CHAPTER 9
NET PRESENT VALUE AND OTHER INVESTMENT CRITERIA

Answers to Concepts Review and Critical Thinking Questions

1. A payback period less than the project’s life means that the NPV is positive for a zero discount rate, but nothing more definitive can be said. For discount rates greater than zero, the payback period will still be less than the project’s life, but the NPV may be positive, zero, or negative, depending on whether the discount rate is less than, equal to, or greater than the IRR. The discounted payback includes the effect of the relevant discount rate. If a project’s discounted payback period is less than the project’s life, it must be the case that NPV is positive.

2. If a project has a positive NPV for a certain discount rate, then it will also have a positive NPV for a zero discount rate; thus, the payback period must be less than the project life. Since discounted payback is calculated at the same discount rate as is NPV, if NPV is positive, the discounted payback period must be less than the project’s life. If NPV is positive, then the present value of future cash inflows is greater than the initial investment cost; thus PI must be greater than 1. If NPV is positive for a certain discount rate R, then it will be zero for some larger discount rate R*; thus the IRR must be greater than the required return.

3. a. Payback period is simply the accounting break-even point of a series of cash flows. To actually compute the payback period, it is assumed that any cash flow occurring during a given period is realized continuously throughout the period, and not at a single point in time. The payback is then the point in time for the series of cash flows when the initial cash outlays are fully recovered. Given some predetermined cutoff for the payback period, the decision rule is to accept projects that payback before this cutoff, and reject projects that take longer to payback.
   b. The worst problem associated with payback period is that it ignores the time value of money. In addition, the selection of a hurdle point for payback period is an arbitrary exercise that lacks any steadfast rule or method. The payback period is biased towards short-term projects; it fully ignores any cash flows that occur after the cutoff point.
   c. Despite its shortcomings, payback is often used because (1) the analysis is straightforward and simple and (2) accounting numbers and estimates are readily available. Materiality considerations often warrant a payback analysis as sufficient; maintenance projects are another example where the detailed analysis of other methods is often not needed. Since payback is biased towards liquidity, it may be a useful and appropriate analysis method for short-term projects where cash management is most important.

4. a. The discounted payback is calculated the same as is regular payback, with the exception that each cash flow in the series is first converted to its present value. Thus discounted payback provides a measure of financial/economic break-even because of this discounting, just as regular payback provides a measure of accounting break-even because it does not discount the cash flows. Given some predetermined cutoff for the discounted payback period, the decision rule is to accept projects whose discounted cash flows payback before this cutoff period, and to reject all other projects.
b. The primary disadvantage to using the discounted payback method is that it ignores all cash flows that occur after the cutoff date, thus biasing this criterion towards short-term projects. As a result, the method may reject projects that in fact have positive NPVs, or it may accept projects with large future cash outlays resulting in negative NPVs. In addition, the selection of a cutoff point is again an arbitrary exercise.

c. Discounted payback is an improvement on regular payback because it takes into account the time value of money. For conventional cash flows and strictly positive discount rates, the discounted payback will always be greater than the regular payback period.

5.  
a. The average accounting return is interpreted as an average measure of the accounting performance of a project over time, computed as some average profit measure attributable to the project divided by some average balance sheet value for the project. This text computes AAR as average net income with respect to average (total) book value. Given some predetermined cutoff for AAR, the decision rule is to accept projects with an AAR in excess of the target measure, and reject all other projects.

b. AAR is not a measure of cash flows and market value, but a measure of financial statement accounts that often bear little resemblance to the relevant value of a project. In addition, the selection of a cutoff is arbitrary, and the time value of money is ignored. For a financial manager, both the reliance on accounting numbers rather than relevant market data and the exclusion of time value of money considerations are troubling. Despite these problems, AAR continues to be used in practice because (1) the accounting information is usually available, (2) analysts often use accounting ratios to analyze firm performance, and (3) managerial compensation is often tied to the attainment of certain target accounting ratio goals.

6.  
a. NPV is simply the present value of a project’s cash flows. NPV specifically measures, after considering the time value of money, the net increase or decrease in firm wealth due to the project. The decision rule is to accept projects that have a positive NPV, and reject projects with a negative NPV.

b. NPV is superior to the other methods of analysis presented in the text because it has no serious flaws. The method unambiguously ranks mutually exclusive projects, and can differentiate between projects of different scale and time horizon. The only drawback to NPV is that it relies on cash flow and discount rate values that are often estimates and not certain, but this is a problem shared by the other performance criteria as well. A project with NPV = $2,500 implies that the total shareholder wealth of the firm will increase by $2,500 if the project is accepted.

