5

ALLOWING FOR RISK IN PROJECT APPRAISAL

Case study 5.1

Two risky ventures . . .

One that will (probably) not pay off . . .

The £200 billion gamble – Wireless Telecommunications

In 2000 the telecom companies of Europe committed themselves to what may prove to be one of the biggest gambles ever. They agreed to pay £80–£100bn to purchase 3G (third generation) licenses from various European governments. As a result they will be able to offer internet access from mobile phones.

The 'winners' of the auctions for licenses will, in addition to handing over thousands of millions to government, have to invest another £100bn building the infrastructure needed to deliver the service to the customer supposedly hungry for internet-enabled phones. By the middle of 2001, so great was the outflow of cash that major telecommunication companies had become burdened with extraordinary amounts of debt. For example, in 1998 BT had debts of roughly £1bn. Over the next three years these rose to over £20bn and serious concern was expressed in the City of London about the excessive debt. Over the same period France Telecom's debt rocketed to over €63bn and Deutche Telekom's went to €60bn. Shares tumbled as shareholders worried that too much was being paid for projects based on a high degree of optimism. Nobody knows whether consumers really want to surf the internet with their phones. Furthermore, the level of competition is likely to be so intense that the companies may lose money even with millions of customers.

Perhaps, as the new technology develops, an application will be discovered that induces consumers rush to pay for and the investment projects turn out to be very rewarding for shareholders. Perhaps the 3G projects will be superseded by new technology (4G?) before they are properly up and running. The truth is that we will not know for many years. Such is the fun and excitement of real world business decisions!

And one that did . . .

Camelot

Camelot bid for, and won, the right to create the UK's national lottery. They invested in a vast computer network linking 30,000 retail outlets and paid for 300 man-years to develop specialized software. Camelot also had to train 91,000 staff to operate the system, which can handle over 30,000 transactions a minute, and spend large amounts on marketing. The gamble seems to have paid off. In 2003 the Camelot produced a pre-tax profit of £42.3m. The owners of Camelot – Cadbury Schweppes, De La Rue, Fujitsu, Thales Electronics and Royal Mail Enterprises – have a political battle on their hands trying to persuade the public and authorities that they took a risk and things happened to turn out well. It could have been so different; they could have made a multi-million pound investment followed by public indifference and enormous losses.

Source for Camelot: – based on *Financial Times*, 5 June 1996, Camelot's annual report 2003.

Introduction

Businesses operate in an environment of uncertainty. The 3G gamble and Camelot examples show that managers can never by sure about what will happen in the future. There is the upside possibility of events turning out to be better than anticipated and the downside possibility of everything going wrong. Implementing an investment project requires acceptance of the distinct possibility that the managers have got it wrong; that the project or enterprise will result in failure. However, to avoid any chance of failure means the adoption of a 'play-safe' or 'do-nothing' strategy. This may itself constitute a worse business sin, that of inertia, and will result in greater failure. There has to be an acceptance of risk and of the potential for getting decisions wrong, but this does not mean that risk cannot by analyzed and action taken to minimize its impact.

What is risk?

A key feature of project appraisal is its orientation to the future. Management rarely has precise forecasts regarding the future return to be earned from an investment. Usually the best that can be done is to make an estimate of the range of the possible future inflows and outflows. There are two types of expectations individuals may have about the future: certainty and uncertainty.

- *Certainty* Under expectations of certainty, future outcomes can be expected to have only one value. That is, there is not a variety of possible future eventualities – only one will occur. Such situations are rare, but there are some investments that are a reasonable approximation to certainty, for instance, lending to a reputable government by purchasing three-month Treasury bills. Unless you are very pessimistic and expect catastrophic change over the next three months, such as revolution, war or a major earthquake, then you can be certain of receiving your original capital plus interest. A firm could undertake a project that had almost complete certainty by investing its funds in Treasury bills, and receiving a return of, say, 4 percent per year. Shareholders may not, however, be very pleased with such a low return.
- *Risk and uncertainty* The terms risk and uncertainty are used interchangeably in the subsequent analysis. Strictly speaking, risk occurs when specific probabilities can be assigned to the possible outcomes. Uncertainty applies in cases when it is not possible to assign probabilities. Risk describes a situation where there is not just one possible outcome, but an array of potential returns. Also we assume that we know the probabilities for each of the possible futures. The range and distribution of these possible outcomes may be estimated on the basis of either objective probabilities or subjective probabilities (or a combination of the two).

