

**A practical guide to modelling
uncertainty with Microsoft® Excel**

MASTERING RISK MODELLING

- **Helps you understand and manage risk through the confident use of models**
- **A systematic method of developing Excel models for fast development and error checking**

second edition

Mastering Risk Modelling



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Mastering Risk Modelling

A practical guide to modelling uncertainty with
Microsoft® Excel

Second Edition

ALASTAIR L. DAY



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- finance and operating lease structuring as a consultant and lessor;
- financial books including those published by the FT such as *Mastering Financial Modelling (second edition)*, *Mastering Risk Modelling*, *Mastering Financial Mathematics in Excel* and *The Financial Director's Guide to Purchasing Leasing*;
- eLearning material.

More information at www.financial-models.com

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Conventions

The main part of the text is set in Times Roman, whereas entries are set in Courier. For example:

Enter the Scenario Name as Base Case

Items on the menu bars are also shown in Courier.

Select Tools, Goalseek

The names of functions are in capitals. This is the payment function, which requires inputs for the interest rate, number of periods, present value and future value:

`=PMT (INT, NPER, PV, FV, TYPE)`

Equations are formed with the equation editor and shown in normal notation. For example, net present value:

$$\frac{NPV = (CashFlow)^N}{(1+r)^N}$$

Genders: the use of 'he' or 'him' refers to masculine or feminine and this is used for simplicity to avoid repetition.

Overview

WHO NEEDS THIS BOOK?

Business has always meant taking risks in order to secure a return. In the last century, this was often a game of chance where outcomes could not be accurately predicted. Developments in computing and theory have led to a big change in how risk and reward is perceived, priced and managed.

Financial modelling has come into its own since the original development of Visicalc and Lotus 1-2-3 as the preferred tool for financial calculations. Many people acquired their first computers in order to complete their budgets in Lotus 1-2-3. The omnipresence of Microsoft Office means that techniques can be demonstrated more simply in Excel than with hand-held financial calculators such as the HP12C or TI BA II Plus.

Banks and financial institutions increasingly use advanced risk management tools to manage portfolios and assess client credit risk. This is reinforced by the provisions of Basel II or Solvency II. Additionally, risk modelling plays a significant part in structured and project finance as a method of identifying and managing potential difficulties. In the corporate sector, directors of UK public companies are tasked with disclosing the main risks facing the company as part of the risk management process. In the US, the provisions of the Sarbanes–Oxley Act mean that critical spreadsheets have to be audited for accuracy. Given the emphasis on risk management, this book mixes financial theory with practice and introduces a number of Excel templates as the basis for more complex risk models.

The requirement for financial modelling is certain to develop further in future owing to:

- advances in computer technology and speed on the desktop and in mobile computing;
- the continued development of more specific risk software (e.g. @RISK and Crystal Ball);
- more historic data being available for analysis within organizations;
- the use of models being a required skill for financial executives and business students alike.

The key objectives of this book are to:

- provide financial managers with practical templates for applying risk and uncertainty to Excel;
- improve financial managers' abilities with Excel;
- demonstrate a systematic method of developing Excel models for fast development and reduced errors;
- provide a library of basic templates for further development as an illustration of the methods.

This book aims to assist two key groups:

- 1 Excel users with a basic understanding of model design and a wish to extend their Excel modelling skills;
- 2 practitioners who want to be able to build more complex models using advanced Excel features.

The areas of responsibility are:

- CFOs and finance directors;
- financial controllers;
- analysts;
- accountants;
- corporate finance personnel;
- treasury managers;
- risk managers;
- middle office staff;
- general managers;
- personnel in banks, corporates and government who make complex decisions and who could benefit from a modelling approach;
- academics, business and MBA students.

Therefore, people interested in this book range from a company accountant who wants to be able to understand investment risk to managers who require more complex models.

The book is international in its outlook and will provide examples relevant to both the UK and overseas.

HOW TO USE THIS BOOK

- Install the Excel application templates using the simple SETUP command. There is a key to the file names at the back of the book.
- Work through each of the chapters and the examples.
- Use the book, spreadsheets and templates as a reference guide for further work.
- Practise and improve your efficiency and competence with Excel.

THE SECOND EDITION

Since the publication of the first edition, the power and use of spreadsheets has grown together with the need to measure and manage risk. Whilst there are bespoke tools available for decision trees and simulation, the presence of Office on most executives' desktops means that the Excel interface is widely understood. At the same time companies are finding that models do not always provide the correct answers when applied to securitization, 'sub-prime' portfolios or options trading. The interpretation of results and the application of extreme scenarios also need consideration. The requirement is for modelling to promote a decision-making framework rather than provide all the answers.

Systematic Finance models follow a precise design specification and all the spreadsheet models have been rewritten to take account of this uniform approach to layout, colours and method, and to take advantage of more features in Excel. The introduction of Microsoft Office 2007 marks a radical redesign of the Office interface since the Excel versions of the early 1990s. Where possible the methods for Office 2003 and 2007 are shown to allow a transition from earlier Office editions.

Alastair L. Day

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Executive summary

This is a summary of the book by chapter presented in a tabular form.

Chapter	Topic	Items
1	Overview	Scope of the book Example model Basic statistics in Excel – tools and methods Objectives of risk modelling
2	Review of model design	Model design and structure – key steps Advantages Disadvantages Modelling objectives Design objectives and mistakes Useful features Auditing methods
3	Risk and uncertainty	Definition of risk Uncertainty Response to risk Methods used
4	Project finance model	Sources of risk Forecasting financial data Risk process Methods
5	Simulation	Simulation methods Building blocks of simulation Procedure and programming Real estate example
6	Financial analysis	Process Environment Industry Financial statements Profit and loss Balance sheet

		<ul style="list-style-type: none"> Operating efficiency Profitability Financial structure Du Pont or core ratios Market ratios Trend analysis Cash flow Forecasts Financial analysis summary
7	Credit risk	<ul style="list-style-type: none"> Cash flow Cover ratios Sustainability formulas Capacity to borrow and repay Beaver model Bathory model Z scores Springate model Logit analysis H Factor Ratings agencies
8	Equity valuation	<ul style="list-style-type: none"> Introduction and methods Cash flows Capital structure Risk factors Sensitivity analysis Management summary
9	Bonds	<ul style="list-style-type: none"> Bond prices Interest rates Yield, duration and convexity Duration and maturity Convexity Comparison of methods
10	Options	<ul style="list-style-type: none"> Reasons to manage risk Options Options example Options hedging strategy Options simulation VBA approach Black–Scholes Binomial trees
11	Real options	<ul style="list-style-type: none"> Introduction and method Project – determining value Option to delay a project Option to abandon a project Option to expand a project



12	Equities	Portfolio optimization Historic data Returns summary Simulation to find optimum risk and return Portfolio
13	Risk adjusted return on capital	Capital allocation Risk adjusted return on capital calculation Inputs and calculations Sensitivity Returns
14	Value at risk	Value at Risk methodology VAR for a single asset VAR for a two asset Three asset VAR
15	Credit risk and credit metrics	Introduction and theory Portfolio approach Overview of components Single asset Two bond portfolio Simulation method
	Appendix	Appendix Excel 2007 Software specification Installation SFL File list

Introduction

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Scope of the book

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Example model

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Objectives of risk modelling

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Summary
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SCOPE OF THE BOOK

Mastering Financial Modelling, an earlier book, provides an introduction to Excel financial modelling and shows how to use Excel in a disciplined manner to develop applications. Since spreadsheet models are often poorly planned and developed with significant errors, it provides a specific method for developing applications. This book develops these ideas to include risk analysis and to show how techniques can be added to simpler models in order to:

- make the models more comprehensive;
- accept that the real world is uncertain and models should be able to cope with a range of possible outcomes;
- derive more useful management information;
- understand how the model ‘flexes’ with change;
- act as a further method of checking the model’s outputs.

Financial modelling is the term often used for applications from simple spreadsheets to complex models. In this book, the term *financial model* is used to denote a dedicated spreadsheet written to solve a business problem. Here are two definitions:

- 1 Spreadsheet: *Program for organizing numerical data in tabular formats allowing rapid calculations with changing variables.*
- 2 Model: *Theoretical construct in a spreadsheet that represents numerical processes by a set of variables and a set of logical and quantitative relationships between them.*

The basic need is to answer a business problem such as the minimum budgeted cash flow over the next 12 months, the net present value of an investment or the price of an option. The spreadsheet does not simply hold data but is organized as an analytical tool for decision making. The objective is often to represent a closed system such as the investment in new equipment, together with forecast revenue and expenditure. The model therefore represents a computer program written to solve the problem, which is different to using the spreadsheet merely for holding data or adding up a few numbers. The model could be written in Visual Basic or C++ but it is usually quicker, easier and more intuitive to develop a model in Excel.

You could also consider a spreadsheet for personal use where you can keep in your head the workings of the sheet. Where a spreadsheet requires distribution to others then it should be considered as a model where there should be some rules in how it is developed and presented.

Models underpin decisions and the basic risk process could be described as:

- defining objectives, since you need to be clear about objectives and output answers or reports;
- identifying all possible courses of action to weigh up advantages and disadvantages;
- assembling data or variables that are relevant and understanding the extent of the accuracy and relevance of the data available;
- building the computer models to assist and organize any decisions;
- assessing the decision and comparing options by using the data outputs;
- implementing a decision and monitoring the subsequent variances to the original plan;
- monitoring the effect of decisions and if the project fails ensuring that lessons can be learnt.

However much effort is expended on the ‘correct’ variables for the model, there must always be some potential for error or variance since a model is only a best guess of the likely outcomes. Risk here is often considered to be the potential downside resulting from a business decision.

The advantage of Excel is that most people have had some exposure to the language and are comfortable with the interface and commands. Since there is a similarity of presentation within the Microsoft Office suite, users can write simple spreadsheets quickly. The disadvantages of such a free approach are when decisions need to be taken or when an application needs to be distributed or maintained. Whilst you can write fragments of code for your own use, any files for use by others should be clear and auditable. In particular, the disadvantages of many Excel models are as follows:

- wide range of abilities on the part of the authors;
- most people use less than 10 per cent of capability (e.g. they may never have used the statistical or array functions or inserted a pivot table);
- a lack of standard structure or design method making auditing all but impossible;
- a poor structure leads to a lack of clarity and confusing output reports;
- it is easy to make mistakes since errors can lie undetected (for years!) – users are often overconfident about their abilities and often assume their code is error free;
- Excel is not a recognized programming language and therefore there are no standards for naming cells or documenting the work;
- duplication of effort arises since most users do not develop templates for specific types of applications;

- spreadsheets do not cope well with text (but then there is the option of Microsoft Word).

