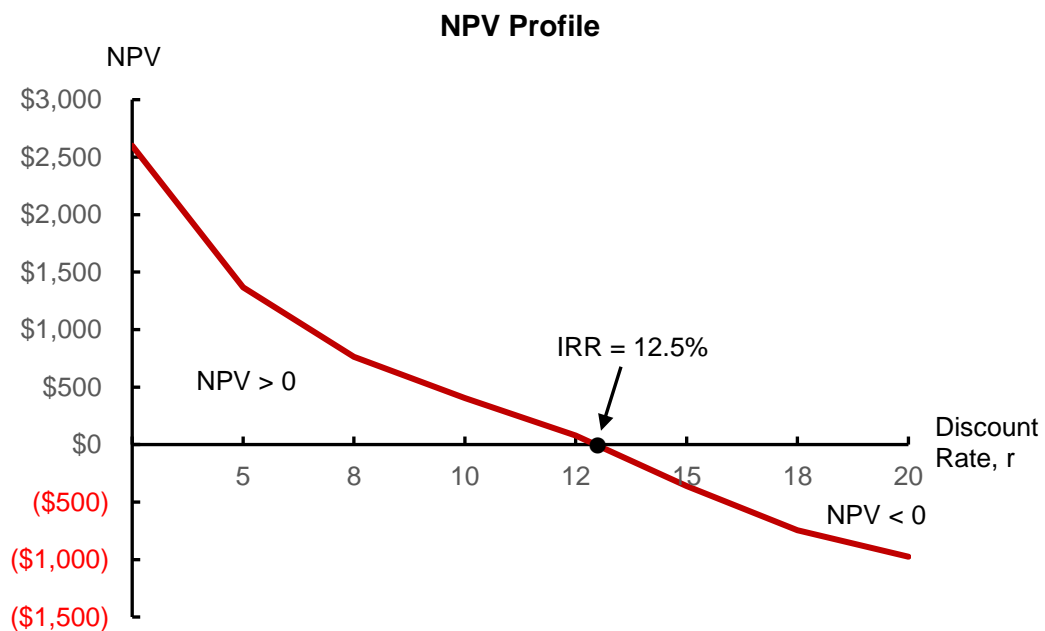
Remember that the IRR represents the rate of return the firm will earn if the project is purchased. So, simply stated, the project must earn a return that is greater than the cost of the funds used to purchase it. In our example,  $IRR = 12.5\%$ , which is greater than  $r = 12\%$ , so the project is acceptable.

- Comparison of the NPV and IRR Methods—summarizing what we have discussed to this point, we know that a project is acceptable if its NPV is greater than zero. If a project has an NPV greater than zero, then it *generates a return that is greater than the cost of the funds used to purchase the project*. We also know that a project is acceptable if its IRR is greater than the firm’s required rate of return. When a project has an IRR greater than the required rate of return, then it *generates a return that is greater than the cost of the funds used to purchase the project*. As you can see by the italicized phrases, accepting a project using the NPV technique provides the same benefit as accepting a project using the IRR technique. As a result, both the NPV technique and the IRR technique should always give the same accept/reject decision—that is, if a project is acceptable using the NPV method, it also is acceptable using the IRR method, and vice versa. As we will discover shortly, however, when comparing two or more projects, the two techniques do not always agree as to which project is better (best).
  - NPV profiles—an NPV profile is a graph that shows the NPVs of a project at various required rates of return. To construct an NPV profile, compute the NPV of a project at different discount rates and then plot the results. For our example, the following table shows the results of

computing the NPV of the project at different discounts rates, or required rates of return:

<u>Discount rate</u>	<u>NPV</u>
0.0%	2,600.00
5.0	1,368.51
8.0	763.00
10.0	404.61
<b>12.0</b>	<b>77.82</b>
15.0	(360.47)
18.0	(745.03)
20.0	(975.57)

The NPV profile for this project, which is created by plotting these values, is:



As you can see, the point where the curve intersects the horizontal axis represents the project's IRR.

