



This is “Capital Budgeting Decision Making”, chapter 13 from the book [Finance for Managers \(index.html\)](#) (v. 0.1).

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## Chapter 13

### Capital Budgeting Decision Making

#### Which Project(s) Should We Undertake?

PLEASE NOTE: This book is currently in draft form; material is not final.

Life is full of choices. Should we spend our money or save it? Should we buy a new DVD or a book? Should we loan money to our unemployed cousin? All of these examples involve a tradeoff; because we did one thing, we can't do another. Businesses face the same type of decisions. Should we buy a new machine or fix the old one? Should we build the new plant in Kansas or in Mexico? To help decide which project to do, we need a framework with which to evaluate them.

Companies, like people, have many goals but limited resources. If the objective is to maximize stakeholder value, how do we choose the project with the greatest return? Capital budgeting decision making techniques are a series of analyses to help us decide which project is best. To decide which project will add the most value to the company, managers use capital budgeting techniques. This way, decisions are made based on financial data, instead of political pressure or gut instinct.

## 13.1 Introduction to Capital Budgeting Techniques

PLEASE NOTE: This book is currently in draft form; material is not final.

### LEARNING OBJECTIVES

1. Explain the difference between independent and mutually exclusive projects.
2. Apply the ideas of capital budgeting techniques to different projects.

The goal with capital budgeting is to select the projects that bring the most value to the firm. Ideally, we'd like to select all of the projects that add value, and avoid those that lose value. In an ideal situation, we can raise sufficient financing to undertake all of these value adding projects. By default, we will assume most firms are operating in this environment.

Some firms, however, have the additional limitation of using **capital rationing**<sup>1</sup>, in that they have a determined amount of funds available to allocate to capital projects, and the projects will compete for these funds. This can occur if the firm has difficulty accessing capital markets, for example. Under capital rationing, some projects that add value might not have sufficient funds to proceed, so the goal is to select the subset of profitable projects that maximizes value. There exist linear programming techniques that can be used when faced with a capital rationing constraint; they are, however, beyond the scope of this text.

We'll look at three popular decision making techniques: Payback Period, Net Present Value (NPV), and internal rate of return (IRR). There exist a multitude of lesser used techniques, many of which are variants of these three most popular, but these three are the most commonly used today.

### Independent vs. Mutually Exclusive Projects

1. When a firm has limited funds to dedicate to capital projects, and projects compete for these limited funds.

When we shop for our first car, we might find many available options that meet our minimum criteria of price, model, color, etc. Will we purchase all of those that meet the cutoff? Of course not! We only need one car, so we will pick only the best one.

We have no need of a second car, at this point in our lives, so the purchase of one car *excludes* the purchase of a second.

If only one project can be selected from a set of projects (usually by making the other options unnecessary), they are **mutually exclusive projects**<sup>2</sup>. For example, consider if our company needs more capacity to make product, and we decide to build one new plant. If we build the plant in Mexico, then we won't also want to build one in Canada, since we only need one. Projects that compete with each other or eliminate the need for the other projects are mutually exclusive. In this case, we will only select the option that is best by our decision criteria.

If, instead, we consider projects that are operationally unrelated to each other, we can choose to do none of them, all of them, or some subset of the projects. These projects are **independent projects**<sup>3</sup>, where the cash flows of one project are not influenced by the selection of other projects. If the project meets the minimum capital budgeting requirements then we should undertake the project.

#### KEY TAKEAWAYS

Capital budgeting techniques help us determine which project to undertake. First we need to determine the relevant cash flows and whether or not the projects are independent or mutually exclusive.

- Capital budgeting techniques are a series of tools to help us determine which projects to undertake.
- Only the best of mutually exclusive projects should be selected.
- All projects that meet the minimum criteria should be selected if the projects are independent.

#### EXERCISE

1. Are these mutually exclusive or independent projects?
  - a. Deciding between repairing a machine or replacing it.
  - b. Deciding which market to enter next.

2. A decision where only one project can be selected from a set of projects (usually by making the other options unnecessary).