Companies usually assume that executives are proficient in Excel since they have qualified in finance, but this is not always the case. Financial modelling demands a disciplined approach just like any other programming language. Since Excel does not have to be compiled before use, people often produce disorganized designs with little regard for future development or maintenance. For instance, dates can be hard coded and of course will work this year, but next year you have to search through the model and change all entries. Similarly, authors often mix numbers and formulas in the same cell so that others cannot work out where to input data and of course the author finds it impossible to check for mistakes. Owing to a lack of clear objectives, the model may also not even produce a clear answer to the original question.

Most financial models consist of input variables, calculations and some kind of output. The objectives of modelling should include some of the following:

- analysing and processing data into information;
- modelling a considered view or forecast of the future (e.g. project cash flows);
- processing data quickly and accurately into clear and relevant management information;
- testing assumptions in a 'safe' environment before mistakes are made (e.g. project scenarios);
- supporting management decision making through a structured approach. (Modelling often produces too much information and one objective may be to reduce the detail in summaries.);
- understanding more precisely the variables or rules in a problem to ensure that the whole system is modelled;
- learning more about processes and the behaviour of variables, in particular the importance of key variables and how they behave;
- discovering the sensitivity and risk inherent in the model.

EXAMPLE MODEL

Figure 1.1 shows a simple example of revenue and costs. The inputs are shown tinted grey and the schedule below calculates the net revenue at the end of the five-year period. This is the sum of cells C27:H27.

Figure 1.1

Simple model

	A	B	C	D	E	F	G	H
1								
2	Model							
3								
4								
5			Start	Growth				
6	Revenue		1,000.00	3.00				
7	Costs:							
8	Materials		400.00	2.00				
9	Sales Cost		200.00	2.50				
10	Administration		300.00	3.00				
11								
12			1	2	3	4	5	Total
13								
14	Revenue		1,000.00	1,030.00	1,060.90	1,092.73	1,125.51	5,309.14
15								
16	Costs:							
17	Materials		(400.00)	(408.00)	(416.16)	(424.48)	(432.97)	(2,081.62)
18	Sales Cost		(200.00)	(205.00)	(210.13)	(215.38)	(220.76)	(1,051.27)
19	Administration		(300.00)	(309.00)	(318.27)	(327.82)	(337.65)	(1,592.74)
20								
21	Total Cost		(900.00)	(922.00)	(944.55)	(967.68)	(991.39)	(4,725.62)
22								
23	Net Revenue		100.00	108.00	116.35	125.05	134.12	583.51
24								
25	Percentage Margin		10.00	10.49	10.97	11.44	11.92	10.99
26								
27	Cumulative Net Revenue		100.00	208.00	324.35	449.39	583.51	583.51
28								
29	Total Net Revenue		583.51					

This is a deterministic or input–calculation–output model since the inputs or variables are fixed. For example, sales growth is 3 per cent from a base of 1000. These figures represent the best estimate of the value of each input variable but they are still single points rather than ranges.

OBJECTIVES OF RISK MODELLING

The deterministic model above may not provide all the answers. The future is uncertain and there are factors that are within the organization's control and those, such as the weather, over which it has little or no control. Whilst analysts may wish to control or know the future, risk modelling seeks to apply mathematical theory to the problem. In the simple problem above, the organization may wish to know how likely it is to achieve the forecast net revenue. Corporate finance theory advises that organizations and individuals are rational and risk averse. This means that they take a defined risk for a desired return. Translated into this example, this could be rephrased as the forecast net revenue and the possible variance or standard deviation. There would be no point in accepting this budget if possible results ranged from 100 to 700 since a result of 100 would be unacceptable. The managers may then wish to know what the chance is of the forecast net revenue falling below 200. Developing a more sophisticated model could help to uncover the risk and uncertainty in the budget.

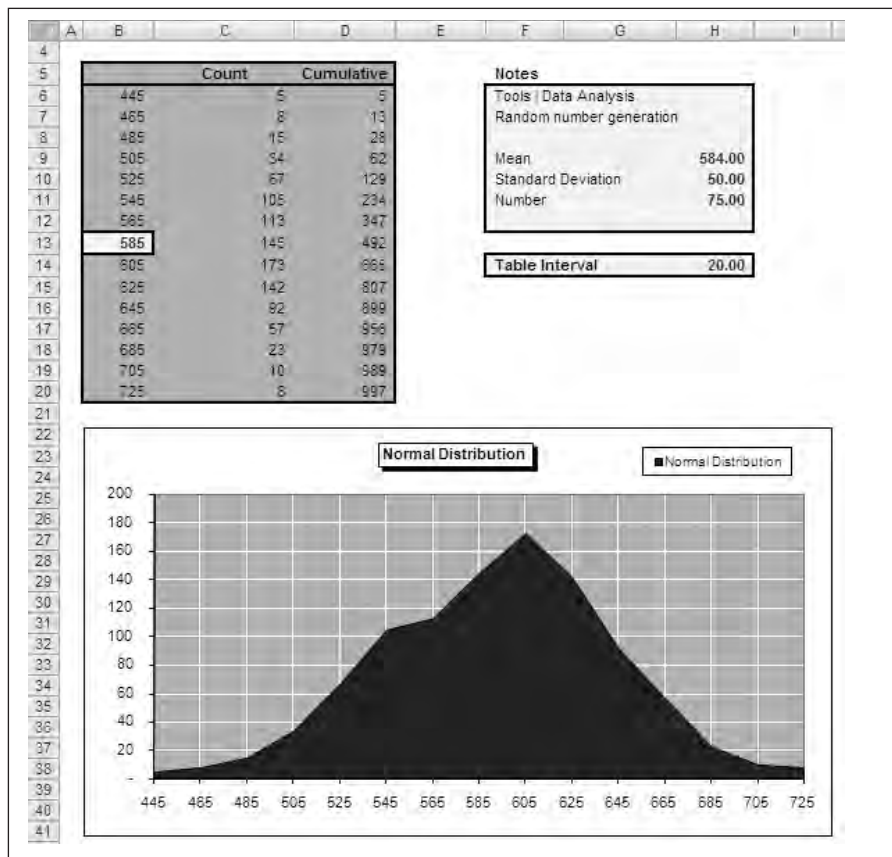
To illustrate the concept of return and variance, Figure 1.2 shows the result of 1000 random numbers on the Normal_Distribution2 sheet based on a mean of 584 and a standard deviation of 50. The data were generated using the random number generator in Tools, Data Analysis.

The table uses a FREQUENCY function as an array to count the values within pre-defined ranges.

= FREQUENCY(\$C\$6:\$C\$80,\$E\$6:\$E\$20)

Normal distribution

Figure 1.2



Note that the distribution has extended tails on either side of the mean. Analysis concentrates on the downside and the number of potential results that fall below a required level. Table 1.1 uses Tools, Data Analysis, Descriptive Statistics to generate a description of the distribution.

Table 1.1

Descriptive statistics

Mean	582.9898481
Standard error	1.592886606
Median	586.2308387
Mode	557.862761
Standard deviation	50.37149731
Sample variance	2537.287741
Kurtosis	0.167480937
Skewness	-0.084604382
Range	328.1966201
Minimum	426.6767336
Maximum	754.8733537
Sum	582989.8481
Count	1000
Largest (1)	754.8733537
Smallest (1)	426.6767336

Risk models provide:

- an understanding of risk since a single answer may not be enough for decision making;
- multiple answers to better understand the range of outcomes;
- the inclusion of elements of risk or uncertainty (e.g. future cash flows);
- the chance to test inherently inaccurate forecasts;
- likely outcomes under a number of different assumptions or scenarios;
- information on the behaviour of key variables.

Modelling helps to identify risk since you need to be able to test all the variables. Sales forecasts are notoriously optimistic and so what happens if you downgrade the timescale when an item of equipment starts to generate revenue? The percentage is a variable that must be modelled to gauge its effect on the eventual answer.

Alternatively, risk could be divided into:

- *risk*, which can be measured and is subject to probability mathematics;
- *uncertainty*, which consists of random events or variables (e.g. the weather) or which emanates from a lack of knowledge about the system being modelled (model risk). In the latter case variables are not included in the model, but could have a significant impact on the outcome.

The notion that risk exists in all business decisions is therefore key; however, risk may not always be negative since simple analysis may lead to missed opportunities. Analysis may confirm that the potential downside is minor or

that a project is too pessimistic and greater sales growth is possible. One approach is to review the impact and likelihood as a matrix and try to group and prioritize risks. The approach then hinges on three questions:

- 1 What is the source of the risk?
- 2 What is its likely impact and likelihood?
- 3 Can it be managed, priced, reduced or handled in some other form?

Management can then concentrate on those variables that fall in the top right-hand box of the matrix shown in Figure 1.3.

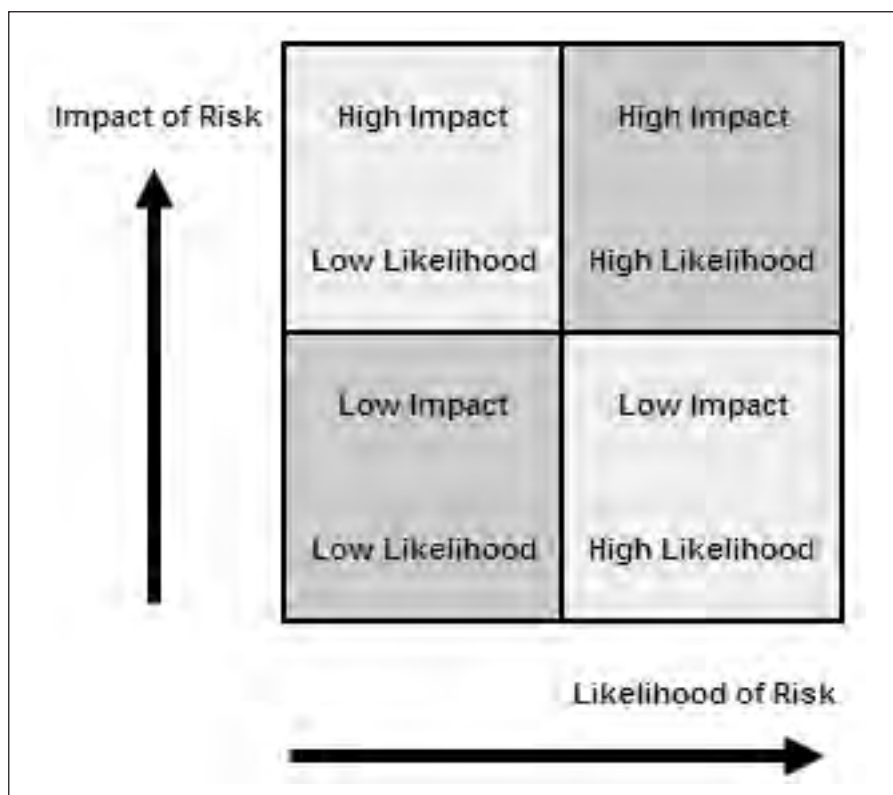
Excel provides techniques and functions for generating multiple answers and dealing with uncertainty. These include:

- Data tables, which are one- or two-dimensional grids of possible answers. Since most models include a few key variables, this allows more information of how a model ‘flexes’ with variation in key variables.
- Scenarios which allow the inclusion of individual cases within the model (e.g. best case, worst case).
- ‘What if’ analysis involving the use of several scenarios with probabilities assigned to them. For example, you could value a company based on several future scenarios of market penetration and assign probabilities to each scenario. A single net present value (NPV) could then be transformed into an expected net present value (ENPV) based on probability.
- Decision trees using probability mathematics and utility theory to place a value on decisions.
- Optimization techniques such as Solver where the desired result is known but there is uncertainty about the inputs required.
- Simulation techniques involving the generation of large numbers of possible scenarios to find the range of possible results. Simulation is considered in more detail in Chapter 5.

