5
Investment appraisal

5.1 Introduction to investment appraisal

In this chapter we will evaluate real investment decisions whereby entrepreneurs and companies consider whether a certain level of investment will generate sufficient cash flows in the future to make the investment worthwhile. In this section you will be introduced to three main forms of investment appraisal: (i) payback, (ii) net present value (NPV) and (iii) internal rate of return (IRR). We will also look at combinations of these.

Graham and Harvey\(^1\) surveyed 392 chief financial officers (CFOs) and asked them a variety of questions about capital budgeting decisions. They found that “Most respondents select net present value and internal rate of return as their most frequently used capital budgeting techniques; 74.9% of CFOs always or almost always ... use net present value … and 75.7% always or almost always use internal rate of return …”

When asked to state, on a scale of 0 (never) to 4 (always), “how frequently does your firm use the following techniques when deciding which projects or acquisitions to pursue?”, the mean score was 3.09 for IRR, 3.08 for NPV and 2.53 for payback for the entire sample of firms.

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However, for small firms the mean score was 2.87, 2.83 and 2.72 respectively, while for large firms it was 3.41, 3.42 and 2.25 respectively. It is evident that payback is preferred by small firms but NPV and IRR is more popular with large firms.

5.2 The net present value decision rule

We have previously seen that a dollar today is worth more than a dollar in the future. It is therefore not appropriate to focus on the actual level of future cash flows, as in “present value” terms they will decline over time. Therefore, if we wish to evaluate an investment project we need to focus on discounted cash flows, not the actual level of cash flows.

Moreover, previously we have learned that equities and bonds carry with them different degrees of risk and hence have different required rates of return. It follows that the interest rate used to discount cash flows will vary from investment to investment.

The net present value of a project can be found by:

\[ NPV = -I_0 + \sum_{t=1}^{T} \frac{CF_t}{(1 + r)^t} \]

where \( I_0 \) represents the initial investment in time period 0, \( CF_t \) represents the cash flow in period \( t \), \( r \) is the required rate of return and \( T \) is the time of the final cash flow. Note that \( CF_t \) can be positive or negative. The nature of the cash flows that are considered in net present value evaluation are referred to as incremental cash flows, i.e. cash flows that are added to a firm’s existing cash flows as a result of accepting the project. In addition the project should consider any external effects that the project would have. For example, cannibalisation is an externality in which the investment reduces cash flows elsewhere in the company; for example, the launch of a new product may take sales away from existing products.

Often when a project is being considered there would have been prior spending such as marketing consultancy or a feasibility study. These costs are referred to as sunk costs and would be incurred whether the project was accepted or not. As such, these costs would not affect the future cash flows and should not be considered.

Example

Consider three investment projects, A, B and C, whose incremental cash flows are detailed below. The sum of the three projects’ incremental cash flows are identical at $1.2m; however the three projects differ in their timing, and as we have seen in section 5.1, the timing of the cash flows influences the discount factor, which in turn influences the present values.
Without doing any calculations, what would the ranking of the projects be?

<table>
<thead>
<tr>
<th>Project/Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>−$2m</td>
<td>$1.6m</td>
<td>$1.6m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>−$2m</td>
<td></td>
<td>$1.6m</td>
<td>$1.6m</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>−$1m</td>
<td>$1.6m</td>
<td>$0.6m</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As a dollar in the future is worth less than a dollar today, we will clearly prefer projects that deliver cash in earlier periods. In this case we would favour projects A and C over project B. It follows that we would also prefer projects that require less initial investment; hence we would prefer project C over project A. The ranking is therefore: C then A then B.

The NPV decision rule is as follows:

- accept any project if its NPV > 0 or if NPV = 0
- reject a project if its NPV < 0

The notion that a project with a small, or even zero, NPV should be accepted often causes bewilderment. The rationale is that as long as the project is evaluated at a discount rate commensurate with its risk, then the providers of capital (bondholders and shareholders) are receiving their expected return and hence the project should be accepted.

A very simple model of company valuation proposes a company’s value as:

\[
\text{value of net assets} + \text{present value of future opportunities}
\]

Hence if we accept a project, albeit with a very small NPV, then we are still increasing the value of the company.