3. A decision where the cash flows of one project are not influenced by the selection of other projects.

## 13.2 Payback Period

PLEASE NOTE: This book is currently in draft form; material is not final.

### LEARNING OBJECTIVES

1. Explain Payback Period.
2. Calculate payback period for a project.

Our first decision making technique is very intuitive and very easy to calculate. **Payback period**<sup>4</sup> is the amount of time until the initial investment is recovered. For example, a project costs \$100 and we earn \$20 (after tax) a year. We will have our \$100 back in five years. Simple enough!

Cash flows may be uneven, but this barely adds to the complexity. Consider the same project that cost \$100, but earns \$40 the first year (all after-tax), \$30 the second year, \$25 the third year, \$20 the fourth year and \$20 the fifth year? What is our payback period now? We receive our \$100th investment during the 4th year, so our payback period is between 3 and 4 full years. Some companies will always round up to the next higher year (“Our investment will be fully paid back in four years...”). Others will add some “precision” by attempting to figure out what fraction of the year has passed. The result is comprised of two parts: the number of full years and the partial year. The number of full years is our initial result, rounded down (in our example, three). If a balance remains then the partial year is the remaining cost at the beginning of the year divided by the cash flow that year. That gives us a portion of the year that it takes to get the balance of the project paid off.

*Equation 13.1 Payback Period*

Payback Period = Number of Full Years + Partial Year

*Equation 13.2 Partial Year*

$$\text{Partial Year} = \frac{\text{Unrecovered Cost Beginning of Year}}{\text{Cash Flow that Year}}$$

4. The amount of time until our initial investment is recovered.

In our example, \$95 has been recovered in the first three years, leaving  $\$100 - \$95 = \$5$ . Since we will receive \$25 dollars in the fourth year, our partial year is  $\$5 / \$20 = 0.25$ . Our total payback period is then  $3 + 0.25 = 3.25$  years.

Companies that utilize payback period will set a maximum threshold that all accepted projects must remain under. If projects are mutually exclusive, then typically the one with the shortest payback period is chosen.

### Payback Period in Action

Gator Lover's Ice Cream is a small ice cream manufacturer. Gator Lover's Ice Cream wants to either open a new store (Project A) or buy a new machine to mass produce ice cream to sell to supermarkets (Project B). The relevant cash flows are shown in Table 13.1 "Gator Lover's Ice Cream Project Analysis".

Table 13.1 Gator Lover's Ice Cream Project Analysis

	Project A	Project B
<b>Initial Investment</b>	(\$48,000)	(\$52,000)
<b>Year</b>	<b>Operating Cash Inflows (after-tax)</b>	
1	\$15,000	\$18,000
2	\$15,000	\$20,000
3	\$15,000	\$15,000
4	\$15,000	\$12,000
5	\$15,000	\$10,000
Total Years 1-5	\$75,000	\$75,000

Figure 13.1 *Timeline for Project A*

Figure 13.2 *Timeline for Project B*

Let's calculate the payback period for both projects. Project A cost \$48,000 and earns \$15,000 every year. So after three years we have earned \$45,000, leaving only

\$3,000 remaining of the initial \$48,000 investment. The cash flow in year four is \$15,000. The \$3,000 divided by \$15,000 gives us 0.2.

$$\text{Payback Period Project A} = 3 + \frac{3,000}{15,000} = 3.2 \text{ years}$$

Project B cost \$52,000 and earns back uneven cash flows. In year one the project earns \$18,000, in year two it earns \$20,000 and it earns \$15,000 in the third year. At the end of the second year it has earned back \$18,000 + \$20,000 = \$38,000, leaving \$52,000 - \$38,000 = \$14,000. In the third year the project earns \$15,000. The balance of \$14,000 will be paid off by the \$15,000 earned that year. The \$14,000 is divided by the \$15,000 to give us 0.93.

$$\text{Payback Period Project B} = 2 + \frac{14,000}{15,000} = 2.93 \text{ years}$$

If our threshold is 4 years, then both projects would be viable. If the projects are independent, then both should be undertaken. If the projects are mutually exclusive, then we would pick Project B, as the payback period is shorter.