One other factor in modelling is perhaps the perception of risk in the process. In only relatively few circumstances are the probabilities and possible outcomes completely clear and risk is bounded by perception. Modelling is one part of the process and you have to look at the perception of risk and the potential upsides and downsides. One individual may be less risk averse than another, which will have an effect on the process and the outcome.

Figure 1.3

Impact-likelihood matrix



SUMMARY

This chapter has introduced some ideas of risk and uncertainty and the objective in the following chapters is to demonstrate how single-answer deterministic models can be made more useful and provide better management information. The following chapters provide a number of techniques and discuss several applications:

- projects and investments
- financial analysis
- credit and credit risk
- portfolios
- equity valuation
- fixed income
- derivatives.

Review of model design

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Introduction

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Design objectives

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Common errors

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Number formats

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Lines and borders

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Colour and patterns

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Specific colour for inputs and results

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Data validation

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Controls – combo boxes and buttons

.....
Conditional formatting

.....
Use of functions and types of functions

.....
Add-ins for more functions

.....
Text and updated labels

.....
Recording a version number, author, etc.

.....
Using names

Pasting a names table

Comment cells

Graphics

Dynamic graphs to plot individual series

Data tables

Scenarios

Spreadsheet auditing

Summary

File: MRM2_02

INTRODUCTION

A book on modelling would not be complete without a chapter on model design. Modelling should help with crystallizing the variables in a particular problem and clarifying the calculations and outputs required. As stated, models are often ill thought out and therefore may not answer the problem or be flexible enough for further development. As institutions develop larger libraries of Excel models, it is becoming increasingly important to build in future maintenance into modelling.

DESIGN OBJECTIVES

Users should develop a systematic method for developing spreadsheet models. Initial questions should include:

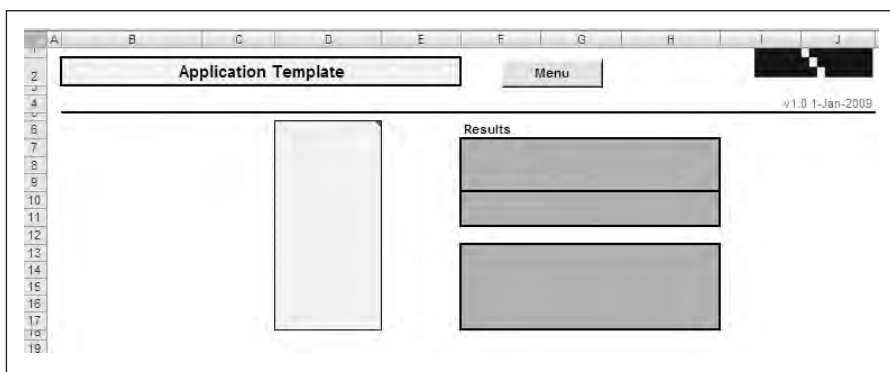
- What is the overall objective of the model?
- What reports or outputs are needed?
- What is the key question to be answered?
- Who will use it?
- What are the components of the problems and how can the problem be sub-divided into smaller sections?
- What should be the overall structure of the model?

The rule is to spend more time on initial planning in order to save time later. The aims should be:

- A clear layout with easily visible inputs, calculations and outputs. Users need to understand the structure quickly: otherwise they tend to get frustrated. Badly designed models can cloud thinking rather than enhance understanding.
- A clear area for user inputs, in one place with a distinctive input colour.
- Easy-to-understand workings with areas set aside for derivation of interim variables.
- Simplicity in the formation of cell formulas. Some spreadsheet users appear to think it is good practice to make the cell formulas as complex as possible. This only makes the model difficult to understand and more costly to maintain.
- Consistency in approach and method. You will notice that all the spreadsheets in this book follow a consistent design method. The method has been developed over a number of years and it works well. For example, there is always a cell name called 'Version' or 'Contact', and a title at the top left of every sheet (see Figure 2.1).

Figure 2.1

Standard layout



- Ease of use so that users do not have to understand the full structure of the model. For example, it is always useful to have a management summary close to an inputs area. As you change variables, you get immediate feedback on the answer. This saves clicking along several sheets to the answer.
- Future ease of maintenance and modification through a modular design. This means that you can add more features as needs change, without a complete redesign.
- To reduce code as far as possible by not calculating any answer more than once. For example, you calculate the dates for the top of the schedule on the first schedule and then look them up on all other schedules. This is true also of text labels where the first instance should be entered and then further instances looked up from the first. The objective is always to reduce the amount of 'hard coding' to ensure that all changes cascade through the model.
- In most cases, a single point model does not provide enough information. A model should demonstrate how the answer varies or 'flexes' when you change key variables.
- Moving on from variances, the model should cope with levels of risk and uncertainty. This book provides techniques for widening the scope of models with risk techniques.
- Precise and clear management reporting through the use of sensitivity or charts in order to demonstrate clear analysis. The ultimate answer needs to be clear and accessible to any user. You should bear in mind that different users have varying priorities.

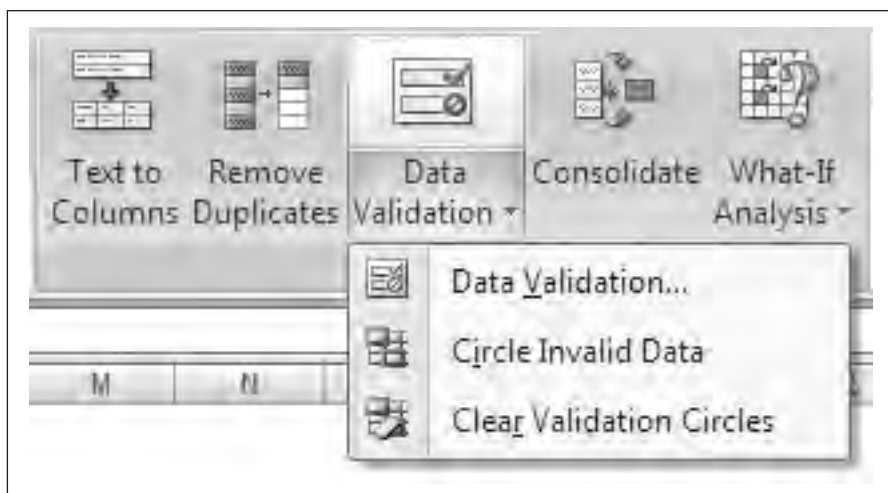
COMMON ERRORS

Below is a checklist of common spreadsheet errors encountered when auditing and checking models. This list is not exhaustive, but merely serves to confirm the weaknesses exposed by poor design and method.

- No form of layout with inputs, calculations and outputs clearly marked. A common mistake is not to put all the inputs together and mark the areas as inputs, calculation and output.
- No inputs section since it is always clearer to set up an inputs area or sheet and bring together all the key variables.
- No specific colour for inputs and results. This book uses bold for inputs and grey boxes for outputs. This improves understanding since you expect certain elements on all sheets. In Excel, blue cells are always inputs.
- No use of names for key variables since it is usually clearer to name the main variables in the inputs section. Formulas throughout the rest of the workbook are then easier to understand.
- No borders or shading leading to a bland design. You can quickly include simple borders and colours to improve the appearance if you keep the Formatting toolbar visible. The models in this book all follow the same principles of tint and appearance.
- No data validation of inputs to allow users to enter any value. Using Data, Validation, you can allow different data types and set maximums and minimums or other operators (see Figure 2.2).

Data validation

Figure 2.2



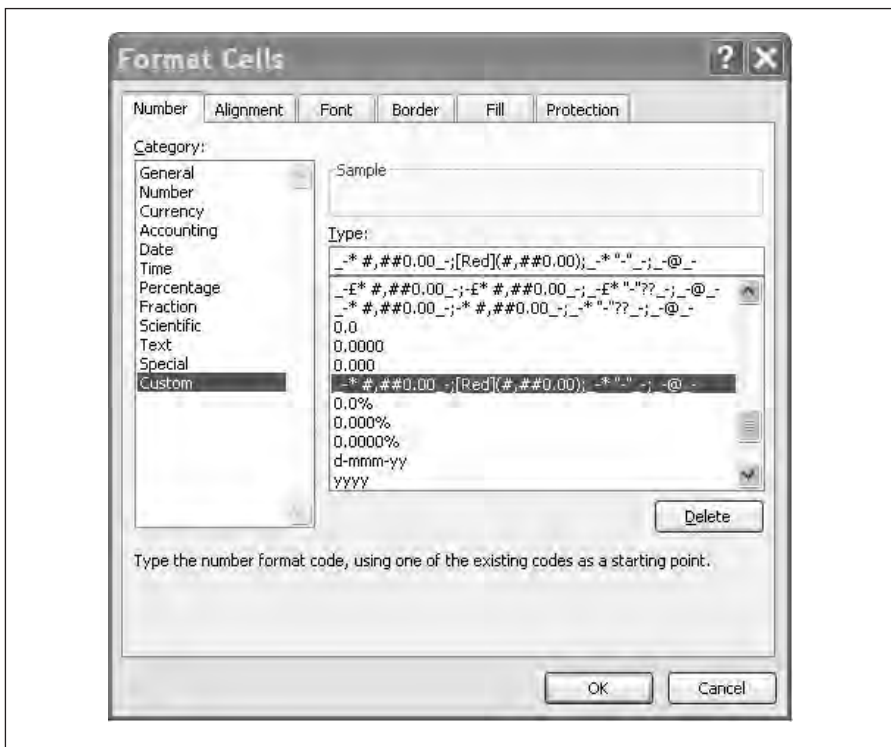
Office 2007 – Data, Data Tools, Data Validation (Office 2003 – Data, Validation)

- A mixture of number formats used on the same sheet with differing numbers of decimal places. Users also often use numbers and decimals as percentages on the same sheet. You can save custom number formats (see Figure 2.3), which can be useful, for example for adding inputs. It is possible to use the syntax to create new formats using these rules:

Syntax: "Positive";"Negative";"Zero";"Text"

Figure 2.3

Custom number formats



Office 2007 – Home, Number, Custom Formats (Office 2003 – Format, Number, Custom)

For example, 12 months could be entered as #0 "Months".