7.  
a. The IRR is the discount rate that causes the NPV of a series of cash flows to be exactly zero. IRR can thus be interpreted as a financial break-even rate of return; at the IRR, the net value of the project is zero. The IRR decision rule is to accept projects with IRRs greater than the discount rate, and to reject projects with IRRs less than the discount rate.

b. IRR is the interest rate that causes NPV for a series of cash flows to be zero. NPV is preferred in all situations to IRR; IRR can lead to ambiguous results if there are non-conventional cash flows, and it also ambiguously ranks some mutually exclusive projects. However, for stand-alone projects with conventional cash flows, IRR and NPV are interchangeable techniques.

c. IRR is frequently used because it is easier for many financial managers and analysts to rate performance in relative terms, such as “12%”, than in absolute terms, such as “$46,000.” IRR may be a preferred method to NPV in situations where an appropriate discount rate is unknown are uncertain; in this situation, IRR would provide more information about the project than would NPV.
8.  
   a. The profitability index is the present value of cash inflows relative to the project cost. As such, it is a benefit/cost ratio, providing a measure of the relative profitability of a project. The profitability index decision rule is to accept projects with a PI greater than one, and to reject projects with a PI less than one.
   
   b. PI = (NPV + cost)/cost = 1 + (NPV/cost). If a firm has a basket of positive NPV projects and is subject to capital rationing, PI may provide a good ranking measure of the projects, indicating the “bang for the buck” of each particular project.

Solutions to Questions and Problems

2. To calculate the payback period, we need to find the time that the project has recovered its initial investment. The cash flows in this problem are an annuity, so the calculation is simpler. If the initial cost is $1,700, the payback period is:

   Payback = 2 + ($350 / $675) = 2.52 years

   There is a shortcut to calculate payback period when the project cash flows are an annuity. Just divide the initial cost by the annual cash flow. For the $3,300 cost, the payback period is:

   Payback = $3,300 / $675 = 4.89 years

   The payback period for an initial cost of $5,600 is a little trickier. Notice that the total cash inflows after eight years will be:

   Total cash inflows = 8($675) = $5,400

   If the initial cost is $5,600, the project never pays back. Notice that if you use the shortcut for annuity cash flows, you get:

   Payback = $5,600 / $675 = 8.29 years

   This answer does not make sense since the cash flows stop after eight years, so again, we must conclude the payback period is never.
4. When we use discounted payback, we need to find the value of all cash flows today. The value today of the project cash flows for the first four years is:

Value today of Year 1 cash flow = $2,800 / 1.14 = $2,456.14  
Value today of Year 2 cash flow = $3,700 / 1.14^2 = $2,847.03  
Value today of Year 3 cash flow = $5,100 / 1.14^3 = $3,442.35  
Value today of Year 4 cash flow = $4,300 / 1.14^4 = $2,545.95

To find the discounted payback, we use these values to find the payback period. The discounted first year cash flow is $2,456.14, so the discounted payback for a $5,200 initial cost is:

Discounted payback = 1 + ($5,200 – 2,456.14) / $2,847.03 = 1.96 years

For an initial cost of $8,000, the discounted payback is:

Discounted payback = 2 + ($6,400 – 2,456.14 – 2,847.03) / $3,442.35 = 2.32 years

Notice the calculation of discounted payback. We know the payback period is between two and three years, so we subtract the discounted values of the Year 1 and Year 2 cash flows from the initial cost. This is the numerator, which is the discounted amount we still need to make to recover our initial investment. We divide this amount by the discounted amount we will earn in Year 3 to get the fractional portion of the discounted payback.

If the initial cost is $11,000, the discounted payback is:

Discounted payback = 3 + ($10,400 – 2,456.14 – 2,847.03 – 3,442.35) / $2,545.95 = 3.65 years

9. The NPV of a project is the PV of the inflows minus the PV of the outflows. Since the cash inflows are an annuity, the equation for the NPV of this project at an 8 percent required return is:

\[
\text{NPV} = -$67,000 + $15,400(PVIFA_{8\%, 9}) = -$29,202.07
\]

At an 8 percent required return, the NPV is positive, so we would accept the project.

The equation for the NPV of the project at a 20 percent required return is:

\[
\text{NPV} = -$67,000 + $15,400(PVIFA_{20\%, 9}) = -$4,923.12
\]

At a 20 percent required return, the NPV is negative, so we would reject the project.