Objective probabilities

An objective probability can be established mathematically or from historical data. The mathematical probability of a tossed coin showing a head is 0.5. The probability of taking the Ace of Hearts from a pack of 52 cards is 0.0192 (or 1/52). A probability of 0 indicates nil likelihood of outcome. A probability of 1 denotes that there is absolute certainty that this outcome will occur. A probability of 0.3 indicates that there is an expectation that in three times out of ten this will occur. The probabilities for all possible outcomes must sum to 1. We will now examine an example of an objective probability assessment based on historical data for the supermarket retailer Safeburys. If the firm is considering a project that is similar to numerous projects undertaken in the past it may be able to obtain probabilities for future profitability. For instance, Safeburys is examining the proposal to build and operate a new supermarket in Birmingham. Because the firm has opened and operated 100 other supermarkets in the past, and has been able to observe their profitability it is able to assign probabilities to the performance of the supermarket it is proposing to build (*see* Table 5.1 and Figure 5.1).

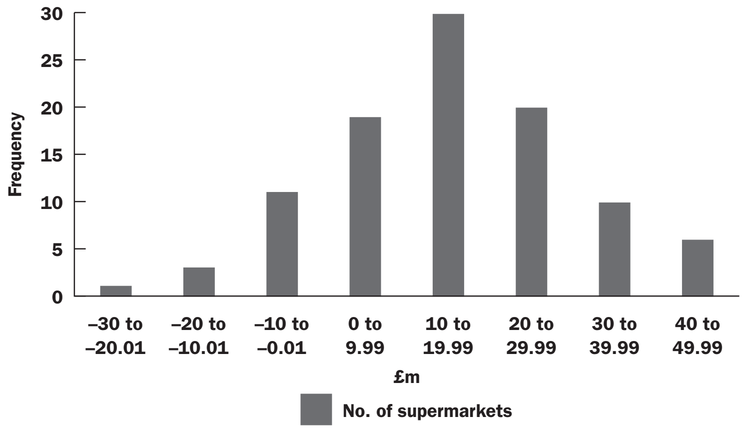
TABLE 5.1
Safeburys' profitability frequency distribution of existing 100 supermarkets

Profitability range (£m)	Frequency (Number of stores)	Probability
–30 to –20.01	1	0.01
–20 to –10.01	3	0.03
–10 to –0.01	11	0.11
0 to 9.99	19	0.19
10 to 19.99	30	0.30
20 to 29.99	20	0.20
30 to 39.99	10	0.10
40 to 49.99	6	0.06
TOTAL	**100**	**1.00**

An examination of this sort of historical record may be a useful first step in the process of making a decision. However, it must be borne in mind that the probabilities may have to be modified to take into account the particular circumstances surrounding the site in Birmingham. For instance, demographic trends, road connections and competitor activity may influence the probabilities for profit or loss. Even with large quantities of historical data there is often still a lot of room for subjective assessment in judging the range of possible outcomes.

Even with large quantities of historical data there is often still a lot of room for subjective assessment.

FIGURE 5.1
Frequency distribution of supermarket profitability



Subjective probabilities

In many project assessments there are no past records to help in the creation of the distribution of probabilities profile. For instance, the product may be completely new, or a foreign market is to be entered. In situations like these, subjective probabilities are likely to dominate, that is, personal judgment of the range of outcomes along with the likelihood of their occurrence. Managers, individually or collectively, must assign probability numbers to a range of outcomes.

It must be acknowledged that the probabilities assigned to particular eventualities are unlikely to be entirely accurate and thus the decision-making that follows may be subject to some margin of error. But consider the alternative of merely stating the most likely outcomes. This can lead to less well-informed decisions and greater errors. For example, a firm might be considering two mutually exclusive projects, A and B. Both projects are expected to be shareholder-wealth-enhancing, based on the estimate of the most likely outcome. The most likely outcome for A is for it to be shareholder-wealth-enhancing, with a 95 percent chance of occurrence. Similarly the most likely outcome for B is a shareholder-wealth-enhancing return, with a 55 percent chance of occurrence (*see* Table 5.2).

TABLE 5.2
Probability outcomes for two projects

Outcome	Project A probability	Project B probability
Shareholder-wealth-enhancing	0.95	0.55
Not shareholder-wealth-enhancing	0.05	0.45

By using probabilities, a more informed decision is made. The project appraiser has been forced to consider the degree of confidence in the estimate of expected viability. It is clear that Project A is unlikely to fail, whereas Project B has a fairly high likelihood of failure. We will examine in detail the use of probability distribution for considering risk later in the chapter, but now turn to more pragmatic, rule-of-thumb and intuitively easier methods for dealing with project risk.