- No version number or author name to show the exact version being used. It is a good idea to have a version number and record the differences

between one date and another. In a few months' time models should produce the same answers as today. It is a good idea to have a sheet in a model to record changes from one version to another as a form of document control.

- No menu system or macro-driven buttons for easy navigation around a workbook.
- Users often mix numbers and formulas in the same cells. The calculation area of the model should have no 'hard' inputs and the only input numbers should be in the inputs area. Any mixture leads to auditing and consistency problems as below:

```
=E16*1.05*1.02
```

- More than one formula per line is a common problem since again it makes spreadsheets hard to understand. On a cash flow model with months as the column headers, you expect the same formula for each month rather than a mixture.
- Cell formulas can be overwritten with numbers where users have not checked sheets for consistency and allowed errors.
- Labels are sometimes hard coded and it makes sense to make labels as dynamic as possible. For example, it makes more sense to label a cell with a dynamic label such as 'Price with a volatility of 20 per cent' rather than 'Price'.
- No use of graphics in reporting in order to show clearly the results. Most people are usually inefficient in understanding grids of data and the important results are best confirmed by graphics.
- No commenting of individual cells to show workings or provide explanations. This can be achieved by Review, Comments or the use of Data, Validation. In the latter case, you select the second tab for input message. Here you can insert a message, which will be displayed when you click on the cell.
- No conditional formatting to highlight answers or change the cell formatting dependent on the answer. This is a useful feature of Excel since you can establish rules for each cell.
- No use of functions to reduce the amount of code and the possibility of errors. Whilst you can calculate monthly rentals, such as the formula below, it is usually better to use a built-in function such as PMT:

```
=1/((1-(1/(1+Monthly_Rate)^Term_Months)))/Monthly_Rate)
```

- Sheets are often not set up for printing. Good design means thinking about the output and making sure that the information can be printed out.

- Management reporting or summary is often unavailable. For example a complex model usually contains too much information to be accessible to users of different levels. A summary demonstrates the answers to key questions without the levels of detail in the rest of the model. For example, a project finance model could contain a summary of the costs and potential net revenues to fund debt and equity. The important ratios such as return on equity and debt service covers could also be shown.
- Following on from management reporting, sensitivity analysis helps to show the behaviour of the model to changes in variables. Forecasts are often too optimistic and you need to test the model to ensure that the inputs are sensible.
- Documentation or explanation on how the model works is often omitted. For the purposes of maintenance, details of variables, key calculations, structure of the model and any other relevant information can be presented as notes on a separate sheet in the workbook.

EXCEL FEATURES

The model is MRM2_02.xls as shown in Figure 2.4. Each of the sections in this chapter is covered on a sheet in the model. Open the file and click along the bottom to see the progression of sheets.

This is a simple net present value model which adds up the cash flows for a period and multiplies them by a 10 per cent discount factor. The net present value in cell C14 is gained by adding up the discounted cash flows.

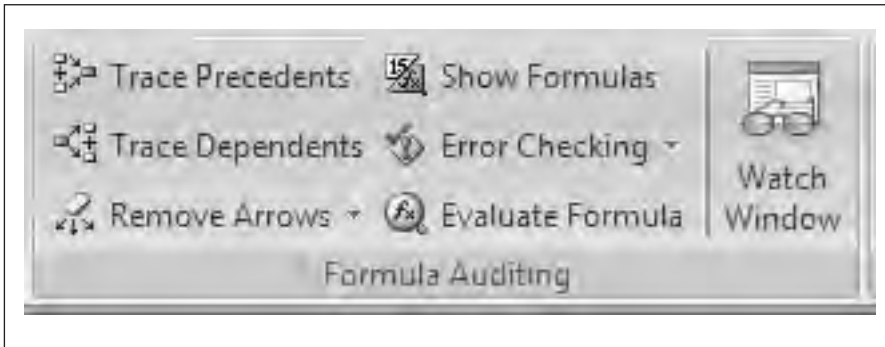
Figure 2.4

Original present value model

	A	B	C	D	E	F	G	H	I
1		Present Value							
2									
3			0	1	2	3	4	5	
4									
5		Capital value	-100000						
6		Cash flows		28000	28000	28000	28000	28000	
7									
8		Total	-100000	28000	28000	28000	28000	28000	
9									
10		Factor	1.00	0.91	0.83	0.75	0.68	0.62	
11									
12		Net cash flow	-100000	25454.55	23140.5	21036.81	19124.38	17385.8	
13									
14		NPV	5142.03						
15									

Options view

Figure 2.5



If you go to Formulas, Formula Auditing, you can select Show Formulas, which allows you to see the formulas. Alternatively, you can press Ctrl and ' together and this toggles between view formulas and normal view.

Office 2003 – Tools, Options, View or Tools, Formula Auditing, Formula Auditing Mode

As you can see, this is only producing a net present value based on the cash flows using the formula:

$$\text{Period_Factor} = \frac{(1)}{(1 + 10\%)^{\text{Period_Number}}}$$

Figure 2.6 shows the formulas view displaying all the cell references.

Original model formula

Figure 2.6

	A	B	C	D	E
1		Present Value			
2					
3			0	1	2
4					
5		Capital value	-100000		
6		Cash flows		28000	28000
7					
8		Total	=SUM(C5:C7)	=SUM(D5:D7)	=SUM(E5:E7)
9					
10		Factor	=1/(1+10%)^(C3)	=1/(1+10%)^(D3)	=1/(1+10%)^(E3)
11					
12		Net cash flow	=C8*C10	=D8*D10	=E8*E10
13					
14		NPV	=SUM(C12:H12)		

FORMATS

The model is presently a mixture of inputs and calculations (see Figure 2.7) and the first job is to reorganize the layout. This involves:

- inserting lines and moving the inputs;
- referring to the inputs in the cash flows and calculations;
- labelling where possible to look up the values in inputs, for example B9 is now C3;
- correcting the factors with an input;
- using different fonts and typefaces to break up the monotony.

Figure 2.7

Formats

	A	B	C	D	E	F	G	H
1	Present Value							
2								
3	Capital value		100000		Management Summary			
4	Periodic cash flow		28000		NPV	6142.03		
5	Discount rate		10%					
6								
7			0	1	2	3	4	5
8								
9	Capital value		-100000					
10	Periodic cash flow			28000	28000	28000	28000	28000
11								
12	Total		-100000	28000	28000	28000	28000	28000
13								
14	Factor		1.00	0.91	0.83	0.75	0.68	0.62
15								
16	Net cash flow		-100000	25454.55	23140.5	21038.81	19124.38	17385.8
17								
18	NPV		6142.03					

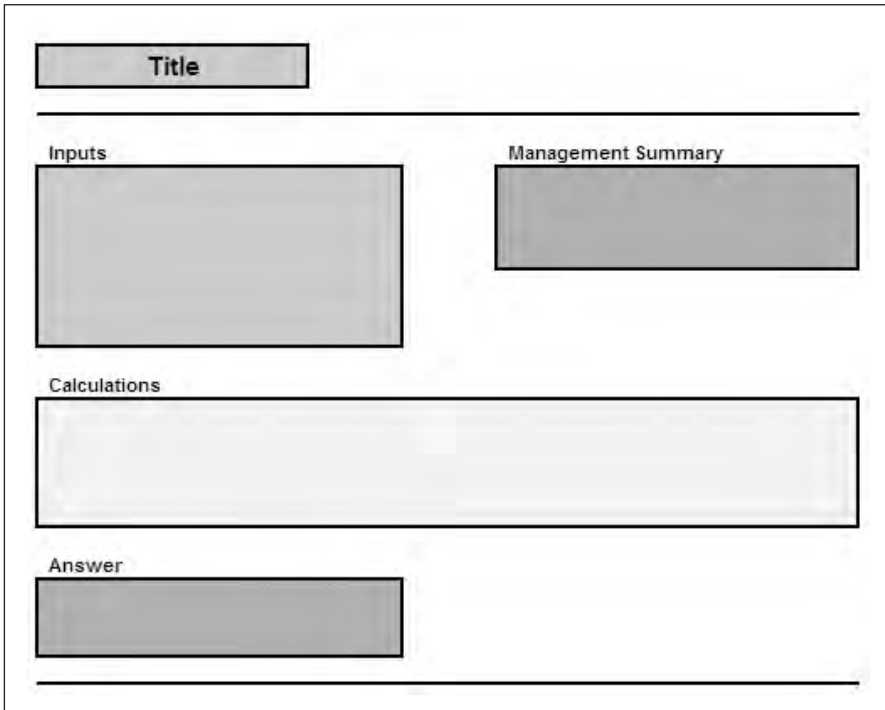
The title, inputs, summary and answer are now clear in a bold typeface and the model follows a defined layout (see Figure 2.8).

NUMBER FORMATS

The number formats are inconsistent with no separators and two different sets of decimal places.

Layout

Figure 2.8



Go to Home, Number, Number, More Number Formats (Excel 2003 – Format, Format Cells, Number) to change the default settings (see Figure 2.9).

You can experiment with different custom formats where positive, negative and zero is separated by semi-colons. Colours are inserted in square brackets. Text is enclosed in inverted commas (e.g. Format) so that ‘years’ is added to the number: 0 “years”. You insert your custom format in the Type box or amend an existing format.

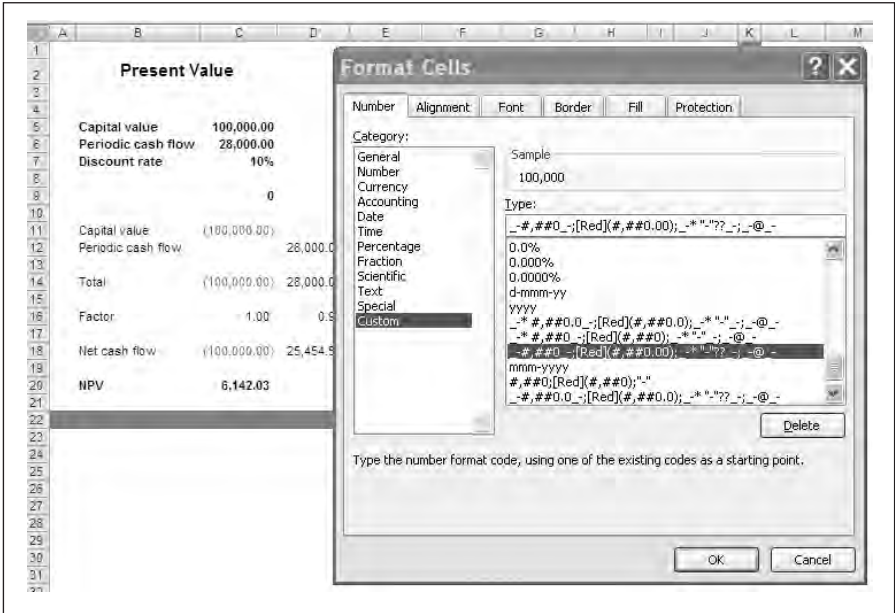
This extract in Figure 2.9 shows the accounting format with positive numbers slightly set to the left and negative numbers in red with brackets around them. Zero is a dash to avoid confusion or schedules of zeros. This type of format is easy to read on laser printers whereas a minus sign is often hard to read on negative numbers.

```
Accounting style format: _-* ,##0.00_-;[Red]
(,##0.00);_-* "-"_-
```