**Example**

Assume the cash flows from the construction and sale of student accommodation are as follows:

<table>
<thead>
<tr>
<th>Year 0</th>
<th>Year 1</th>
<th>Year 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>−$300,000</td>
<td>−$200,000</td>
<td>+$600,000</td>
</tr>
</tbody>
</table>

Assuming a 7% required rate of return, using the NPV decision rule would this project be accepted?

If \( r = 7\% = 0.07 \), then the three discount factors are:

- Year 0: \( 1/1.07 = 1 \)
Year 1: $1/1.07^2 = 0.935$
Year 2: $1/1.07^3 = 0.873$

The NPV is then:

\[-$300,000 + 0.935 \times -$200,000 + 0.873 \times $600,000 = $36,800\]

On the basis of NPV we should therefore accept this project.

Note that the above answer assumes rounding to three decimal places. The actual answer, with no rounding, is $37,147.35.

In section 4.1 you were introduced to the Excel function PV, which is able to find the present value of a future stream of equal cash flows. It is not appropriate to use that function here and instead we must use the NPV function. For example:

\[\text{npv}(0.07,-200000,600000)\]

This returns the result $337,145.35, which represents the present value (at 7%) of cash flows of $200,000 and $600,000 in years 1 and 2 respectively. If we deduct from this the initial investment of $300,000, we arrive at the previous answer of $37,145.35.

Suppose you own a food van at a football stadium that sells pies, chips, burgers, soft drinks and hot drinks. You have five years left on your contract and do not expect it to be renewed. Your busiest period is the 15-minute half-time break, and long queues limit your sales. You have developed three different proposals to reduce the queues and increase profits. The table below shows the incremental cash flows.

<table>
<thead>
<tr>
<th>Project/Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reconfigure van to serve from both sides</td>
<td>–$75,000</td>
<td>$40,000</td>
<td>$40,000</td>
<td>$40,000</td>
<td>$40,000</td>
<td>$40,000</td>
</tr>
<tr>
<td>Install more efficient equipment</td>
<td>–$25,000</td>
<td>$20,000</td>
<td>$20,000</td>
<td>$20,000</td>
<td>$20,000</td>
<td>$20,000</td>
</tr>
<tr>
<td>Buy a bigger van</td>
<td>–$150,000</td>
<td>$60,000</td>
<td>$60,000</td>
<td>$60,000</td>
<td>$60,000</td>
<td>$60,000</td>
</tr>
</tbody>
</table>

You have decided that a 15% discount rate is appropriate, given the risk of the investment. What is the NPV of each proposal?

<table>
<thead>
<tr>
<th>Project/Year</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reconfigure van to serve from both sides</td>
<td>$59,086.20</td>
</tr>
<tr>
<td>Install more efficient equipment</td>
<td>$42,043.10</td>
</tr>
<tr>
<td>Buy a bigger van</td>
<td>$51,129.31</td>
</tr>
</tbody>
</table>
Clearly the owner of the hot food van can only choose one of the outcomes. The projects are therefore considered to be mutually exclusive. On the basis of the NPV calculations above, the best decision is to reconfigure the van so that it can serve from both sides.

The spreadsheet for this exercise can be found here. Please ensure you click on Section 5 and the 5.2 tab at the bottom of the spreadsheet.

**5.3 The relationship between NPV and discount rate**

Consider once again the equation for the present value of a cash flow:

\[ PV = \frac{1}{(1 + r)^t} \times Cash\ Flow \]

The first term above is the discount factor. Hopefully it is evident that the larger is \( r \), then the larger the denominator and the smaller is the discount factor. Returning once again to the example in section 5.2:

<table>
<thead>
<tr>
<th>Year 0</th>
<th>Year 1</th>
<th>Year 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>−$300,000</td>
<td>−$200,000</td>
<td>+$600,000</td>
</tr>
</tbody>
</table>

As \( r \) increases, the present value of the positive cash flow will decrease. At the same time the PV of the second construction payment in year 1 will also decrease, though that will be viewed as an advantage from the investor’s point of view.

Using the NPV function in Excel it is trivial to plot NPV against the discount rate.
From the chart above it is evident that there is a negative and non-linear relationship between NPV and discount rates. It is also evident that eventually, as \( r \) increases, there is some discount rate whereby the sum of the present values of future incremental cash flows exactly offsets the cash flow in year 0 and the net present value is zero. In the chart above this appears to happen at a discount rate of approximately 12%. Note that this diagram is near identical to the diagram in Chapter 4 depicting the relationship between bond prices and yield to maturity, albeit here we have a cash flow out in year 0 which causes the curve to shift downwards.