Suppose the firm in our example is considering another project with the following characteristics:

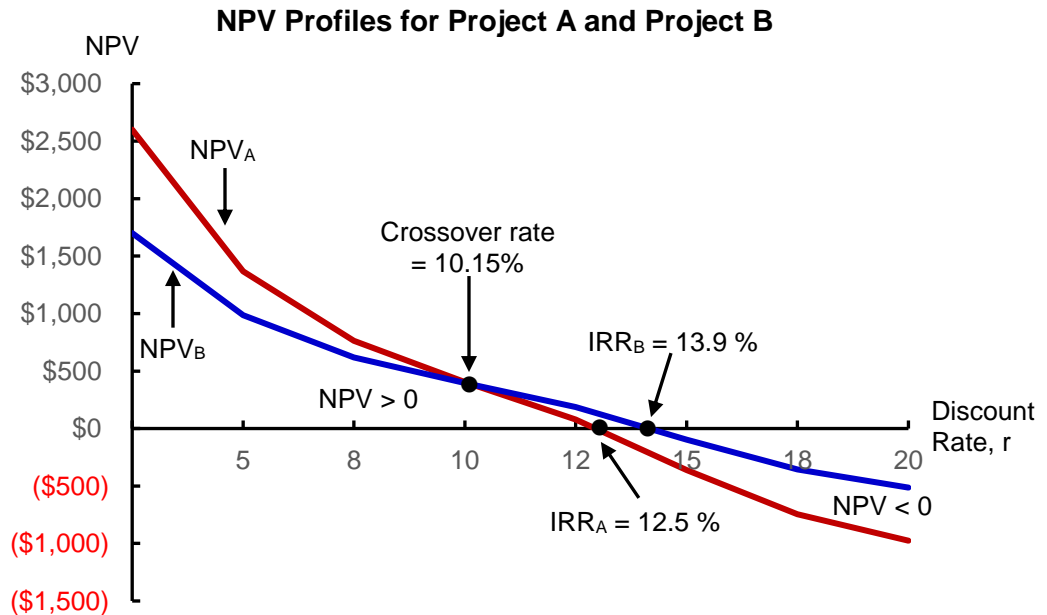


<u>Year</u>	<u>Cash Flow</u>	<u>PV of CF @ 12%</u>
0	\$(5,000)	\$(5,000.00)
1	2,400	2,142.86
2	1,800	1,434.95
3	900	640.60
4	900	571.97
5	700	397.20
		<u>\$ 187.57 = NPV</u>

The NPVs for this project, which we will call Project B, at various discount rates are:

<u>Discount rate</u>	<u>NPV</u>
0.0%	\$1,700.00
5.0	984.72
8.0	617.82
10.0	394.96
<b>12.0</b>	<b>187.57</b>
15.0	( 97.62)
18.0	( 355.42)
20.0	( 513.82)

Plotting these NPVs with the NPVs of the first project, which we call Project A, produces the following NPV profile graph:



Examining the graph, you should notice a few points: (1) At lower discount rates Project A has a higher NPV, while Project B has the higher NPV at higher rates. The reason for this is that,

although Project B generates less total cash flow over its life (that is, \$1,700 compared to \$2,600 for Project A), the cash flows are received sooner (earlier) than for Project A. As a result, the cash flows can be reinvested to produce a higher rate of return, which is evidenced by the fact that  $IRR_B > IRR_A$ . (2) The slope of the curve for Project A is steeper than for Project B, which indicates that the NPV of Project A is more sensitive to changes in the discount rate than Project B—that is, the NPV change is greater for Project A than for Project B when the discount rate changes. (3) There is a point, which we refer to as the *crossover point*, where  $NPV_A = NPV_B$ . In this case the crossover point is where the discount rate equals 10.15 percent; at this point,  $NPV_A = NPV_B = \$379$ . This rate was computed by taking the difference between the cash flows for both projects and then determining the IRR of the results. In other words,

Year	Cash Flows		Difference = $CF_A - CF_B$
	Project A	Project B	
0	\$(5,000)	\$(5,000)	\$0
1	800	2,400	(1,600)
2	900	1,800	( 900)
3	1,500	900	600
4	1,200	900	300
5	3,200	700	2,500

Treat the values in the last column as a separate cash flow stream and then compute the IRR just like you would for either Project A or Project B—that is,  $CF_0 = \$0$ ,  $CF_1 = -\$1,600$ ,  $CF_2 = -\$900$ ,  $CF_3 = \$600$ ,  $CF_4 = \$300$ , and  $CF_5 = \$2,500$ . You should find  $IRR = 10.15\%$ , which is the crossover point. As the graph shows, if the discount rate is below 10.15 percent, the NPV of Project A is greater than the NPV of Project B and, if the discount rate is above 10.15 percent the NPV of Project A is less than the NPV of Project B. If the discount rate equals 10.15 percent, then  $NPV_A = NPV_B = \$379$ .