### Shortfalls of Payback Period

Payback period may not tell the whole story. Consider a project such as researching a new drug? Development can take over a decade before positive cash flows are seen, but the potential upside could be huge! What about the cash flows that happen after the end of the payback period? Payback period is a popular tool because it's quick to calculate and easy to explain, but it is not always appropriate, and can lead to the rejection of long-term projects that add value. Often, companies will use payback period on only projects requiring smaller investments where the risk is small, and use a more complex method, such as NPV or IRR, for more involved projects.

### KEY TAKEAWAYS

Payback period is a quick and easy way to determine how long until we get our money back.

- Payback period calculates the number of whole years, plus the partial year until we are paid back.
- Payback period is a quick and easy calculation, but needs reinforcement from other capital budgeting decision methods when evaluating complex projects.

### EXERCISES

1. Calculate the payback period for the following:

Project A: Initial Cost \$80,000 earns \$19,000 per year.

Project B: Initial Cost \$100,000 earns \$25,000 per year.

2. What are the downsides of using of using payback period to analyze a project?

## 13.3 Net Present Value

PLEASE NOTE: This book is currently in draft form; material is not final.

### LEARNING OBJECTIVES

1. Define and calculate Net Present Value.
2. Apply the accept/reject decision rule of NPV.
3. Explain the limitations of Net Present Value.

Our next capital budgeting method we introduced when we discussed time value of money, and have used it to value stocks and bonds. Discounting all of the cash flows for an investment to the present, adding inflows and subtracting outflows, is called finding the **net present value (NPV)**<sup>5</sup>. The larger the NPV, the more financial value the project adds to our company; NPV gives us the project amount of value that a project will add to our company. Projects with a positive NPV add value, and should be accepted. Projects with negative NPVs destroy value, and should be rejected. It is generally regarded as the single best criterion for screening projects.

NPV considers the time value of money, because the cash flows are discounted back at the firm's rate of capital ( $r$ ). This rate, also called the discount rate or the required return, is the minimum return a firm must earn on a project to have the firm's market value remain unchanged. If the amount earned on the project exceeds the cost of capital, NPV is positive, so the project adds value and we should do the project.

#### NPV decision criteria (independent projects):

- If the NPV is greater than zero ( $NPV > 0$ ) than **accept** the project
- If the NPV is less than zero ( $NPV < 0$ ) than **reject** the project.

5. Discounting all of the cash flows for an investment to the present, adding inflows and subtracting outflows.

If funds are unlimited then we would accept any project with a positive NPV. With mutually exclusive projects, we pick the *highest* NPV (or the least negative, if we need to pick one and all are below zero). Under capital rationing, we usually want to pick the set of projects with the highest combined NPV that we can afford.

Let's look at the NPV for the two Gator Lover's Ice Cream projects. Assume a discount rate of 10%.

Project A

$$\text{NPV Project A} = (\$48,000) + \frac{\$15,000}{(1 + .10)} + \frac{\$15,000}{(1 + .10)^2} + \frac{\$15,000}{(1 + .10)^3} + \frac{\$15,000}{(1 + .10)^4} + \frac{\$15,000}{(1 + .10)^5}$$

$$\text{NPV Project A} = (\$48,000) + \$13,636.36 + \$12,396.69 + \$11,269.72 + \$10,245.20 + \$9,313.82 = \$8,861.80$$

Also written as:

$$\text{NPV Project A} = \$13,636.36 + \$12,396.69 + \$11,269.72 + \$10,245.20 + \$9,313.82 - \$48,000 = \$8,861.80$$

NPV can be calculated by hand, by a financial calculator, or in a spreadsheet. The keystrokes for a financial calculator are as follows:

<CF> <2ND> <CLR WORK> -48000 <ENTER> <DOWN ARROW> 15000 <ENTER> <DOWN ARROW> 5 <ENTER> <NPV> 10 <ENTER> <DOWN ARROW> <CPT>

Note: Excel and other spreadsheet programs are tricky with regard to year 0. The NPV function expects flows to start at year 1. So any cash flows from year 0 need to be added separately.