Revisiting a previous example:

<table>
<thead>
<tr>
<th>Project/Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$-2m</td>
<td>$1.6m</td>
<td>$1.6m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>$-2m</td>
<td></td>
<td>$1.6m</td>
<td>$1.6m</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>$-1m</td>
<td>$1.6m</td>
<td></td>
<td>$0.6m</td>
<td></td>
</tr>
</tbody>
</table>

At a discount rate of zero all three projects have an NPV of zero, but when depicted graphically it is clear that, due to the latter’s cash flows, project B’s NPV becomes zero much sooner than that of the other two projects.
The spreadsheet for this exercise can be found here. Please ensure you click on Section 5 and the 5.3 tab at the bottom of the spreadsheet.

5.4 The internal rate of return

It is evident in the example above that there is some r for which the NPV of a project is zero. This r is referred to as the internal rate of return (IRR). The formal definition of a project’s IRR is the rate of discount which, when applied to the project’s cash flows, produces a zero NPV.

The IRR decision rule is then:

    invest in any project that has an IRR greater than or equal to some predetermined cost of capital

The comparison rate is usually the cost of capital, i.e. the discount rate we would have used in an NPV analysis. This is often referred to as the hurdle rate, which makes logical sense, as r reflects the riskiness of the project and, as the risk of the project increases, a higher IRR is required to overcome the higher hurdle. The three projects, A, B and C, analysed earlier have “standard” cash flows, i.e. up-front investment followed by cash inflows. For projects with “standard” cash flows the relationship between NPV and r will be a negative one as depicted in section 5.3 above.
When the length of the project is two periods or less it is a trivial exercise to find the IRR. In particular, returning to project C above, we are solving:

\[-1 + \frac{1.6}{1 + r} + \frac{0.6}{(1 + r)^2} = 0\]

Multiplying through by \((1 + r)^2\):

\[-1(1 + r)^2 + 1.6(1 + r) + 0.6 = 0\]

Setting \((1 + r) = x\):

\[-x^2 + 1.6x + 0.6 = 0\]

which many students will recognise as a quadratic equation in the form:

\[ax^2 + bx + c = 0\]

Hence, \(a = -1\), \(b = 1.6\) and \(c = 0.6\).

The solution to a quadratic equation can be found as:

\[x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}\]

\[x = \frac{-1.6 \pm \sqrt{1.6^2 - 4 \times (-1) \times 0.6}}{2 \times (-1)}\]

\[x = -0.3136 \text{ or } 1.9136\]

As \(x = 1 + r\), then \(r = x - 1\). We can therefore discard the solution \(-0.3136\) and instead use the other solution. Therefore the \(r\) that solves the above equation is 0.9136 or 91.36%. Note that here the answer is independent of the amounts. For example, we would have found the answer to be 91.36% regardless of whether the cash flows were \(-1m, 1.6m, 0.6m\) or \(-2m, 3.2m, 1.2m\) or \(-1bn, 1.6bn, 0.6bn\). Check this for yourself.

Excel has a built-in IRR function. For example, if you enter “=IRR({-1,1.6,0.6})” in Excel you will obtain the answer of 91.36%.

Using the IRR function in Excel gives the internal rates of return to be 38% (project A), 14.4% (project B) and 91.4% (project C), which corresponds with the order in the diagram in section 5.3.

The spreadsheet for this exercise can be found here. Please ensure you click on Section 5 and the 5.4a tab at the bottom of the spreadsheet.
It is also possible to find the IRR of any project manually. Returning to the previous example of the hot food van, buying a bigger van required a cash investment, in year 0, of $150,000. This was followed by positive cash flows of $60,000 for the next five years.

If we have an initial estimate of the NPV at 20%, we find it to be $29,436.73. If we had returned a negative value, we would then have tried a lower discount rate until we returned a positive answer. Now we re-estimate the NPV at a higher discount rate, say 30%, and find the NPV to be −$3,865.81.

We can then find the IRR via interpolation.

\[ i_0 = 0.2, \; i_1 = 0.3, \; NPV_0 = 29,436.73, \; NPV_1 = -3,865.81. \]

Inserting these values into the equation below:

\[
IRR = i_0 + (i_1 - i_0) \times \frac{NPV_0}{NPV_0 + |NPV_1|}
\]

\[
IRR = 0.2 + (0.3 - 0.2) \times \frac{29,436.73}{29,436.73 + |-3,865.81|} = 28.84\%
\]

Note the pair of vertical lines indicates the absolute value.