Adjusting for risk through the discount rate

A traditional and still popular method of allowing for risk in project appraisal is the risk premium approach. The logic behind this is simple: investors require a greater reward for accepting a higher risk – the more risky the project the higher the minimum acceptable rate of return. In this approach a number of percentage points (the premium) are added to the risk-free discount rate. (The risk-free rate of return is usually taken from the rate available on government bonds.) The risk-adjusted discount rate is then used to calculate net present value in the normal manner.

An example is provided by Sunflower plc, which adjusts for risk through the discount rate by adding various risk premiums to the risk-free rate depending on whether the proposed project is judged to be low, medium or high risk (*see* Table 5.3). This is an easy approach to understand and adopt, which explains its continued popularity.

Drawbacks of the risk-adjusted discount rate method

The risk-adjusted discount rate method relies on an accurate assessment of the riskiness of a project. Risk perception and judgment are bound to be, to some extent, subjective and susceptible to personal bias. There may also be a high degree of arbitrariness in the selection of risk premiums. In reality it is extremely difficult to allocate projects to risk classes and identify appropriate risk premiums as personal analysis and casual observation can easily dominate.

Risk perception and judgment are subjective and susceptible to personal bias.

Sensitivity analysis

The net present values calculated in previous chapters gave a static picture of the likely future outcome of an investment project. In many business situations it is desirable to generate a more complete and realistic impression of what may happen to NPV in conditions of uncertainty. Net present value calculations rely on the appraiser making assumptions about some crucial variables: for example

TABLE 5.3
Adjusting for risk – Sunflower plc

Level of risk	Risk-free rate (%)	Risk premium (%)	Risk-adjusted rate (%)
Low	9	+3	12
Medium	9	+6	15
High	9	+10	19

The project currently being considered has the following cash flows:

Point in time (yearly intervals)	0	1	2
Cash flow (£)	–100	55	70

If the project is judged to be low risk:

$$\text{NPV} = -100 + \frac{55}{1 + 0.12} + \frac{70}{(1 + 0.12)^2} = +£4.91$$ **Accept**

If the project is judged to be medium risk:

$$\text{NPV} = -100 + \frac{55}{1 + 0.15} + \frac{70}{(1 + 0.15)^2} = +£0.76$$ **Accept**

If the project is judged to be high risk:

$$\text{NPV} = -100 + \frac{55}{1 + 0.19} + \frac{70}{(1 + 0.19)^2} = -£4.35$$ **Reject**

the sale price of the product, the cost of labor and the amount of initial investment are all set at single values for input into the formula. It might be enlightening to examine the degree to which the viability of the project changes, as measured by NPV, as the assumed values of these key variables are altered. An interesting question to ask might be: If the sale price is raised by 10 percent, by what percentage would NPV increase? In other words, it would be useful to know how sensitive NPV is to changes in component values. Sensitivity analysis is essentially a 'what-if' analysis – for example, what if labour costs are 5 percent lower? or, What if the raw materials double in price? By carrying out a series of calculations it is possible to build up a picture of the nature of the risks facing the project and their impact on project profitability. Sensitivity analysis can identify the extent to which variables may change before a negative NPV is produced. A series of 'what-if?' questions are examined in the example of Acmart plc.

Worked example 5.1
ACMART PLC

Acmart plc has developed a new product line called Marts. The marketing department in partnership with senior managers from other disciplines have estimated the likely demand for Marts at 1,000,000 per year, at a price of £1, for the four-year life of the project. (Marts are used in mobile telecommunications relay stations and the market is expected to cease to exist or be technologically superseded after four years.)

If we can assume perfect certainty about the future then the cash flows associated with Marts are as set out in Table 5.4:

TABLE 5.4
Cash flows of Marts

Initial investment	£800,000	
Cash flow per unit		£
Sale price		1.00
Costs		
Labor	0.20	
Materials	0.40	
Relevant overhead	0.10	
		(0.70)
Cash flow per unit		0.30

The finance department have estimated that the appropriate required rate of return on a project of this risk class is 15 percent. They have also calculated the expected net present value.

Annual cash flow = 30p × 1,000,000 = £300,000.

Present value of annual cash flows

= 300,000 × annuity factor for 4 years @ 15%

		£
	= 300,000 × 2.855	= 856,500
Less initial investment		–800,000
Net present value		+56,500

The finance department are aware that when the proposal is placed before the capital investment committee they will want to know how the project NPV changes if certain key assumptions are altered. As part of the report the finance team ask some 'what-if?' questions and draw a sensitivity graph.

■ *What if the price achieved is only 95p (5% below the expected £1) for sales of 1m units (all other factors remaining constant)?*

Annual cash flow = 25p × 1m = £250,000.