We would be indifferent to the project if the required return was equal to the IRR of the project, since at that required return the NPV is zero. The IRR of the project is:

\[
0 = -$67,000 + $15,400(PVIFA_{\text{IRR}, 9})
\]

\[
\text{IRR} = 17.67\%
\]
10. The IRR is the interest rate that makes the NPV of the project equal to zero. So, the equation that defines the IRR for this project is:

\[ 0 = -13,900 + \frac{6,400}{1 + IRR} + \frac{8,700}{(1 + IRR)^2} + \frac{5,900}{(1 + IRR)^3} \]

Using a spreadsheet, financial calculator, or trial and error to find the root of the equation, we find that:

\[ IRR = 24.07\% \]

11. The NPV of a project is the PV of the inflows minus the PV of the outflows. At a zero discount rate (and only at a zero discount rate), the cash flows can be added together across time. So, the NPV of the project at a zero percent required return is:

\[ NPV = -13,900 + 6,400 + 8,700 + 5,900 = 7,100 \]

The NPV at a 10 percent required return is:

\[ NPV = -13,900 + \frac{6,400}{1.1} + \frac{8,700}{1.1^2} + \frac{5,900}{1.1^3} = 3,541.02 \]

The NPV at a 20 percent required return is:

\[ NPV = -13,900 + \frac{6,400}{1.2} + \frac{8,700}{1.2^2} + \frac{5,900}{1.2^3} = 889.35 \]

And the NPV at a 30 percent required return is:

\[ NPV = -13,900 + \frac{6,400}{1.3} + \frac{8,700}{1.3^2} + \frac{5,900}{1.3^3} = -1,143.51 \]

Notice that as the required return increases, the NPV of the project decreases. This will always be true for projects with conventional cash flows. Conventional cash flows are negative at the beginning of the project and positive throughout the rest of the project.

15. The profitability index is defined as the PV of the future cash flows divided by the initial investment. The equation for the profitability index at a required return of 10 percent is:

\[ PI = \left[ \frac{9,400}{1.1} + \frac{7,600}{1.1^2} + \frac{4,300}{1.1^3} \right] / 15,300 = 1.180 \]

The equation for the profitability index at a required return of 15 percent is:

\[ PI = \left[ \frac{9,400}{1.15} + \frac{7,600}{1.15^2} + \frac{4,300}{1.15^3} \right] / 15,300 = 1.095 \]

The equation for the profitability index at a required return of 22 percent is:

\[ PI = \left[ \frac{9,400}{1.22} + \frac{7,600}{1.22^2} + \frac{4,300}{1.22^3} \right] / 15,300 = .992 \]

We would accept the project if the required return were 10 percent or 15 percent since the PI is greater than one. We would reject the project if the required return were 22 percent since the PI is less than one.
17.  

a. The payback period for each project is:

A: 3 + ($227,000 / $572,000) = 3.40 years

B: 2 + ($6,000 / $25,500) = 2.24 years

The payback criterion implies accepting Project B, because it pays back sooner than Project A.

b. The discounted payback for each project is:

A: $58,000 / 1.15 + $85,000 / 1.15^2 + $85,000 / 1.15^3 = $170,595.87
$572,000 / 1.15^4 = $327,042.86

Discounted payback = 3 + ($455,000 – 170,595.87) / $327,042.86 = 3.87 years

B: $31,000 / 1.15 + $28,000 / 1.15^2 = $48,128.54
$25,500 / 1.15^3 = $16,766.66

Discounted payback = 2 + ($65,000 – 48,128.54) / $16,766.66 = 3.01 years

The discounted payback criterion implies accepting Project B because it pays back sooner than A.

c. The NPV for each project is:

A: NPV = –$455,000 + $58,000 / 1.15 + $85,000 / 1.15^2 + $85,000 / 1.15^3 + $572,000 / 1.15^4
NPV = $42,638.73

B: NPV = –$65,000 + $31,000 / 1.15 + $28,000 / 1.15^2 + $25,500 / 1.15^3 + $19,000 / 1.15^4
NPV = $10,758.52

NPV criterion implies we accept Project A because Project A has a higher NPV than project B.

d. The IRR for each project is:

A: $455,000 = $58,000 / (1+IRR) + $85,000 / (1+IRR)^2 + $85,000 / (1+IRR)^3
+ $572,000 / (1+IRR)^4

Using a spreadsheet, financial calculator, or trial and error to find the root of the equation, we find that:

IRR = 18.15%
B:  
\[ \$65,000 = \frac{\$31,000}{1+\text{IRR}} + \frac{\$28,000}{(1+\text{IRR})^2} + \frac{\$25,500}{(1+\text{IRR})^3} + \frac{\$19,000}{(1+\text{IRR})^4} \]

Using a spreadsheet, financial calculator, or trial and error to find the root of the equation, we find that:

\[ \text{IRR} = 23.65\% \]

IRR decision rule implies we accept Project B because IRR for B is greater than IRR for A.

e. The profitability index for each project is:

A:  
\[ \text{PI} = \left( \frac{\$58,000}{1.15} + \frac{\$85,000}{1.15^2} + \frac{\$85,000}{1.15^3} + \frac{\$572,000}{1.15^4} \right) / \$455,000 \]
\[ \text{PI} = 1.094 \]

B:  
\[ \text{PI} = \left( \frac{\$31,000}{1.15} + \frac{\$28,000}{1.15^2} + \frac{\$25,500}{1.15^3} + \frac{\$19,000}{1.15^4} \right) / \$65,000 \]
\[ \text{PI} = 1.166 \]

Profitability index criterion implies accept Project B because its PI is greater than Project A’s.

f. In this instance, the NPV criteria implies that you should accept Project A, while profitability index, payback period, discounted payback, and IRR imply that you should accept Project B. The final decision should be based on the NPV since it does not have the ranking problem associated with the other capital budgeting techniques. Therefore, you should accept Project A.

19. The MIRR for the project with all three approaches is:

**Combination approach:**
In the combination approach, we find the value of all cash outflows at Time 0, and the value of all cash inflows at the end of the project. So, the value of the cash flows is:

Time 0 cash flow = –$41,000 – $9,400 / 1.10^5

Time 0 cash flow = –$46,836.66

Time 5 cash flow = $15,700(1.10^5) + $19,400(1.10^3) + $24,300(1.10^2) + $18,100(1.10)

Time 5 cash flow = $98,120.77

So, the MIRR using the combination approach is:

\[ 0 = -\$46,836.66 + \$98,120.77 / (1 + \text{MIRR})^5 \]
\[ \$98,120.77 / \$46,836.66 = (1 + \text{MIRR})^5 \]
\[ \text{MIRR} = (\$98,120.77 / \$46,836.66)^{1/5} - 1 \]
\[ \text{MIRR} \approx 15.94\% \]

21. Since the NPV index has the cost subtracted in the numerator, NPV index = PI – 1.
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I = 8%  
NPV CPT  
$29,202.07

I = 20%  
NPV CPT  
$-4,923.12

IRR CPT  
17.67%

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IRR CPT  
24.07%

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$7,100

I = 10%  
NPV CPT  
$3,541.02

I = 20%  
NPV CPT  
$889.35

I = 30%  
NPV CPT  
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@10%: PI = $18,057.10 / $15,300 = 1.180
@15%: PI = $16,747.92 / $15,300 = 1.095
@22%: PI = $15,179.11 / $15,300 = 0.992

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PI = $497,638.73 / $455,000 = 1.094

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<th>C02</th>
<th>F02</th>
<th>C03</th>
<th>F03</th>
</tr>
</thead>
<tbody>
<tr>
<td>$-65,000</td>
<td>$31,000</td>
<td>1</td>
<td>$28,000</td>
<td>1</td>
<td>$25,500</td>
<td>1</td>
</tr>
<tr>
<td>IRR CPT</td>
<td>23.65%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CFo</th>
<th>C01</th>
<th>F01</th>
<th>C02</th>
<th>F02</th>
<th>C03</th>
<th>F03</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0</td>
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<td>1</td>
<td>$28,000</td>
<td>1</td>
<td>$25,500</td>
<td>1</td>
</tr>
<tr>
<td>I = 15%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NPV CPT</td>
<td>$75,758.52</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PI = $75,758.52 / $65,000 = 1.166

e. | CFo | C01 | F01 | C02 | F02 | C03 | F03 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
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<td>NPV CPT</td>
<td>$75,758.52</td>
<td></td>
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</tr>
</tbody>
</table>

f. In this instance, the NPV criteria implies that you should accept Project A, while payback period, discounted payback, profitability index, and IRR imply that you should accept Project B. The final decision should be based on the NPV since it does not have the ranking problem associated with the other capital budgeting techniques. Therefore, you should accept Project A.