To solve in a spreadsheet, the corresponding spreadsheet formula is:

$$=\text{NPV}(\text{periodic rate, cash flows from period 1 to } n) + \text{net of initial cash flows}$$

Using the numbers for Project A, the spreadsheet function looks like this:

$$=\text{NPV}(.10, 15000, 15000, 15000, 15000, 15000) + (-48000) = 8861.80$$

Project B

$$\text{NPV Project B} = (\$52,000) + \frac{\$18,000}{(1 + .10)} + \frac{\$20,000}{(1 + .10)^2} + \frac{\$15,000}{(1 + .10)^3} + \frac{\$15,000}{(1 + .10)^4} + \frac{\$15,000}{(1 + .10)^5}$$

$$\text{NPV Project B} = (\$52,000) + \$16,363.64 + \$16,528.93 + \$11,269.72 + \$8,196.16 + \$6,209.21 = \$6,567.66$$

In this case, **Project A has the higher NPV by \$2,294.14** (\$8,861.80–6,567.66). So we would pick Project A over Project B if they are mutually exclusive. If they are independent, we would accept both projects, since both NPVs are positive.

Figure 13.3 Project A NVP

Figure 13.4 Project B NVP

Net Present Value is the preferred tool by many financial managers, as it properly accounts for the time value of money and the cost of capital. The NPV rule easily handles both mutually exclusive and independent projects.

### Shortfalls of NPV

NPV is a little less intuitive than payback period, so it might be more difficult to explain to others who aren't as well versed in finance. To use NPV requires a discount rate; if we don't have an accurate gauge of the cost of capital, it can be difficult to calculate an NPV.

#### KEY TAKEAWAYS

Net Present Value is the most important tool in capital budgeting decision making. It projects the financial value of the project for the company.

- Net Present Value is the discounted value of all cash flows.
- It is considered to be the best single criterion.
- Positive NPV adds value to a company.
- Accept any project with positive NPV for independent projects.
- Accept the highest NPV project from mutually exclusive projects.

## EXERCISES

1. Calculate the NPV for the following projects with a discount rate of 12%:

Project 1 costs \$100,000 and earns \$50,000 each year for three years.

Project 2 costs \$200,000 and earns \$150,000 in the first year, and then \$75,000 for each of the next two years.

Project 3 costs \$25,000 and earns \$20,000 each year for three years.

2. If the projects are mutually exclusive, which should we accept?
3. If the projects are independent, which should we accept?

## 13.4 Internal Rate of Return

PLEASE NOTE: This book is currently in draft form; material is not final.

### LEARNING OBJECTIVES

1. Define and calculate the internal rate of return (IRR).
2. Apply the accept/reject decision rule for IRR.
3. Explain the limitations of IRR.

**Internal rate of return (IRR)**<sup>6</sup> is another widely used capital budgeting technique; essentially, it is the return we will receive over the life of our investment. It is calculated as the discount rate at which NPV equals zero. In other words, we set NPV equal to \$0 and solve for  $r$ . This is the rate that makes the present value of the cash flows equal to the initial investment. Unfortunately, for some projects there is no easy way to arrive at this rate without using a “guess and check” method; thankfully, computers can do this quite quickly.

How do we know if the project is acceptable or not? Each project that uses internal funds has a cost of capital. If the rate we earn is more than the rate it costs us, then we should undertake the project as it adds to corporate value. If what we earn is less than what it cost us, then the project subtracts from corporate value, and we should not undertake it. To do this we compare IRR to the cost of capital. If the IRR is greater than the cost of capital we should undertake the project.

This decision criterion will only work if the cash flows are ordinary, meaning net outflows early in the project followed by inflows afterward. When cash flows are not ordinary, IRR can produce unusual, sometimes multiple, results.

Here are our decision rules:

**IRR decision criteria (ordinary cash flows ONLY):**

6. The discount rate where the NPV of an investment equals zero.

- If the IRR is greater than cost of capital ( $IRR > WACC$ ) than **accept** the project
- If the IRR is less than cost of capital ( $IRR < WACC$ ) than **reject** the project.