	£
250,000 × 2.855	713,750
Less initial investment	800,000
Net present value	–86,250

■ *What if the price rose by 1%?*

Annual cash flow = 31p × 1m = £310,000.

	£
310,000 × 2.855	885,050
Less initial investment	800,000
Net present value	+85,050

■ *What if the quantity demanded is 5% more than anticipated?*

Annual cash flow = 30p × 1.05m = £315,000.

	£
315,000 × 2.855	899,325
Less initial investment	800,000
Net present value	+99,325

■ *What if the quantity demanded is 10% less than expected?*

Annual cash flow = 30p × 900,000 = £270,000.

	£
270,000 × 2.855	770,850
Less initial investment	800,000
Net present value	–29,150

■ *What if the appropriate discount rate is 20% higher than originally assumed (that is, it is 18% rather than 15%)?*

300,000 × annuity factor for 4 years @ 18%.

	£
300,000 × 2.6901	807,030
Less initial investment	800,000
	+7,030

■ *What if the discount rate is 10% lower than assumed (that is, it becomes 13.5%)?*

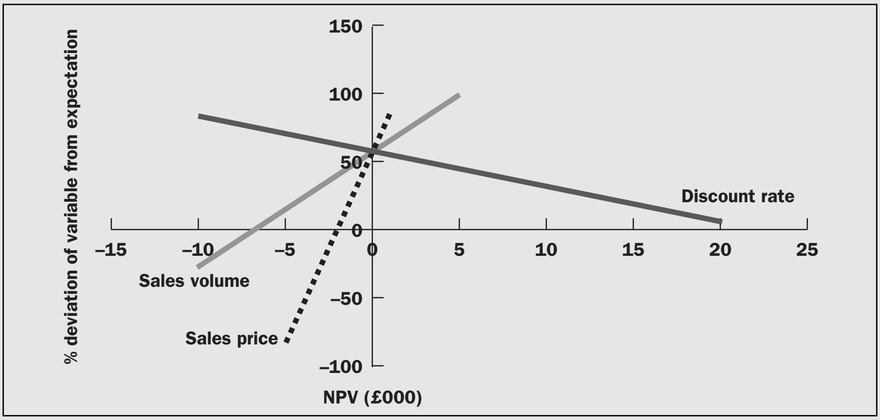
300,000 × annuity factor for 4 years @ 13.5%.

	£
300,000 × 2.944	883,200
Less initial investment	800,000
	+83,200

These findings can be summarized more clearly in a sensitivity graph (*see* Figure 5.2).

An examination of the sensitivity graph gives a clear indication of those variables to which NPV is most responsive. This sort of technique can then be extended to consider the key factors that might cause a project to become unviable. This allows the management team to concentrate their analysis, by examining in detail the probability of actual events occurring which would alter the most critical variables. They may also look for ways of controlling the factors to which NPV is most sensitive in any future project implementation. For example, if a small change in material costs has a large impact, the managers may investigate ways of fixing the price of material inputs.

FIGURE 5.2
Sensitivity graph for Marts



The break-even NPV

The break-even point, where NPV is zero, is a key concern of management. If the NPV is below zero the project is rejected; if it is above zero it is accepted.

The finance team at Acmart now calculate the extent to which some of the variables can change before the decision to accept changes to a decision to reject. (We will not go through all the possible variables.)

- ***Initial investment***. If this rises by £56,500 NPV will be at zero (i.e. Break-even NPV). A percentage increase of:

$$\frac{£56{,}500}{£800{,}000} \times 100 = 7.06\%$$

- ***Sales price***. The cash flow per unit (after costs), c, can fall to 28p before break-even is reached:

$$800{,}000 = c \times 1{,}000{,}000 \times 2.855$$

$$c = \frac{800{,}000}{2.855 \times 1{,}000{,}000} = 0.2802$$

Thus the price can decline by only 2% from the original price of £1. An alternative approach is to look up the point at which the sales price line crosses the NPV axis in the sensitivity graph.

- *Material cost* If the cash flow per unit can fall to 28p before break-even is reached, 2p can be added to the price of materials before the project produces a negative net present value (assuming all other factors remain constant). In percentage terms the material cost can rise by 5% ((2 ÷ 40) × 100) before break-even is reached.
- *Discount rate* We need to calculate the annuity factor that will lead to the four annual inflows of £300,000 equaling the initial outflow of £800,000 after discounting.