- Independent projects—if projects are independent, the simple rule is to invest in all projects that have positive NPVs (IRRs greater than the firm's required rate of return). Remember, that if a project has a positive NPV, then its IRR is greater than the firm's required rate of return.
- Mutually exclusive projects—the firm cannot invest in all projects that have positive NPVs if they are mutually exclusive, because, by definition, only one project can be purchased. Even though we know that when  $NPV > 0$ ,  $IRR > r$  in every case, there are instances when we evaluate two projects and find the following:

$$NPV_1 > NPV_2 > 0 \quad \text{and} \quad r < IRR_1 < IRR_2$$

According to our decision rules, both projects are acceptable because both projects have positive NPVs and IRRs that exceed the firm's required rate of return. But, if the projects are mutually exclusive, which should be chosen? The NPV of Project 1 is greater than the NPV of Project 2, but the IRR of Project 2 is greater than the IRR of Project 1. This poses a problem, because one project is more acceptable using NPV while the other project is more acceptable using IRR. The reason this conflict occurs is because the two techniques have different

reinvestment assumptions. NPV assumes the cash flows received in the future can be reinvested at the firm's required rate of return, while IRR assumes that the cash flows can be reinvested at the project's IRR. Which is a more appropriate assumption? Most people generally agree that the firm can reinvest at its required rate of return, because it can pay off debt or repurchase stock that it used to purchase capital projects. However, it is unlikely the firm can continue to earn (reinvest at) a project's IRR, because competition for the project generally drives down the IRR during the projects life (i.e., other firms will want to purchase the same type of project if it earns an above-average return). Thus, we conclude that the NPV method should be used to determine which project should be purchased when such a conflict occurs when evaluating mutually exclusive projects. In this case, then, Project 1 is more acceptable than Project 2 because  $NPV_1 > NPV_2$ .

- Multiple IRRs—if a project has an unconventional cash flow pattern such that net cash outflows alternate with net cash inflows more than once, then it could have more than one IRR. Each time the sign of the net cash flow changes (from negative to positive) the project will have another IRR. In our examples to this point, the projects have had only one sign change—from negative in Year 0 to positive in Year 1—so they only have one IRR. If we introduced a project with a similar cash flow pattern as the previously mentioned projects except there was a net cash outflow at some point during the life of the project (in addition to the initial investment at Year 0), say, in Year 3, then the new project would have two IRRs.

Following are examples of conventional cash flow patterns and unconventional cash flow patterns:

Conventional cash flow patterns:

(1) - + + + + + + This cash flow pattern has one IRR solution

(2) - - - - + + + This cash flow pattern has one IRR solution

Unconventional cash flow patterns:

(1) - + - + - + + This cash flow pattern has three IRR solutions

(2) - - + + - - + This cash flow pattern has two IRR solutions

- Modified Internal Rate of Return (MIRR)—represents the rate of return that equates the present value of a project's cash outflows with the present value of its cash inflows, which are stated in terms of dollars at the end of the project's life. MIRR is computed as follows:

$$\sum_{t=0}^n \frac{COF_t}{(1+r)^t} = \frac{\sum_{t=1}^n CIF_t (1+r)^{n-t}}{(1+MIRR)^n}$$

Here COF represents cash outflows, CIF represent cash inflows, r is the firm's required rate of return, and n is the life of the project.

The MIRR can be used to solve ranking problems and multiple IRRs.

Example:

Year	Cash Flows	
	Project A	Project B
0	(7,000)	(8,000)
1	2,000	6,000
2	1,000	3,000
3	5,000	1,000
4	3,000	500

Following are the results of solving for NPV, IRR, and discounted payback:

	Asset A	Asset B
Traditional PB	2.80 yrs	<b>1.67 yrs</b>
Discounted PB	3.71 yrs	<b>2.78 yrs</b>
NPV	<b>\$498.12</b>	\$429.22
IRR	18.02%	<b>19.03%</b>

Highlighted (boxed) numbers represent the asset with the better results. Clearly, a ranking conflict exists, because the NPV method favors Asset A, whereas the other methods favor Asset B.

Computing the MIRRs, we have

$$7,000 = \frac{2,000(1.15)^3 + 1,000(1.15)^2 + 5,000(1.15)^1 + 3,000(1.15)^0}{(1 + \text{MIRR}_A)} = \frac{13,114.25}{(1 + \text{MIRR}_A)}$$

Calculator solution: N = 4, PV = -7,000, PMT = 0, FV = 13,114.25; I/Y = 16.99 = MIRR<sub>A</sub>

$$8,000 = \frac{6,000(1.15)^3 + 3,000(1.15)^2 + 1,000(1.15)^1 + 500(1.15)^0}{(1 + \text{MIRR}_B)} = \frac{14,742.75}{(1 + \text{MIRR}_B)}$$

Calculator solution: N = 4, PV = -8,000, PMT = 0, FV = 14,742.75; I/Y = 16.51 = MIRR<sub>B</sub>

MIRR<sub>A</sub> > MIRR<sub>B</sub>, which indicates that Project A is preferable.