The effect is to control the view of the numbers to a maximum of two decimal places. This format can be simplified to: #,##0.00 ; [Red] (#,##0.00) ; -

Figure 2.9

Custom format cells



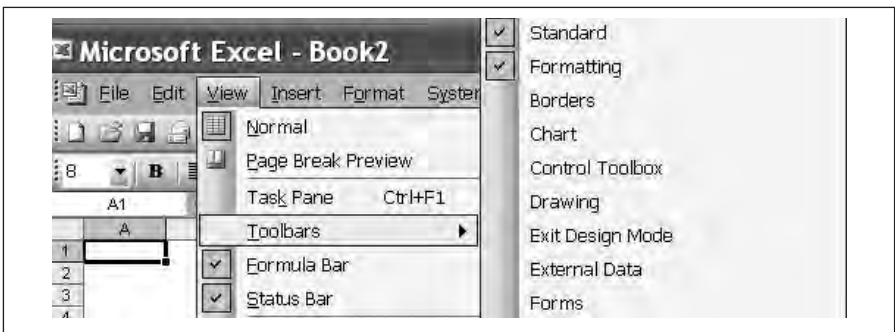
LINES AND BORDERS

Lines and borders assist in breaking up the cell code and make the model look more interesting for the audience both on the screen and in printed output. It is best to keep the Formatting toolbar visible (see Figure 2.10). In Excel 2007, these controls are under Home. In Excel 2003 go to View, Toolbars, Formatting to show this toolbar. This saves always going to Format, Cells, Borders, etc. to add lines.

Figures 2.11 and 2.12 show highlighting cells and then applying a border from the toolbox. Thick lines are placed around the main sections and double lines to indicate a total.

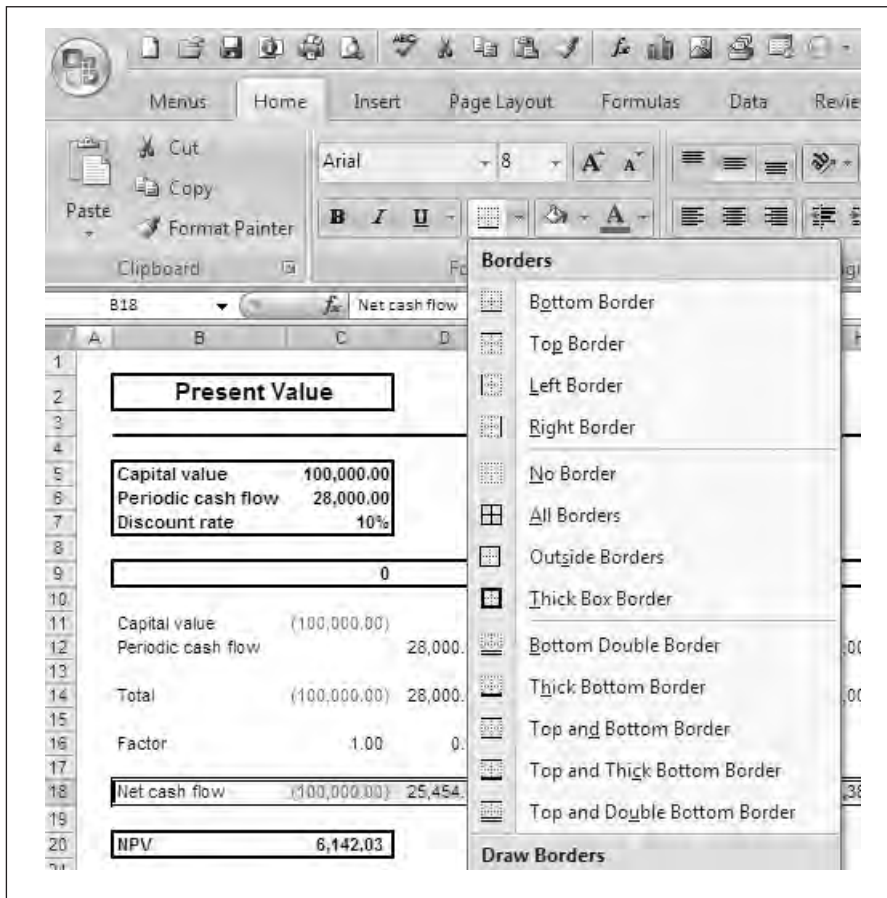
Figure 2.10

Formatting toolbar



Borders

Figure 2.11



Completed borders

Figure 2.12

The screenshot shows the completed spreadsheet with borders applied to the data tables and the NPV result. The data is as follows:

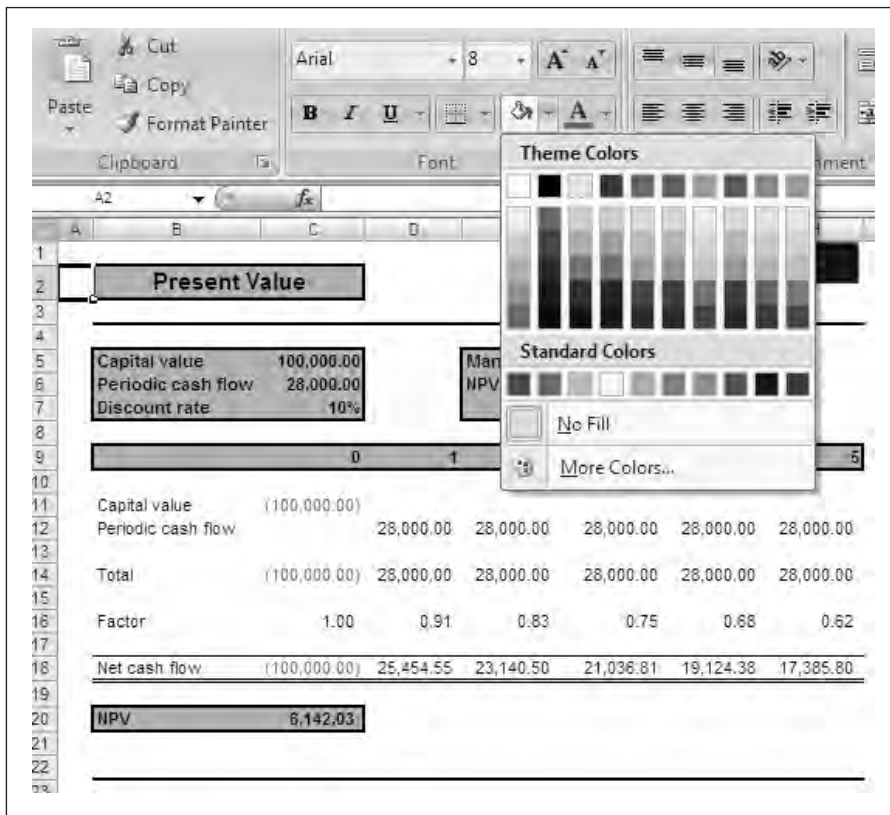
	A	B	C	D	E	F	G	H
1		Present Value						
2								
3								
4								
5		Capital value	100,000.00					
6		Periodic cash flow	28,000.00					
7		Discount rate	10%					
8								
9			0	1	2	3	4	5
10								
11		Capital value	(100,000.00)					
12		Periodic cash flow		28,000.00	28,000.00	28,000.00	28,000.00	28,000.00
13								
14		Total	(100,000.00)	28,000.00	28,000.00	26,000.00	28,000.00	28,000.00
15								
16		Factor	1.00	0.91	0.83	0.75	0.68	0.62
17								
18		Net cash flow	(100,000.00)	25,454.55	23,140.50	21,036.81	19,124.36	17,385.80
19								
20		NPV	6,142.03					
21								
22								

COLOUR AND PATTERNS

Colours and patterns also help to define inputs and outputs. In Figure 2.13 a neutral colour is used for the inputs and grey for the answers, although the screen colours do not show up here. Notice that there are more colour options in Excel 2007 through the use of themes than are present in earlier versions of Excel. These colours are personal, but it is important to be consistent in the use of colours and formats.

Figure 2.13

Colours



SPECIFIC COLOUR FOR INPUTS AND RESULTS

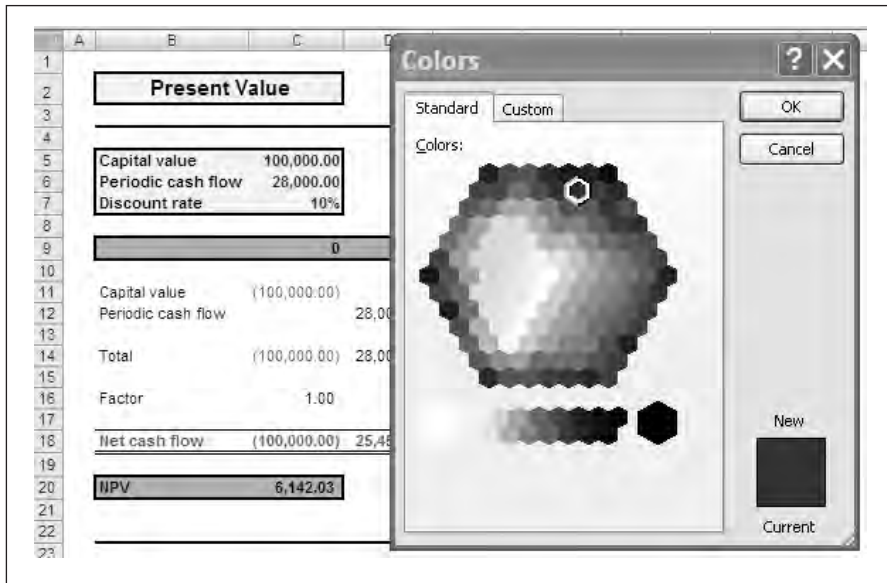
Specific colours for inputs show where data is required. The author always uses blue for inputs, green or black for totals and red or black for calculated results (see Figure 2.14). Colour should be used sparingly as the effect can be too garish for most tastes. Colour is used for function not decoration.

Office 2007 – Home, Font, Theme Colours

With limited colour, the model becomes much clearer for the user and forces the author to keep inputs together for the sake of consistency. The model is now organized and easier for user input than the original model.

Font colours

Figure 2.14



DATA VALIDATION

Data validation allows you to set limits for cells so that if you want a date, the user can only enter a date, or if you want a seven-character text string, the user has to enter this to proceed. In Excel 2003, this is accessed using *Data*, *Validation* on the main menu bar (see Figure 2.15).