300,000 × annuity factor	= 800,000
Annuity factor (four-year annuity)	= 800,000/300,000 = 2.667

The interest rate corresponding to a four-year annuity factor of 2.667 is approximately 18.5%. This is a percentage rise of 23.33%.

$$\frac{18.5 - 15}{15} \times 100 = 23.33$$

This project is relatively insensitive to a change in the discount rate but highly responsive to a change in the sales price. This observation may lead the managers to request further work to improve the level of confidence in the sales projections.

Advantages of using sensitivity analysis

Sensitivity analysis has the following advantages:

- *Information for decision-making* At the very least it allows the decision-makers to be more informed about project sensitivities, to know the room they have for judgmental error and to decide whether they are prepared to accept the risks.
- *To direct search* It may lead to an indication of where further investigation might be worthwhile. The collection of data can be time consuming and expensive; if sensitivity analysis points to some variables being more crucial than others, then search time and money can be concentrated.

- *To make contingency plans* During the implementation phase of the investment process the original sensitivity analysis can be used to highlight those factors that have the greatest impact on NPV. Then these parameters can be monitored for deviation from projected values. The management team can draw on contingency plans if the key parameters differ significantly from the estimates. For example, a project may be highly sensitive to the price of a bought-in component. The management team after recognizing this from the sensitivity analysis prepare contingency plans to: (a) buy the component from an alternative supplier, should the present one increase prices excessively, (b) produce the component in-house, or (c) modify the product so that a substitute component can be used. Which of the three is implemented, if any, will be decided as events unfold.

Drawbacks of sensitivity analysis

The absence of any formal assignment of probabilities to the variations of the parameters is a potential limitation of sensitivity analysis. For Marts the discount rate can change by 23.33 percent before break-even NPV is reached, whereas the price can only change by 2 percent. At first glance, you would conclude that NPV is more vulnerable to the price changes than to variability in the discount rate. However, if you are now told that the market price for Marts is controlled by government regulations and there is a very low probability of the price changing, whereas the probability of the discount rate rising by more than 23.33 percent is high, you might change your assessment of the nature of the relative risks. This is another example where following the strict mathematical formula is a poor substitute for judgment. At the decision-making stage the formal sensitivity analysis must be read in the light of subjective or objective probabilities of the parameter changing.

Strict mathematical formula is a poor substitute for judgment.

A drawback of sensitivity analysis is that each variable is changed in isolation while all other factors remain constant. In the real world it is perfectly possible that a number of factors will change simultaneously. For example, if inflation is higher then both anticipated selling prices and input prices are likely to be raised. The next section presents a partial solution to this problem.

Scenario analysis

With sensitivity analysis we change one variable at a time and look at the result. Managers may be especially concerned about situations where a number of factors change. They are often interested in establishing a worst-case/best-case scenario. That is, what NPV will result if all the assumptions made initially turned out to be too optimistic? And, what would be the result if, in the event, matters went extremely well on all fronts?

Table 5.5 describes a worst-case/best-case scenario for Marts.

TABLE 5.5

Acmart plc: Project proposal for the production of Marts – worst-case and best-case scenarios

Worst-case scenario			
Sales		900,000 units	
Price		90p	
Initial investment		£850,000	
Project life		3 years	
Discount rate		17%	
Labor costs		22p	
Material costs		45p	
Overhead		11p	
Cash flow per unit			£
Sale price			0.90
Costs			
Labor	0.22		
Material	0.45		
Overhead	0.11		
			0.78
Cash flow per unit			0.12
			£
Annual cash flow = 0.12 × 900,000 = £108,000			
Present value of cash flows 108,000 × annuity factor (annuity factor 3 years @ 17%) 108,000 × 2.2096			238,637
Less initial investment			–850,000
Net present value			–611,363
Best-case scenario			
Sales		1,200,000 units	
Price		120p	
Initial investment		£770,000	
Project life		4 years	
Discount rate		14%	
Labor costs		19p	
Material costs		38p	
Overhead		9p	

Cash flow per unit		£
Sale price		1.20
Costs		
Labor	0.19	
Material	0.38	
Overhead	0.09	
		0.66
Cash flow per unit		0.54

Annual cash flow = 0.54 x 1,200,000 = £648,000

		£
Present value of cash flows (4 years @ 14%)	648,000 × annuity factor 648,000 × 2.9137	1,888,078
Less initial investment		–770,000
Net present value		1,118,07

Having carried out sensitivity, break-even NPV and scenario analysis the management team have a more complete picture of the project. They then need to apply the vital element of judgment to make a sound decision.