Let's find the IRR for Gator Lover's Ice Cream potential projects by taking a look at Table 13.2 "Gator Lover's Ice Cream: Internal Rate of Return".

Table 13.2 Gator Lover's Ice Cream: Internal Rate of Return

Firm's Cost of Capital = 10%		
	Project A	Project B
<b>Initial Investment</b>	(\$48,000.00)	(\$52,000.00)
<b>Year</b>	<b>Operating Cash Inflows(after-tax)</b>	
1	\$15,000.00	\$18,000.00
2	\$15,000.00	\$20,000.00
3	\$15,000.00	\$15,000.00
4	\$15,000.00	\$12,000.00
5	\$15,000.00	\$10,000.00
<b>IRR</b>	16.99%	15.43%

If our WACC is 10%, then both projects should be accepted. IRR is, however, not acceptable for mutually exclusive projects! To see why, consider the following example—Which investment would you rather have:

1. Invest \$10,000 now and receive a guaranteed \$20,000 in one year.
2. Invest \$1 now and receive a guaranteed \$10 in one year.

Investment A is double your money ( $IRR = 100\%$ ) while investment B is ten times your money ( $IRR = 900\%$ ). But investment A is on a larger starting sum! We'd love to do investment B over and over again, since it has the higher return, but if we can only pick one of the two, then A is superior. Thus, the higher IRR doesn't necessarily indicate the better investment.

IRR can be calculated by hand, by a financial calculator, or in a spreadsheet. The keystrokes for a financial calculator are similar as those for NPV, but at the

conclusion we ask for IRR instead of entering an interest rate. For example, IRR for Project A is as follows:

```
<CF> <2ND> <CLR WORK> -48000 <ENTER> <DOWN ARROW> 15000 <ENTER> <DOWN ARROW> 5 <ENTER> <IRR> <CPT>
```

The answer of 16.99% is returned.

To solve in a spreadsheet, the corresponding spreadsheet formula is:

=IRR(cash flows from period 0 to  $n$ )

Using the numbers for Project A, the spreadsheet function looks like this:

=IRR(-48000, 15000, 15000, 15000, 15000, 15000) = 16.99%

### Shortfalls of IRR

IRR is more difficult than NPV to calculate by hand because we are calculating a rate of return. Our calculators or spreadsheets ‘search’ for the interest rate. For us to calculate, it would take iterations where we try one interest rate, see if it’s too high or too low and then try again.

Cash flows that aren’t ordinary can produce unusual, sometimes multiple, results. Sadly, most calculators won’t alert the user to this fact, so care must be taken. And in the case of mutually exclusive projects, IRR fails to rank them properly. For these reasons, NPV is typically the preferred criteria, or is at least used to “double check” that IRR isn’t failing because of one of these unusual reasons.

#### KEY TAKEAWAYS

IRR is another method of capital budgeting techniques. We prefer NPV to IRR because of IRR’s potential shortfalls.

- IRR is defined as the discount rate where  $NPV = 0$ .
- IRR should never be used if cash flows aren’t ordinary, or if the projects are mutually exclusive.

## EXERCISES

1. Calculate the IRR for the projects listed in NPV exercises.
2. Which has the highest IRR?
3. If our hurdle rate is 10%, which should we accept?

## 13.5 Other Methods

PLEASE NOTE: This book is currently in draft form; material is not final.

### LEARNING OBJECTIVES

1. Evaluate some other methods to evaluating capital budgeting.
2. Calculate Profitability Index.
3. Discuss MIRR.

So far we have learned payback period, NPV and IRR. These three are the most widely used and methods to evaluate capital projects, and are sufficient for most companies, but many other methods exist. Here we'll discuss two other methods: Profitability index and MIRR.

**Profitability index (PI)**<sup>7</sup> shows the relative profitability of any project: in essence, a 'bang for your buck' calculation. It is the present value per dollar of initial cost. The higher the profitability index, the better, and any PI greater than 1.0 indicates that the project is acceptable because it adds to corporate value.