Office 2007 – Data, Data Tools, Data Validation

In this case, it would be a good idea to limit the three inputs as follows:

- Capital value Positive number greater than zero
- Periodic cash flow Positive number greater than zero
- Discount rate Positive number between 0 and 1, i.e. 100 per cent.

The dialog box has three tabs (see Figure 2.16): for settings, an input message when the cursor is close to the cell, and the error alert to be shown on

incorrect entry. You can choose not to show the Input Message by deselecting the box.

Figure 2.15

Validation settings

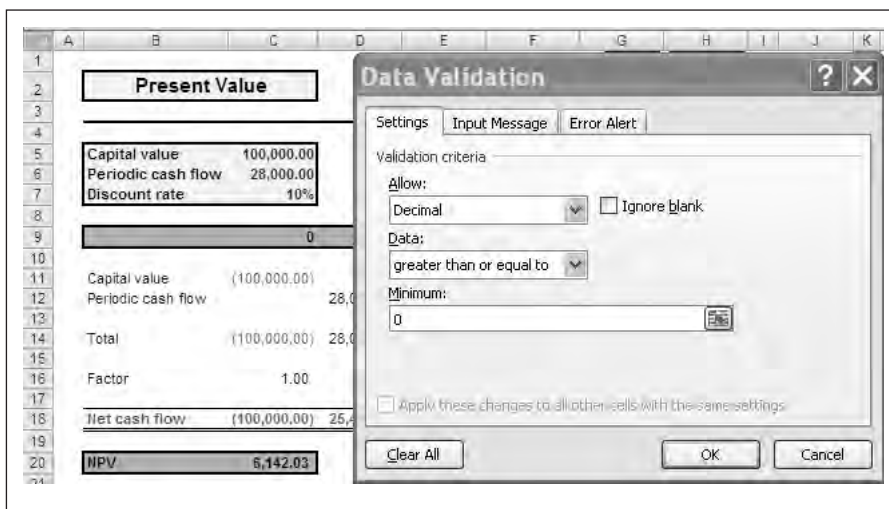
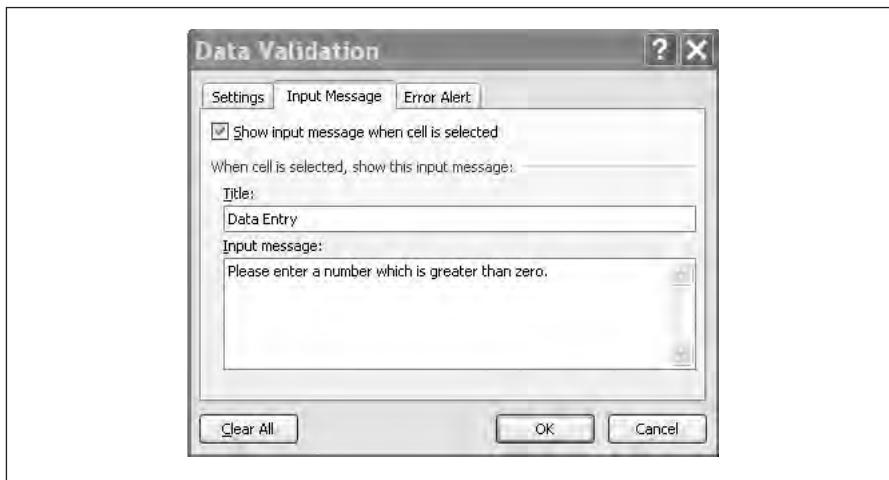


Figure 2.16

Validation: input message



The Error Alert (see Figure 2.17) shows if you enter a wrong figure and will not let you proceed until you comply with the validation terms. This means that the capital value should always be a positive figure, errors are avoided and auditing becomes easier. Note that you should always use Stop as other options allow you to proceed with incorrect data.

Validation error alert

Figure 2.17



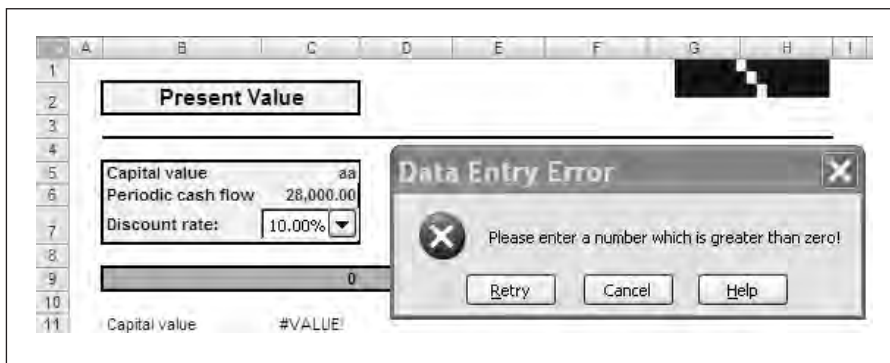
Paste Special validation

Figure 2.18



Figure 2.19

Validation error



Since the periodic cash flows share the same validation, you can Copy and then go to Home, Paste, Paste Special, Validation (Excel 2003 – Edit, Paste, Paste Special, Validation) rather than typing in all the parameters again (see Figure 2.18).

The final validation is simply to ensure that the discount rate is less than 100 per cent. The effect is to narrow the inputs and hopefully ensure that a user will get the correct answers. If he tries to enter a discount rate of 120 per cent, the error message shown in Figure 2.19 appears.

Again, this is simply looking at the model from a user standpoint and trying to coach the users on what they are required to do to get satisfactory answers. Many auditing errors arise from incorrect inputs and this is one way of controlling potential errors.

CONTROLS – COMBO BOXES AND BUTTONS

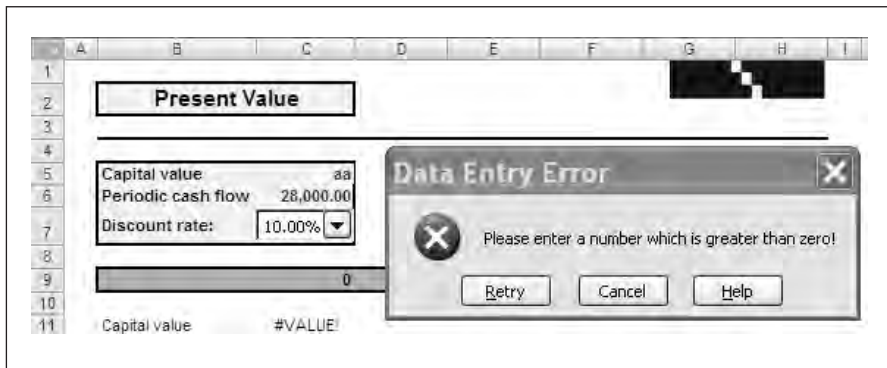
A further tool to speed up inputs and assist users can be found under Developer, Controls, Insert, Form Controls (Excel 2003 – Forms toolbar under View, Toolbars). These are the same controls, which you also find in Access or Visual Basic. In this example, you might wish to allow the user to input a discount rate between 8 per cent and 12 per cent at 0.5 per cent intervals. This cannot be done by validation and a different approach is needed. Validation will only permit an upper or lower value.

The first stage is to insert a workings area at the bottom of the sheet and to cut and paste the discount rate into it (see Figure 2.20). This is to ensure that the model continues to function when a control is placed at cell C7.

The Workings box shows an interval and then rates starting at 8 per cent and incrementing by the amount of the interval (see Figure 2.21).

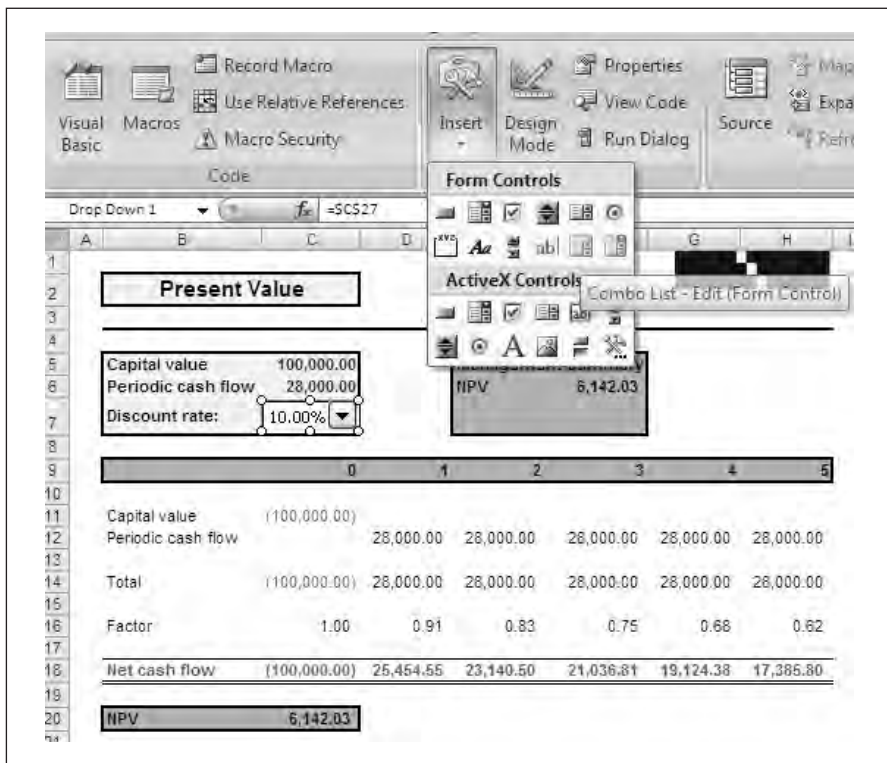
Combo workings 1

Figure 2.20



Combo workings 2

Figure 2.21



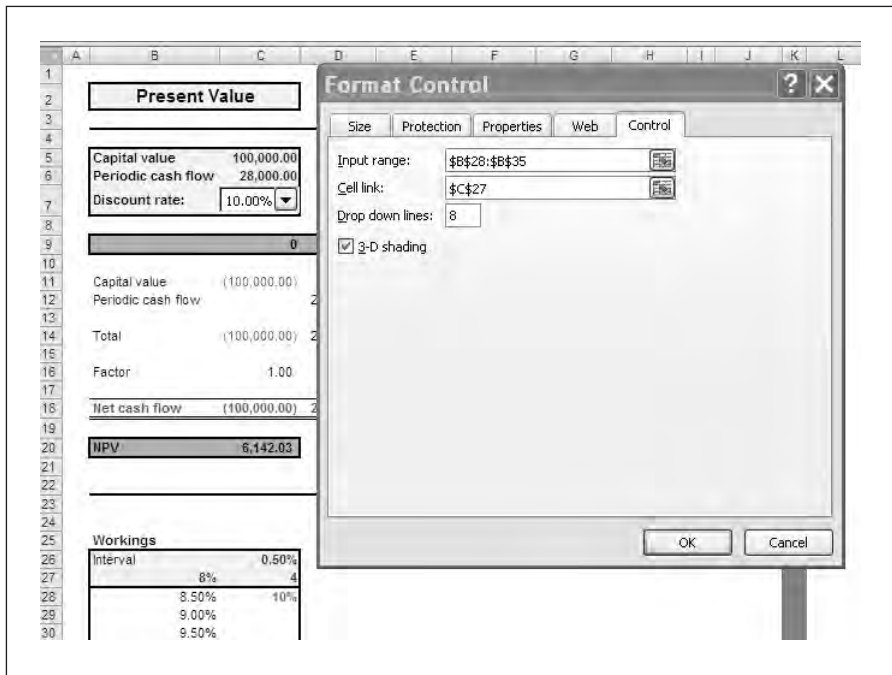
The finished workings box shows the discount rates between 8 per cent and 12 per cent. The interval is not 'hard coded' and is dependent on cell C26. Whilst these are variables, most users do not need this detail and so these items are placed in the workings area and clearly marked.