- Payback period—the number of years, including the fraction of the year, it takes to recapture the initial investment.
  - Traditional payback period (PB)—the time it takes to recapture the project's cost using the unadjusted (raw) cash flows.

The following table shows the payback for Project A:

<u>Year</u>	<u>Cash Flow</u>	<u>Cumulative CF</u>
0	\$(5,000)	\$(5,000)
1	800	(4,200)
2	900	(3,300)
3	1,500	(1,800)
4	1,200	( 600)
5	3,200	2,600

This table shows that the payback period is between four years and five years. The actual payback is:

$$\begin{aligned} \text{Payback period} &= \left( \begin{array}{l} \text{Number of years} \\ \text{before recovery of} \\ \text{original investment} \end{array} \right) + \left( \frac{\text{Amount of investment remaining to be recaptured}}{\text{Total cash flow during year of payback}} \right) \\ &= 4 + \frac{\$600}{\$3,200} \\ &= 4.19 \text{ years} \end{aligned}$$

As the computation shows, it takes a little more than four years for the firm to recapture its original investment for this project. The acceptance rule for payback can be stated as follows:

Accept the project if:  $PB < \text{some number of years set by the firm}$

This project is acceptable if the firm wants to recapture the cost of its investments within five years; but it would not be acceptable if the firm wants to recapture the costs within three years.

Even though the concept of payback is very simple, there are problems with using payback to make capital budgeting decisions. The primary problem is that this technique does not use time value of money concepts—that is, we do not compute the present values of the future cash flows. Another problem is that the cash flows beyond the payback period are ignored. For example, if the project described above had a \$1,000,000 cash flow in Year 5 rather than the \$3,200 given, the project would still have a payback equal to just over four years and it would not be an acceptable project if the payback period imposed by the firm is three years.

- Discounted payback period (DPB)—the time it takes to recapture the project's cost using the present values of the (discounted) cash flows. DPB mitigates the problem that PB has of not including the time value of money in the computation.

To compute DPB, we simply apply the concept of the traditional payback to the present values of the future cash flows as follows:

<u>Year</u>	<u>Cash Flow</u>	<u>PV of CF</u>	<u>Cumulative PV</u>
0	\$(5,000)	\$(5,000.00)	\$(5,000.00)
1	800	714.29	(4,285.71)
2	900	717.47	(3,568.24)
3	1,500	1,067.67	(2,500.57)
4	1,200	762.62	(1,737.95)
5	3,200	1,815.77	77.82 = NPV <sub>A</sub>

Thus, the discounted payback is:

$$\begin{aligned} \text{Payback period} &= \left( \text{Number of years before full recovery of original investment} \right) + \left( \frac{\text{PV of investment remaining to be recaptured}}{\text{PV of total cash flow during year of payback}} \right) \\ &= 4 + \frac{\$1,737.95}{\$1,815.77} \\ &= 4.96 \text{ years} \end{aligned}$$

When using the discounted payback, a project is acceptable if its payback is less than its life. In other words,

Accept the project is:  $DPB < \text{Project's useful life, } n$

In this case, 4.96 years is less than the project's five-year life, so the project is acceptable. Notice, however, we could have made the decision by looking at the last line of the column labeled "Cumulative PV" because that value is the NPV. So, if you set up the problem as we did in the above table and the ending value for the "Cumulative PV" is greater than zero, then  $NPV > 0$  and the project is acceptable.

- Capital Budgeting Summary Questions—You should answer these questions as a summary for the chapter and to help you study for the exam.
  - How do capital budgeting decisions differ from general asset valuation? Are they based on the same concepts?
  - What are the various types of capital budgeting decisions? What does it mean for projects to be independent? Mutually exclusive?
  - What does it mean if you find a project has an IRR equal to 14 percent?
  - If  $NPV > 0$ , what is the relationship between the firm's required rate of return and the project's IRR, and what is the project's discounted payback period relative to its life?
  - How is an NPV profile constructed, and how is it used? What does the crossover point associated with the NPV profiles of two projects mean? How is such information used to make capital budgeting decisions?