Probability analysis

A further technique to assist the evaluation of the risk associated with a project is to use probability analysis. If management have obtained, through a mixture of objective and subjective methods, the probabilities of various outcomes this will help them to decide whether to go ahead with a project or to abandon the idea. We will look at this sort of decision-making for the firm Pentagon plc.

Pentagon plc is trying to decide between five mutually exclusive one-year projects (*see* Table 5.6).

Proposals 1 and 2 represent perfectly certain outcomes. Project 2 has a higher NPV and is the obvious preferred choice. In comparing Project 2 with Projects 3, 4 and 5 we have a problem: which of the possible outcomes should we compare with Project 2's outcome of £20m? Take Project 3 as an example. If the outcome is –£16m then clearly Project 2 is preferred. However, if the outcome is £36m, or even better, £48m, then Project 3 is preferred to Project 2.

TABLE 5.6
Pentagon plc: Use of probability analysis

		Net present value, NPV	Probability of return occurring
Project 1		16	1.0
Project 2		20	1.0
Project 3	Recession	–16	0.25
	Growth	36	0.50
	Boom	48	0.25
Project 4	Recession	–8	0.25
	Growth	16	0.50
	Boom	24	0.25
Project 5	Recession	–40	0.10
	Growth	0	0.60
	Boom	100	0.30

Expected return

A tool that will be useful for helping Pentagon choose between these projects is the expected NPV. This is the mean or average outcome calculated by weighting each of the possible outcomes by the probability of occurrence and then summing the result. That is, multiply the outcome by the probability expressed as a number between 0 and 1; then, add up all the numbers calculated. This is shown in Table 5.7.

The preparation of probability distributions gives the management team some impression of likely outcomes. The additional calculation of expected NPVs adds a further dimension to the informed vision of the decision-maker. Looking at expected NPVs is more enlightening than simply examining the single most likely outcome, which is significantly different from the expected NPV of £26m. For Project 5 the most likely outcome of 0 is not very informative and does not take into account the range of potential outcomes.

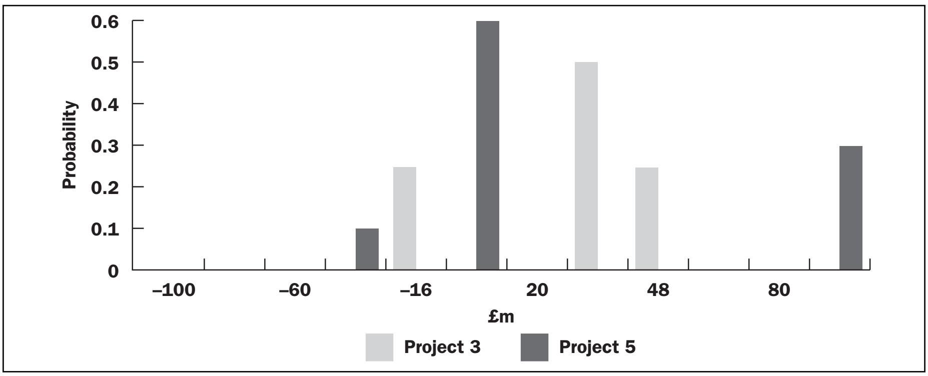
It is important to appreciate what these statistics are telling you. The expected NPV represents the outcome expected if the project is undertaken many times. If Project 4 is undertaken 1,000 times, then on average the NPV will be £12m. If the project is undertaken only once, as is the case in most business situations, there would be no guarantee that the actual outcome would equal the expected outcome.

TABLE 5.7
Pentagon plc: Expected NPV

Pentagon plc		Expected NPV, £m
Project 1	16 × 1	16
Project 2	20 × 1	20
Project 3	–16 × 0.25 = –4	
	36 × 0.50 = 18	
	48 × 0.25 = 12	
		26
Project 4	–8 × 0.25 = –2	
	16 × 0.50 = 8	
	24 × 0.25 = 6	
		12
Project 5	–40 × 0.1 = –4	
	0 × 0.6 = 0	
	100 × 0.3 = 30	
		26

The projects with the highest expected NPV turn out to be Projects 3 and 5, each with an expected NPV of 26. However, we cannot get any further in our decision-making by using just the expected NPV formula, because the formula fails to take account of risk. Risk is concerned with the likelihood that the actual performance might diverge from what is expected. Note that risk in this context has both positive and negative possibilities of diverging from the mean, whereas in everyday speech 'risk' usually has only negative connotations. If we plot the possible outcomes for Projects 3 and 5 against their probabilities of occurrence we get an impression that the outcome of Project 5 is more uncertain than the outcome of Project 3 (*see* Figure 5.3).