The combo box control returns a number for the index of the selection. Here there are eight possible selections and the index number will be placed in cell C27. If you click on the Combo Box in the toolbar, you can draw a combo box in cell C7.

You have to tell the control where to get the input information from and where to put the result. Here the discount rates that need to be displayed are in B28:B35 and the result should be placed in cell C27 (see Figure 2.22).

Figure 2.22

Format control

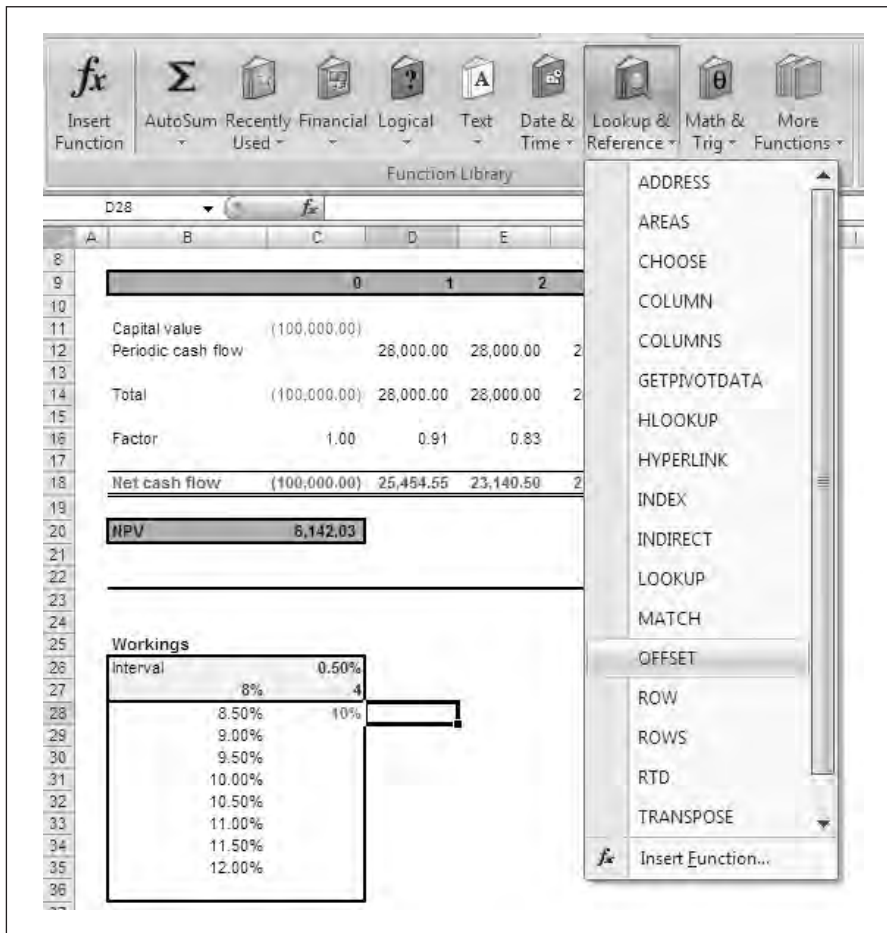


The final stage is to link the discount rate cell C28 with the index cell C27. Since C28 will now be calculated, the colour has been changed to red to avoid confusion. This requires a simple function called OFFSET from the Lookup group, accessed by selecting Formulas Insert Function (Excel 2003 – Insert Function).

The OFFSET function allows you to nominate a starting cell and then go down by X rows and across by Y columns and return the value (see Figure 2.23). Here the example should start at cell B27 and go down by the number of rows returned by the control. You start at B27 and go down by C27 and no columns (see Figure 2.24). This should return the discount rate to be used in the present value calculations.

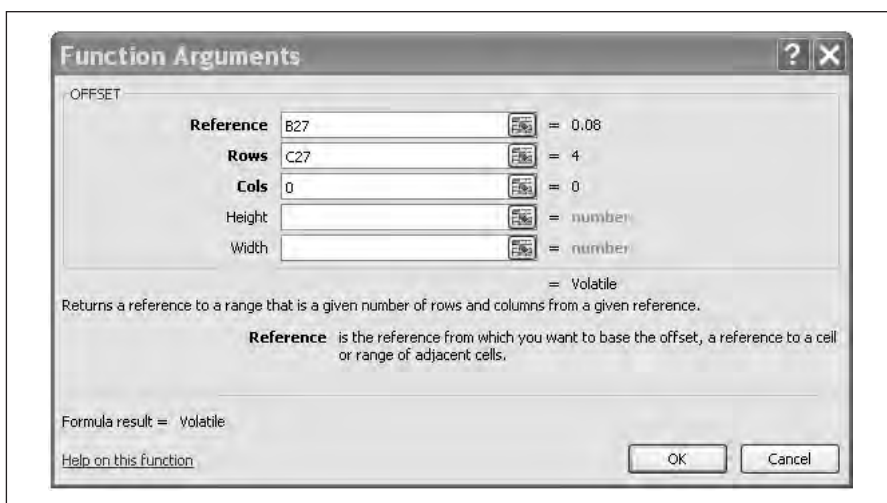
Paste function

Figure 2.23



Offset

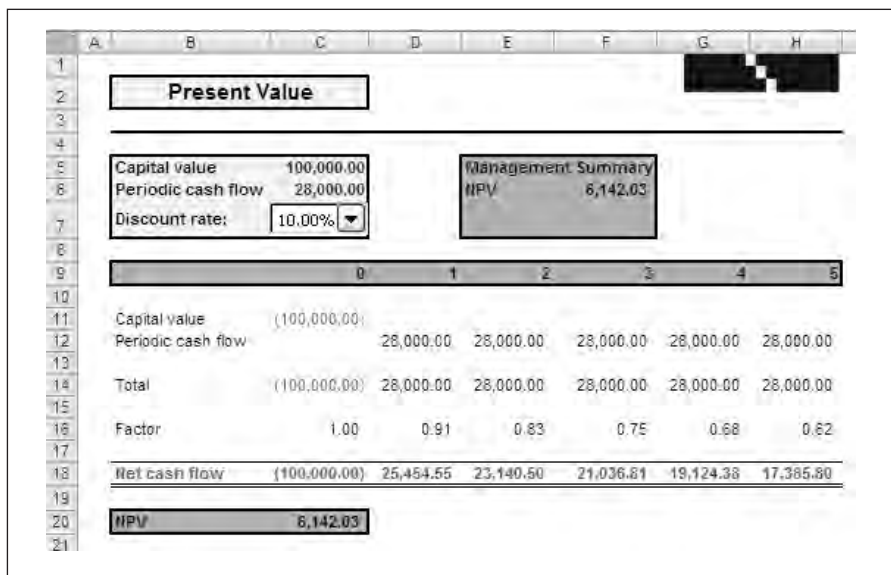
Figure 2.24



The combo box controls the user input and makes it faster to select the individual discount rates (see Figure 2.25). Note that a user could still input data to cells B27, C26 and C27. The combo box runs a macro or routine to update the cell, but does not protect it.

Figure 2.25

Working combo box



There are other controls in the Developer toolbox that you could use to make the inputs more intuitive. For example, spinners and scrollbars allow you to increment a value by one click and provide an input variable for specifying the click value.

Office 2007 – Developer, Controls, Insert, Form Controls

The Scroll Bar sheet shows the inclusion of these two controls as an alternative. Here you right click to format and select an upper and lower value and an incremental value. The solution is slightly more complex since the control does not accept fractions. You therefore have to calculate the eventual discount rate from the position of the scroll bar.

The scroll bar is set to accept values from 1 to 8 and to increment by one. The cell link is cell C26 and the OFFSET function in cell C27 uses this index number (see Figure 2.26).

Scroll bar

Figure 2.26

	0	1	2	3	4	5
Capital value	(100,000.00)					
Periodic cash flow		28,000.00	28,000.00	28,000.00	28,000.00	28,000.00
Total	(100,000.00)	28,000.00	28,000.00	28,000.00	28,000.00	28,000.00
Factor	1.00	0.91	0.83	0.76	0.70	0.64
Net cash flow	(100,000.00)	25,570.78	23,352.31	21,326.31	19,476.08	17,786.37
NPV						7,511.85

CONDITIONAL FORMATTING

Conditional formatting allows you to display cells differently depending on the value in the cell. This means fonts, borders and patterns. In this example, it could be useful to introduce a management test to show if the project succeeds or fails and then display the result accordingly. You can set various types of rules in Excel 2007 and this is more comprehensive than previous versions. (see Figure 2.27).

There is now a new cell C7, which defines the management test requiring a minimum net present value of 7000. The formatting is set using Home, Styles, Conditional Formatting. In Excel 2003 this is found at Format, Conditional Formatting. The result changes to pink when the value is greater than or equal to the value in cell C7. The result is shown in Figure 2.28, where, at 9.5 per cent the project achieves the goal.

You can add further formats by clicking on Add and also copy using Edit, Paste Special, Formats.

USE OF FUNCTIONS AND TYPES OF FUNCTIONS

The model already includes the function `OFFSET`, but the net present values could more easily be calculated using the `NPV` (net present value) function. At present, there is code in cells C17 to H19, which means there are potentially 12 mistakes. The goal should be to reduce code in order to reduce the potential for errors. The solution at present is equivalent to using Excel instead of a set of discount tables.