*Equation 13.3 Profitability Index*

$$\text{Profitability Index} = \frac{\text{Present Value of Future Cash Flows}}{\text{Initial Cost}}$$

For Gator Lover's the PI's are as follows:

$$\text{Profitability Index Project A} = \frac{\$58,861.80}{\$48,000} = 1.22$$

$$\text{Profitability Index Project B} = \frac{\$56,567.66}{\$52,000} = 1.08$$

7. Present value return per dollar of investment.

The profitability index is higher for Project A. PI doesn't work as well if the initial investment is spread out over time, or if the cash flows aren't ordinary, which is why we prefer NPV.

Our final method of evaluating capital projects worth discussing is **modified internal rate of return (MIRR)**<sup>8</sup>. IRR is the expected rate of return if the NPV = 0. This assumes that early inflows will be reinvested at the return of the project itself! Often, the funds earned from a project cannot be reinvested at IRR, but instead earn a lower rate. Therefore, *IRR can overstate the expected rate of return*. To compensate for this overstatement, modified internal rate of return (MIRR) was created. MIRR assumes that funds can be reinvested at the weighted average cost of capital (WACC) or some other specifically stated rate.

In our IRR example, we used a hurdle rate of 10%. But what if the inflows could only be reinvested at 8%? To calculate MIRR, we would use the 8%. Lucky for us, spreadsheets have a function to do this quite easily:

=MIRR(cash flows from period 0 to n, rate for outflows, reinvestment rate)

Project A MIRR (reinvested at 8%) = 12.89%

Project B MIRR (reinvested at 8%) = 11.63%

Compared with our original IRRs of 12.88% for Project A and 15.43% for Project B, it's easy to see that the reinvestment rate has a large impact. Some shortfalls, however: it's harder to calculate (esp. without technology), and requires knowledge of the WACC. If we have the WACC, however, why not calculate NPV?

### So Which Project Wins?

Table 13.3 "Gator Lover's Ice Cream: Summary Chart for Capital Budgeting Decision Making Techniques" a summary chart for the capital budgeting decision making techniques for Gator Lover's Ice Cream's potential projects: Project A and Project B.

Table 13.3 Gator Lover's Ice Cream: Summary Chart for Capital Budgeting Decision Making Techniques

	Project A	Project B
<b>Initial Investment</b>	(\$48,000)	(\$52,000)

8. Internal rate of return assuming that the funds earned cannot be reinvested at IRR.

	Project A	Project B
Technique		
Payback Period	3.2 years	2.8 years
NPV	\$8,861.80	\$6,567.66
IRR	16.99%	15.43%
Profitability Index	1.22	1.08
MIRR	12.89%	11.63%
<b>Winner!</b>	<b>Project A</b>	

And the winner is...Project A. While Project B has a faster payback period, Project A wins in every other category, especially the critical NPV category. If we can only choose one project, Gator Lover's Ice Cream should open a new store (Project A) instead of investing in a new machine (Project B). Of course, if we can do both, that should be our choice.

### KEY TAKEAWAYS

There exist other methods to evaluate projects. We learned Profitability Index and MIRR

- Profitability index is bang for your buck.
- MIRR assumes a different reinvestment rate than IRR.

### EXERCISES

1. Calculate PI for Exercises 1 & 2 in [Section 13.3 "Net Present Value"](#).
2. Explain how the MIRR would compare to IRR for the projects in Exercises 1 & 2 in [Section 13.3 "Net Present Value"](#) if the reinvestment rate is 8%.

## 13.6 Comparing Projects with Unequal Lives

PLEASE NOTE: This book is currently in draft form; material is not final.

### LEARNING OBJECTIVES

1. Explain the difficulty in choosing between mutually exclusive projects with unequal lives.
2. Calculate the equivalent annual annuity (EAA) of a project and use it to evaluate which project is superior.

*Ruth is deciding which shingles to put on her roof. Shingle A costs \$1 per sq. ft. and is rated to last 10 years. Shingle B costs \$1.40 per sq. ft. and is rated to last 15 years. If Ruth intends to stay in her house for the rest of her life, which shingle should Ruth select?*

One particularly troublesome comparison that arises often is when two repeatable mutually exclusive projects have different time lengths. For example, we can use a cheaper substitute, but it won't last as long, so we'll need to replace it more frequently. How do we know which project is better?