FIGURE 5.3
Pentagon plc: Probability distribution for Projects 3 and 5



The range of possible outcomes is relatively narrow for Project 3 and presents an impression of lower risk. This is only a general indication. We need a more precise measurement of the dispersion of possible outcomes. This is provided by the standard deviation.

Standard deviation

The standard deviation, σ, is a statistical measure of the dispersion around the expected value. To calculate the standard deviation we first need to calculate the variance; then take the square root of the variance, σ^2.

Calculating the variance is straightforward if you take it in stages:

Stage 1: First obtain the deviation of each potential outcome from the expected outcome $(x_i - \bar{x})$. So, in the case of Project 3 the first outcome is –16 (this is our x_i) and the expected outcome $(\bar{x})$ is 26. So, subtracting the second number from the first we have –42.

Stage 2: Square the result from stage one for each of the outcomes $(x_i - \bar{x})^2$. So, for the first outcome of Project 3 we take the –42 and multiply by itself: $-42 \times -42 = 1{,}764$.

Stage 3: Multiply the number generated in stage 2 by the probability of that outcome occurring. In the case of the first outcome of Project 3 we multiply 1,764 by 0.25 = 441. That is, $(x_i - \bar{x})^2\, p_i$.

Stage 4: Finally, add together the results of all these calculations for that particular project. So, for Project 3 we add 441 to 50 to 121. Which gives a variance of 612 (see Table 5.8).

Note that the variance is a very large number compared with the original potential outcome: for Project 3 these were –16, 36 and 48, whereas the variance is over 600, because the variance measures in pounds squared or NPVs squared, etc. The next stage is to obtain the standard deviation, σ, by taking the square root of the variance. This measures variability around the expected value in straightforward pound or return terms. The standard deviation provides a common yardstick to use when comparing the dispersions of possible outcomes for a number of projects. So, for Project 3 the standard deviation is 24.7.

TABLE 5.8
Pentagon plc: Calculating the standard deviations for the five projects

	Outcome (NPV)	Probability	Expected NPV, £m	Deviation	Deviation squared	Deviation squared times probability
Project	x_i	p_i	$\bar{x}$	$x_i - \bar{x}$	$(x_i - \bar{x})^2$	$(x_i - \bar{x})^2 p_i$
1	16	1.0	16	0	0	0
2	20	1.0	20	0	0	0
3	–16	0.25	26	–42	1,764	441
	36	0.5	26	10	100	50
	48	0.25	26	22	484	121
					Variance	= 612
					Standard deviation	= 24.7
4	–8	0.25	12	–20	400	100
	16	0.5	12	4	16	8
	24	0.25	12	12	144	36
					Variance	= 144
					Standard deviation	= 12
5	–40	0.1	26	–66	4,356	436
	0	0.6	26	–26	676	406
	100	0.3	26	74	5,476	1,643
					Variance	= 2,485
					Standard deviation	= 49.8

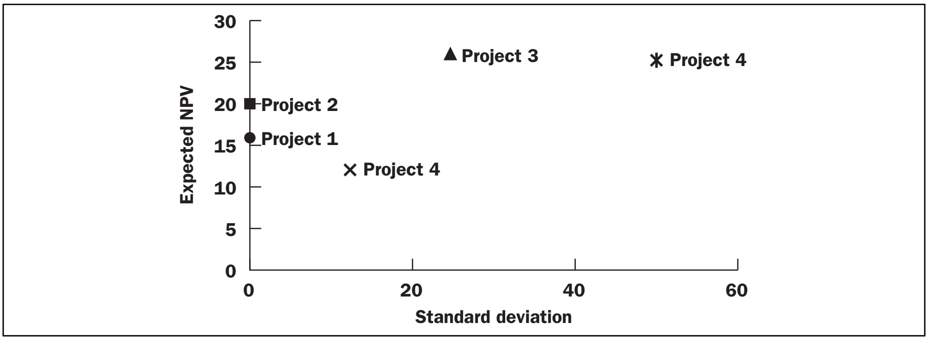
If we now put together the two sets of measurements about the five projects we might be able to make a decision on which one should be selected (*see* Table 5.9).

TABLE 5.9
Pentagon plc: Expected NPV and standard deviation

	Expected NPV, $\bar{x}$	Standard deviation, σ
Project 1	16	0
Project 2	20	0
Project 3	26	24.7
Project 4	12	12
Project 5	26	49.8

Project 1 would not, presumably, be chosen by anyone because it is dominated by Project 2. Also, Project 4 is obviously inferior to Project 2 because it has both a lower expected NPV and it is more risky (as defined by its higher standard deviation). That leaves us with Projects 2, 3 and 5. To choose between these we need to think about attitudes to the risk return trade off. Most people and organizations when faced with two projects offering the same NPV (expected NPV) but different levels of risk (variability around the expected NPV) would choose the less risky option. This assumption of *risk aversion* allows us to eliminate Project 5 because it offers the same expected NPV as Project 3, but it has a higher standard deviation.