The actual value for IRR, found using the IRR function, was 28.65%. The relationship between NPV and \( r \), for values of \( r \) from 20% to 30%, is depicted below. Essentially, the equation above defines a chord between the coordinates (20%, $29,436.73) and (30%, −$3,865.81) and determines where that chord intersects the horizontal axis.
Example

A bespoke kitchen-maker can purchase a specialist machine for $40,000. The investment is expected to generate $20,000 and $40,000 in cash flows for two years respectively. Using the interpolation method outlined above, what is the IRR on this investment? If the kitchen-maker views the risk of the project to be commensurate with a discount rate of 20%, would you accept this project? Hint: use 25% as the initial guess and 35% as the higher guess.

<table>
<thead>
<tr>
<th>i0</th>
<th>0.25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>0</td>
</tr>
<tr>
<td>CF</td>
<td>−$40,000</td>
</tr>
<tr>
<td>PV</td>
<td>−$40,000</td>
</tr>
<tr>
<td>NPV0</td>
<td>$1,600.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>i1</th>
<th>0.35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>0</td>
</tr>
<tr>
<td>CF</td>
<td>−$40,000</td>
</tr>
<tr>
<td>PV</td>
<td>−$40,000</td>
</tr>
<tr>
<td>NPV1</td>
<td>−$3,237.31</td>
</tr>
</tbody>
</table>

IRR 28.31%
Note the “actual” IRR is 28.08%. If the hurdle rate is 20%, then on the basis of IRR this project should be accepted.

The spreadsheet for this exercise can be found [here](#). Please ensure you click on Section 5 and the 5.4b tab at the bottom of the spreadsheet.

You can change the initial guesses in the spreadsheet above and observe the impact on the interpolated IRR. You should observe that the further apart the guesses are, the less accurate is the IRR.

### 5.5 Pitfalls with using the internal rate of return

Certain cash flows can generate an NPV equal to zero at two different discount rates. Consider a project with the following cash flows:

<table>
<thead>
<tr>
<th>Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash flow</td>
<td>−$1,000,000</td>
<td>$800,000</td>
<td>$1,000,000</td>
<td>$1,300,000</td>
<td>−$2,200,000</td>
</tr>
</tbody>
</table>

The relationship between NPV and the discount rate is depicted below.
For this project there exist two IRRs: one at approximately 6.6% and another at approximately 36.6%, making it impossible to apply the IRR decision rule.

Traditional projects that require an initial investment followed by several years of positive cash flows generate a negative relationship between NPV and the discount rate. However, projects where the cash flows switch from positive to negative (and perhaps back again) produce a perverse relationship between NPV and the discount rate.

Consider a project with the following cash flows:

<table>
<thead>
<tr>
<th>Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash flow</td>
<td>$20,000</td>
<td>$-72,000</td>
<td>$86,400</td>
<td>$-34,560</td>
</tr>
</tbody>
</table>

The relationship between NPV and the discount rate is depicted below.
The IRR of this project is 20%.

This relationship is contrary to what we would normally expect. We would think that, since this project has an IRR of 20%, we should accept it. But if the opportunity cost of capital is 10%, less than the IRR, the project has a very small negative NPV and we should reject it.

The greatest weakness of the internal rate of return rule is its inability to handle mutually exclusive projects. When we have mutually exclusive projects, only one can be selected. This is in contrast to non-mutually exclusive projects where all those with a positive NPV should be accepted, since by doing so the value of the firm is increased. Examples of mutually exclusive projects include sole use of a scarce resource such as retail space or requiring one production technique to produce a product.

Example

Suppose that the Davenport Corporation has two alternative uses for a very large warehouse. It can store classic cars (investment A) or touring caravans (investment B). The cash flows are as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash flow (A)</td>
<td>−$200,000</td>
<td>$200,000</td>
<td>$20,000</td>
<td>$20,000</td>
</tr>
<tr>
<td>Cash flow (B)</td>
<td>−$200,000</td>
<td>$20,000</td>
<td>$20,000</td>
<td>$240,000</td>
</tr>
</tbody>
</table>
The chart below illustrates the NPV of these two projects at various discount rates.