If the projects are either independent or not repeatable, we can use NPV confidently. All positive NPVs should be selected if they are independent, and the highest NPV will indicate the best choice if they aren't repeatable. But it can be the case that the highest NPV project can be inferior to a shorter project with a lower NPV.

To analyze this problem, we need to calculate the **equivalent annual annuity (EAA)**<sup>9</sup>, which is the steady cash payment received by an annuity with the same length and NPV as the project. For example, we know that Gator Lover's Ice Cream Project A lasted for 5 years and had an NPV of \$8,861.80 at a rate of 10%. If we solve for the yearly payment of an annuity with a PV of \$8,861.80,  $r = 10\%$ ,  $n = 5$  years, and  $FV = 0$ , we get an EAA of \$2,337.72. Thus, we should be indifferent between receiving the cash flows of Project A and receiving \$2,337.72 per year for 5 years (since they both have the same NPV)!

9. The steady cash payment received by an annuity with the same length and NPV as the project.

Once EAAs are calculated for all projects being considered, it's a simple matter of picking the higher one.

### KEY TAKEAWAYS

- If projects are independent or not repeatable, the impact of differing life is irrelevant.
- If the projects are mutually exclusive and repeatable, then the impact of the differing life must be accounted for by comparing their EAA.

### EXERCISES

1. Compute and compare the following projects' NPVs and EAAs at a 10% discount rate.

Project J costs \$100,000 and earns \$50,000 each year for five years.

Project K costs \$200,000 and earns \$150,000 in the first year and then \$75,000 for each of the next three years.

Project L costs \$25,000 and earns \$20,000 each year for two years.

2. Which project should be selected if they are mutually exclusive and repeatable?

## 13.7 Approaches for Dealing with Risk

PLEASE NOTE: This book is currently in draft form; material is not final.

### LEARNING OBJECTIVES

1. Explain risk in capital budgeting.
2. Describe and implement scenario analysis.
3. Describe and implement sensitivity analysis.

We have estimated the potential earnings from our projects, but what about the risk involved? What's the likelihood that we estimated these cash flows properly? What the numbers are much worse? Ideally, the systematic risk involved with our project has been accounted for by our WACC used (see previous chapter for discussion of this), but managers still need to account for projection errors and evaluate the potential range of outcomes. There are several ways to deal with risk in capital budgeting. We present two of the most common here: scenario analysis and sensitivity analysis.

**Sensitivity analysis**<sup>10</sup> measures the sensitivity of our project to a change in one variable. Also called “what-if” analysis, it looks at how sensitive our outcome is to a change in one variable (for example, projected sales). Intuitively we know that our outcome is more dependent on certain inputs to our equation than to other inputs. If we change just that one variable (holding everything else constant), how much does the outcome change? Sensitivity analysis tells us by how much are we more sensitive to a change in sales than we are to a change in, say, WACC or some other variable. We can then dedicate resources to ensure a more accurate estimate for the inputs with the larger effects.

**Scenario analysis**<sup>11</sup> gives us several different ‘scenarios’ or likely outcomes for our project. We can analyze what will happen if we have a best-case, worst-case and most-likely-case scenario. This measures the variability of the returns and can present us with a variety of situations and financial outcomes so that we are adequately prepared for each one. In scenario analysis we can change many variables and estimate a new outcome. We can then look at the ‘range’ of possible

10. Indicates how much NPV will change if we change one particular variable.

11. Uses several possible scenarios to determine the range of possible NPV outcomes.

outcomes by analyzing the difference between the best-case and worst-case scenarios.

For Project A, we had annual cash inflows (after-tax) of \$15,000 for five years. But what if our worst-case scenario occurred and the annual cash flows were only \$10,000 per year? Or what if, best case, we earned \$20,000 per year? What would our NPV be under each of these different scenarios? Let's calculate.