FIGURE 5.4
Pentagon plc: Expected NPVs and standard deviations



Projects 1, 4 and 5 are recognizably inferior, leaving a choice between Projects 2 and 3. From this point on there is no simple answer. The solution depends on the risk-return preferences of the decision-maker. This is fundamentally a matter for subjective judgment and different management teams will make different choices. When the author has put the choice between Projects 2 and 3 to MBA classes of middle and senior managers, approximately one-half take the safe option of Project 2. However, others in the class say that for the sake of a little more risk, Project 3 gives a significantly higher NPV and so should be accepted. The board of directors of Pentagon need to weigh up the risk preferences of the owners of the company and choose one project or the other. In doing so they may like to consider how this new project fits with the rest of the company's projects. If the firm already has a broad set of projects (operations, strategic business units, product lines, etc.) and many of these projects tend to do well in circumstances when Project 3 does badly, and *vice versa*, they may consider the benefits of diversification make them inclined to accept this investment.

Problems with using probability analysis

Too much faith can be placed in quantified subjective probabilities

When dealing with events occurring in the future, managers can usually only make informed guesses as to likely outcomes and their probabilities of occurrence. A danger lies in placing too much emphasis on analysis of these subjective estimates once they are converted to numerical form. It is all too easy to carry out detailed computations with accuracy to the n^{th} degree, forgetting that the fundamental data usually have a small objective base. Again, mathematical purity is no substitute for thoughtful judgment.

The alternative to the assignment of probabilities, that of using only the most likely outcome estimate in the decision-making process, is both more restricted in vision and equally subjective. At least probability analysis forces the decision-maker to explicitly recognize a range of outcomes and the basis on which they are estimated, and to express the degree of confidence in the estimates.

Too complicated

Investment decision-making and subsequent implementation often require the understanding and commitment of large numbers of individuals. Probability analysis can be a poor communication tool if important employees do not understand what the numbers mean. Perhaps here there is a need for education combined with good presentation.

Probability analysis can be a poor communication tool if important employees do not understand what the numbers mean.

Projects may be viewed in isolation

The context of the firm may be an important variable, determining whether a single project is too risky to accept, so a project should never be viewed in isolation. Take a firm with a large base of stable low-risk activities. It may be willing to accept a high-risk project because the overall profits might be very large and even if the worst happened the firm will survive. On the other hand, a small firm that already has one highly risky activity may only accept further proposals if they are low risk.

Evidence of risk analysis in practice

UK firms have increased the extent of risk analysis in project appraisal over the past 20 years. Table 5.10 summarizes these techniques. This trend has been encouraged by a greater awareness of the techniques and aided by the availability of computing software. Sensitivity and scenario analysis remain the most widely adopted approaches. Probability analysis is now used more widely than in the past but few smaller firms use it on a regular basis. Beta analysis, based on the capital-asset pricing model (discussed in Chapter 10) is rarely used. Simple, rule-of-thumb approaches have not been replaced by the more complex methods. Firms tend to be pragmatic and to use a number of techniques in a complementary fashion.

TABLE 5.10
Risk analysis techniques used in UK firms

	Small %	Medium %	Large %	Total %
Sensitivity/scenario analysis	82	83	89	85
Shorten the payback period	15	42	11	20
Raise the required rate of return	42	71	50	52
Probability analysis	27	21	42	31
Beta analysis	3	0	5	3
Subjective assessment	44	33	55	46

Source: Arnold and Hatzopoulos (2000), sample of 96 firms: 34 small, 24 medium, 38 large. Survey date July 1997.

Conclusion

This chapter has dealt with some of the more sophisticated aspects of project analysis. It has, hopefully, encouraged the reader to consider a wider range of factors when embarking on investment appraisal. Greater realism and more information clears away some of the fog which envelops many capital investment decision-making processes.

Human communication, enthusiasm and commitment are as vital to investment returns as assessing risk correctly.

However, this chapter has focussed primarily on the technical/mathematical aspects of the appraisal stage of the investment process sequence. While these aspects should not be belittled, as we ought to improve the analysis wherever we can, it should be noted that a successful program of investment usually rests far more on quality management of other stages in the process. Issues of human communication, enthusiasm and commitment are as vital to investment returns as assessing risk correctly.