![NPV Chart](chart.png)

Both projects require the same up-front investment. However, project B’s large cash flow occurs in period 3, whereas project A’s large cash flow occurs in period 1. Consequently, at lower discount rates the benefit from the extra net cash flow of $40,000 from project B makes it the preferred project. But as the discount rate rises, and the $240,000 period 3 cash flow is discounted more heavily, project A becomes the preferred project. The investment decision, at various discount rates, is detailed below:

<table>
<thead>
<tr>
<th>Discount rate</th>
<th>NPV(A)</th>
<th>NPV(B)</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td>$25,893.53</td>
<td>$44,509.23</td>
<td>Accept Project B</td>
</tr>
<tr>
<td>10%</td>
<td>$13,373.40</td>
<td>$15,026.30</td>
<td>Accept Project B</td>
</tr>
<tr>
<td>15%</td>
<td>$2,186.24</td>
<td>–$9,681.93</td>
<td>Accept Project A</td>
</tr>
<tr>
<td>20%</td>
<td>–$7,870.37</td>
<td>–$30,555.56</td>
<td>Accept neither</td>
</tr>
</tbody>
</table>

Using the NPV decision rule it is therefore clear that the decision depends on the adopted discount rate. There is one discount rate, 10.55%, where investors are indifferent between the two projects. This is referred to as the crossover rate and how to calculate it is detailed in section 5.6.
Due to the pattern of the cash flows, the NPV of project B tends towards zero faster than that of project A, and the two IRRs are 16.04% and 12.94% for projects A and B respectively. If we assume a hurdle rate of, for example, 10%, it is tempting when using the IRR rule to select project A, as the margin that the IRR has over the hurdle rate is larger. However, at a discount rate of 10%, the NPV rule would select project B. Therefore, in the face of mutually exclusive projects, the IRR rule is unable to distinguish between them.

The spreadsheet for this exercise can be found here. Please ensure you click on Section 5 and the 5.5a, 5.5b and 5.5c tabs at the bottom of the spreadsheet.

5.6 The crossover rate

The crossover rate is the discount rate at which the NPVs of two projects are equal.

Assume that the first project requires an investment of A and its cash flows at the end of years 1, 2 and 3 are \( CF_{A,1}, CF_{A,2} \) and \( CF_{A,3} \); then the NPV is:

\[
NPV_A = I_A + \frac{CF_{A,1}}{(1 + r)^1} + \frac{CF_{A,2}}{(1 + r)^2} + \frac{CF_{A,3}}{(1 + r)^3}
\]

If a second project requires an investment of B and generates cash flows of \( CF_{B,1}, CF_{B,2} \) and \( CF_{B,3} \), then the NPV is:

\[
NPV_B = I_B + \frac{CF_{B,1}}{(1 + r)^1} + \frac{CF_{B,2}}{(1 + r)^2} + \frac{CF_{B,3}}{(1 + r)^3}
\]

At the crossover rate the NPVs of the two projects are equal; hence we can find it by equating the NPV for the first project with the NPV for the second project and solving for \( r \):

\[
I_A + \frac{CF_{A,1}}{(1 + r)^1} + \frac{CF_{A,2}}{(1 + r)^2} + \frac{CF_{A,3}}{(1 + r)^3} = I_B + \frac{CF_{B,1}}{(1 + r)^1} + \frac{CF_{B,2}}{(1 + r)^2} + \frac{CF_{B,3}}{(1 + r)^3}
\]

Example

Returning to the cash flows in the Davenport Corporation example:

<table>
<thead>
<tr>
<th>Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash flow (A)</td>
<td>–$200,000</td>
<td>$200,000</td>
<td>$20,000</td>
<td>$20,000</td>
</tr>
<tr>
<td>Cash flow (B)</td>
<td>–$200,000</td>
<td>$20,000</td>
<td>$20,000</td>
<td>$240,000</td>
</tr>
</tbody>
</table>