Table 13.4 Gator Lover's Ice Cream: Best Case, Worst Case, and Likely Scenarios

		Project A	
Initial Investment		(\$48,000)	r = 10%
<b>Operating Cash Inflows</b>			
Year	Best Case	Most Likely	Worst Case
1	\$20,000	\$15,000	\$10,000
2	\$20,000	\$15,000	\$10,000
3	\$20,000	\$15,000	\$10,000
4	\$20,000	\$15,000	\$10,000
5	\$20,000	\$15,000	\$10,000
Total	\$100,000	\$75,000	\$50,000
NPV	\$27,815.74	\$8,861.80	(\$10,092.13)

From Table 13.4 "Gator Lover's Ice Cream: Best Case, Worst Case, and Likely Scenarios", we see that our previous NPV calculation was the most likely case and it had a positive NPV of \$8,861.80. The best case provides NPV equal to \$27,815.74 and the worst-case has a negative NPV of \$10,092.13. The **NPV range**<sup>12</sup> is the difference between the best case and the worst-case or in this situation a range of \$37,907.87. We can hopefully earn somewhere between a negative \$10,092 and a positive \$27,815. Obviously we hope for the \$27,815! But it's helpful to know that we may lose \$10,092 under the worst-case scenario.

There are several other techniques a company can use to deal with risk in capital budgeting. Other, more sophisticated techniques exist (such as simulation analysis), but they are beyond the scope of this text.

12. The difference between the best-case scenario and the worst-case scenario NPV.

### KEY TAKEAWAYS

Risk is important to consider in capital budgeting. Fortunately we have several techniques to deal with risk.

- Sensitivity Analysis tells us how sensitive our NPV is to changes in one key input.
- Scenario Analysis gives us a NPV range between the best and worst case scenarios, and models the most likely outcomes.

### EXERCISES

1. Project J costs \$100,000 and is projected to earn \$50,000 each year for five years, with a discount rate of 10%. Calculate how sensitive NPV is to our discount rate if it might be as high as 12%.
2. Compute the NPV for the best case scenario if Project J earns \$75,000 per year and the discount rate is only 9%.

## 13.8 The Bigger Picture

PLEASE NOTE: This book is currently in draft form; material is not final.

### LEARNING OBJECTIVES

1. Explain how capital budgeting decisions fit into the larger picture of corporate finance.
2. Evaluate the ethical implication of capital budgeting decisions.

In many ways, this chapter is the culmination of all that has come before in the text. All of our discussion has given us the tools to evaluate projects and be informed about the financial value of projects that we might undertake. Managers can use these criteria to approve positive value projects, which should increase the value of the company. In future chapters, we examine what make up the cash flows that we are analyzing, and how we might influence the inputs of a project.

Every successful business argument for going forward with a project should be rooted in the information presented in this chapter. While there might be considerations beyond the finances, without a financial valuation it is impossible for a manager to grasp the implication on stakeholders' value.

### Ethical Considerations

It is tempting to proclaim “NPV positive means accept the project” without thinking of the ramifications of such a decision. Purchasing a new machine might mean that jobs will be lost or pollution reduced. It is impossible to accurately put a financial value on a life lost, and yet every day we must make decisions that account for a trade-off among these types of factors.

Just as it is important not to make a decision without understanding the financial impact, it would be folly to limit ourselves to only this perspective.

### KEY TAKEAWAYS

- Making decisions is ultimately what everyone in business does. These tools allow us to properly factor in financial value to make decisions.
- When making decisions, we need the numbers, but we also need to look beyond the numbers.

### EXERCISES

1. Even factoring in potential litigation costs, the NPV for recalling a car with a faulty gas tank is lower than the decision to do nothing. What are some other considerations a manager should incorporate into the decision making process?
2. We have the technology to build a car that would eliminate deaths in car crashes. Granted, it would look and drive like a tank and cost \$1 million. Should we mandate that all cars be so designed? If not, haven't we put a price on those lives that will be lost in future car crashes?

## 13.9 End-of-Chapter Assessment Problems

PLEASE NOTE: This book is currently in draft form; material is not final.

### END-OF-CHAPTER EXERCISES

- 1.
- 2.
- 3.
- 4.
- 5.