If we want to solve this manually, we must combine both sets of cash flows into one problem, set the answer to zero and solve as in an IRR exercise.
Set this to zero by subtracting the NPV of project B from the NPV of project A:

\[
I_A - I_B + \frac{CF_{A,1}}{(1+r)^1} + \frac{CF_{A,2}}{(1+r)^2} + \frac{CF_{A,3}}{(1+r)^3} - \frac{CF_{B,1}}{(1+r)^1} - \frac{CF_{B,2}}{(1+r)^2} - \frac{CF_{B,3}}{(1+r)^3} = 0
\]

\[
I_A - I_B + \frac{(CF_{A,1} - CF_{B,1})}{(1+r)^1} + \frac{(CF_{A,2} - CF_{B,2})}{(1+r)^2} + \frac{(CF_{A,3} - CF_{B,3})}{(1+r)^3} = 0
\]

\[
200,000 - 200,000 + \frac{(200,000 - 20,000)}{(1+r)^1} + \frac{(20,000 - 20,000)}{(1+r)^2} + \frac{(20,000 - 240,000)}{(1+r)^3} = 0
\]

\[
\frac{180,000}{(1+r)^1} + 0 + \frac{-220,000}{(1+r)^3} = 0
\]

\[
\frac{180,000 - 220,000}{(1+r)^1} - \frac{220,000}{(1+r)^3} = 0
\]

\[
\frac{180,000}{(1+r)^1} = \frac{220,000}{(1+r)^3}
\]

\[
\frac{180,000}{220,000} = \frac{(1+r)^2}{(1+r)^3}
\]

\[
(1+r)^2 = \frac{220,000}{180,000}
\]

\[
r = \sqrt{\frac{220,000}{180,000}} - 1 = 10.55%
\]

The chart below confirms this result. It is clear that when the line representing the NPV of project A intersects with the line representing the NPV of project B, then the “NPVA-NPVB” line is zero.
As both projects require the same investment, the project (A-B) can be considered as having non-standard cash flows of +$180,000 in year 1 and −$220,000 in year 3. If we switch the problem around and look at NPV of A – NPV of B, then the problem looks more familiar:
As a rule it is easier to evaluate the projects at a discount rate of zero and subtract the smaller NPV from the larger. At a discount rate of 0% the NPV of project B is $80,000, while the NPV of project A is $40,000. It is then a trivial exercise to find the IRR via interpolation:

$$IRR = i_0 + (i_1 - i_0) \times \frac{NPV_0}{NPV_0 + |NPV_1|}$$

NPV of B-A at 5% = $18,615.70, NPV of B-A at 15% = $-11,868.17

$$IRR = 0.05 + (0.15 - 0.05) \times \frac{18,615.70}{18,615.70 + |-11,868.17|} = 11.1\%$$

The actual answer is 10.55%, and we would get closer to that if we chose guesses closer together. Project B is preferred when the discount rate is less than 10.55%, but when the discount rate rises to over 10.55% project A is preferred.

The spreadsheet for this exercise can be found [here](#). Please ensure you click on Section 5 and the 5.6 tab at the bottom of the spreadsheet.
5.7 Payback

After net present value (NPV) and internal rate of return (IRR), the next most popular form of investment appraisal is payback. According to Graham and Harvey, 56.74% of respondents always or almost always stated that they used the payback approach.2

Payback is extremely simple, as it merely calculates the time period taken to return the initial investment. It is often quoted in years and months or years and fractions of a year. For example, if a project requires an initial investment of $45,000 and returns cash flows of $15,000 per annum for five years, it is evident that this project returns the investment in three years. The payback period of three years would then be compared to the company’s internally determined payback period, and if the project returns the investment within this payback period it will be accepted; if it doesn’t, it will be rejected.

It is convention to assume that cash flows are evenly distributed throughout the time period. For example, revisiting the previous project, if the cash flows were $20,000 per annum then the payback period would be 2.25 years, as after year 2 $5,000 is outstanding and with a cash flow of $20,000 in year 3 this would arrive 0.25 of the way through the year.

A clear advantage of payback is that it is easy to understand and calculate. It is often used as a supplementary screening technique, especially in the case of mutually exclusive projects where IRR is unable to select the most appropriate. An obvious disadvantage of the payback approach is that it ignores the time value of money and ignores cash flows beyond the company’s payback period. To overcome the issue of ignoring the time value of money it is possible to use modified payback, whereby we determine the number of periods required not to recover the actual level of cash flows, but the present value of cash flows.

Activity 5.1

Calculate the simple payback of a project that requires investment of $60,000 followed by annual cash flows of $25,000 for three years. Assuming a discount rate of 5% per annum, then calculate the modified payback.