Figure 2.27

Conditional formatting

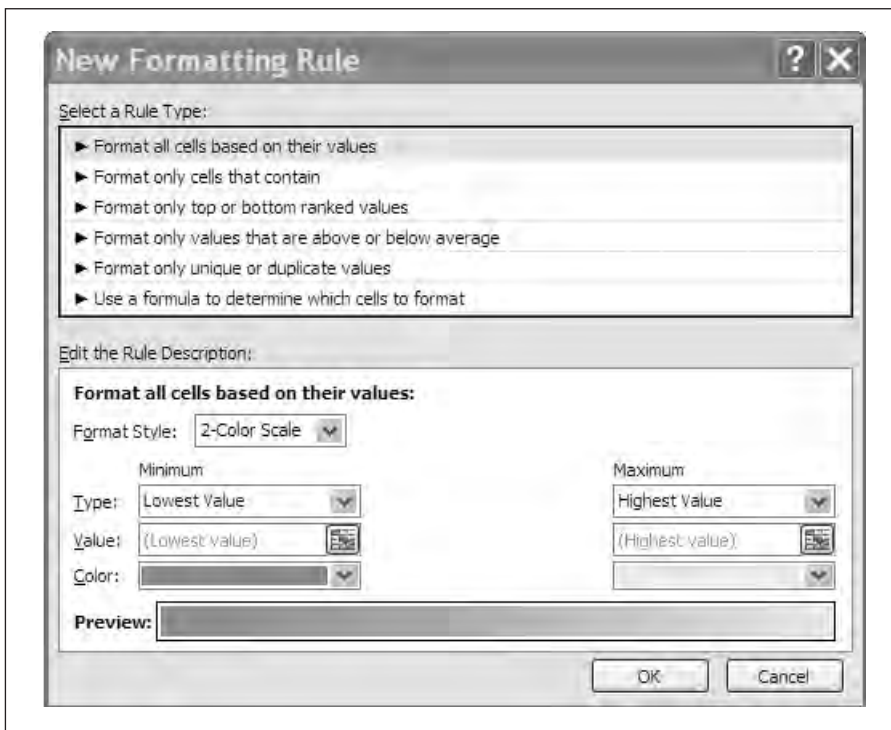


Figure 2.28

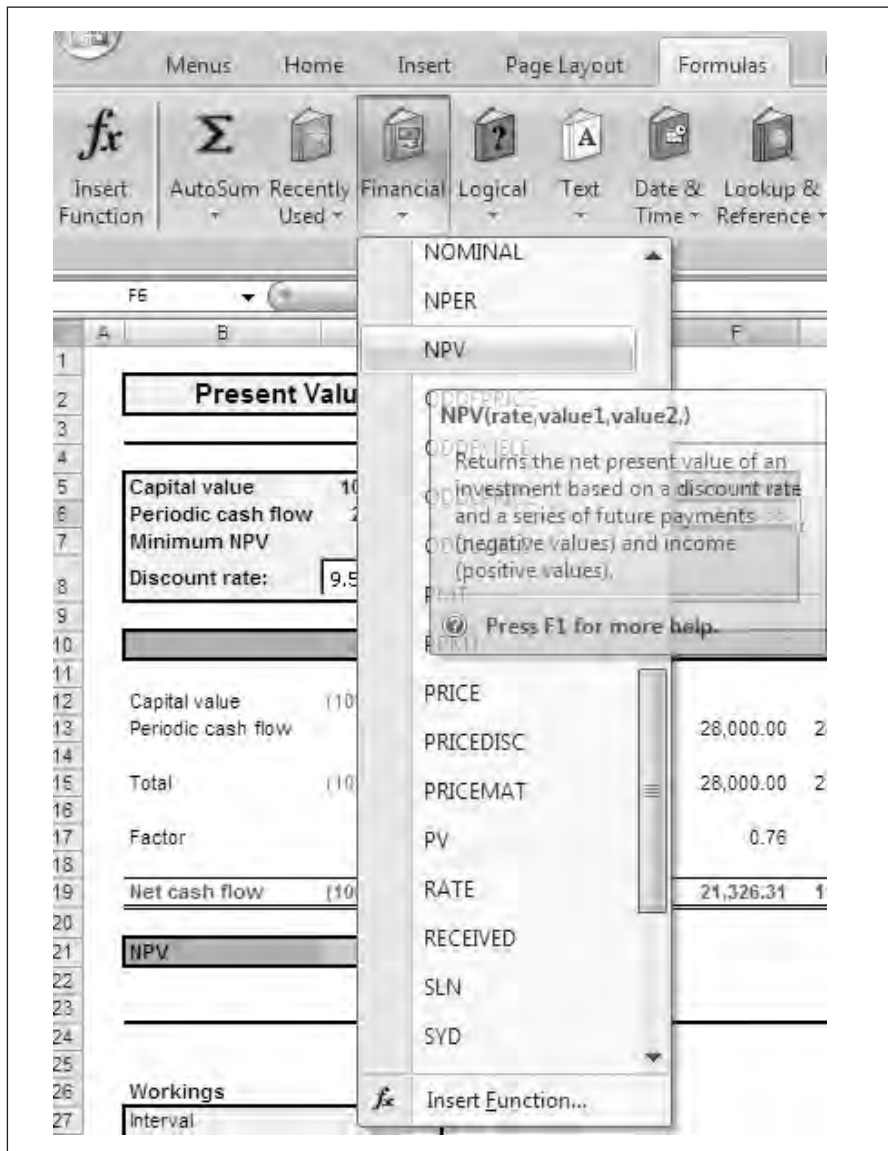
NPV result

	A	B	C	D	E	F	G	H
1	Present Value							
2								
3								
4								
5	Capital value	100,000.00			Management Summary NPV 7,511.85			
6	Periodic cash flow	28,000.00						
7	Minimum NPV	7,000.00						
8	Discount rate:	9.50%						
9								
10			0	1	2	3	4	5
11								
12	Capital value	(100,000.00)						
13	Periodic cash flow		28,000.00	28,000.00	28,000.00	28,000.00	28,000.00	
14								
15	Total	(100,000.00)	28,000.00	28,000.00	28,000.00	28,000.00	28,000.00	
16								
17	Factor		1.00	0.91	0.83	0.76	0.70	0.64
18								
19	Net cash flow	(100,000.00)	25,570.78	23,352.21	21,326.31	19,476.08	17,786.37	
20								
21	NPV		7,511.85					
22								
23								

You can use *Formulas*, *Function Library* (Excel 2003 – *Insert*, *Function* from the *Menu Bar* or the *Standard toolbar*) and functions are divided into sections for easy reference. Select *Financial Functions* and scroll down to *NPV* (see *Figure 2.29*).

NPV function

Figure 2.29



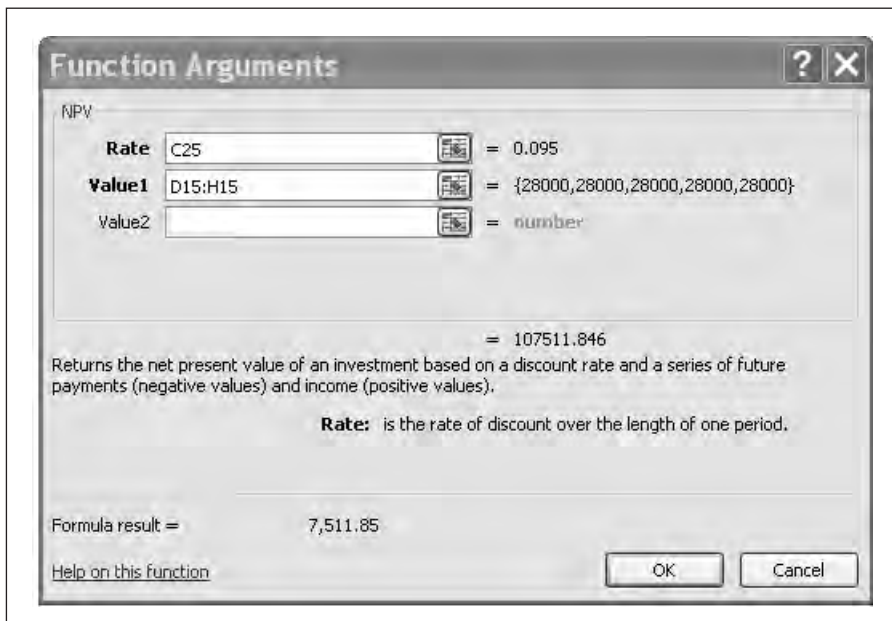
The NPV function discounts outstanding cash flows and so the years one to five are selected. You then add the cash flow at period 0.

`=NPV (C25 ,D15 :H15) +C15`

This results in the correct answer of 7511.85 at the discount rate of 9.5 per cent.

Figure 2.30

Function detail



Notice the spreadsheet is now much simpler with a reduction in the necessary rows. You can always obtain help on the functions by pressing the Question Mark (see Figure 2.30). Within the Help for the selected function, you can view a listing of alternative functions by selecting See Also.

ADD-INS FOR MORE FUNCTIONS

The typical installation of Excel contains the basic functions, but more functions are available in the Analysis Toolpak. For example, NPV assumes that each period contains the same number of days. XNPV allows you to enter dates when the cash flows are received.

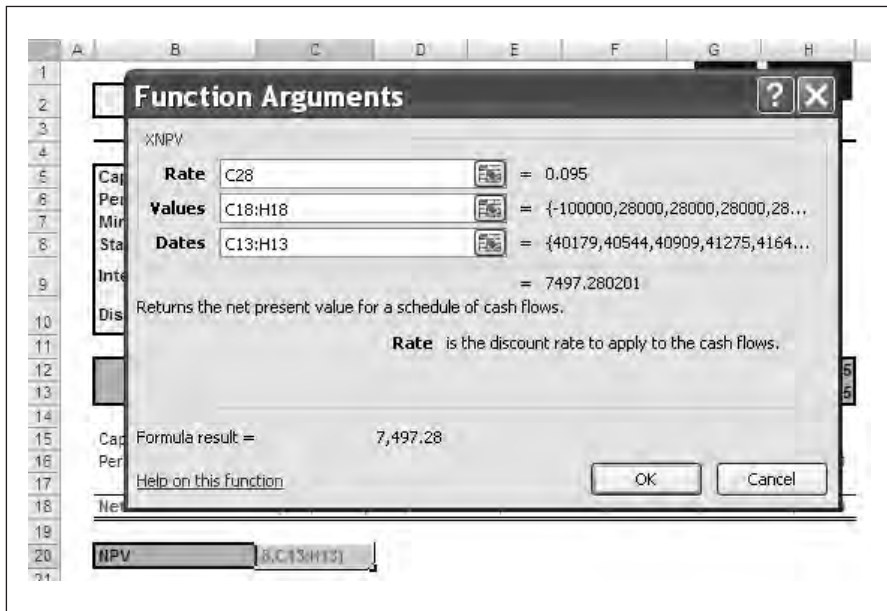
To ensure that you have access to extended functions go to Office Button, Excel Options, Add-ins (Excel 2003 – Tools, Add-Ins, Analysis Toolpak). Tick this item and press OK to install it. The Toolpak will then be available every time you open Excel. If it is not available as an add-in, you will need to reinstall Excel using the original Office disks.

The next sheet uses the XNPV function and EDATE, which is a date function that advances the date by multiples of one month at a time (see Figure 2.31). You provide a start date and then the number of months to be advanced. Since the interval is a variable, there is a new control in the inputs area which points towards a set of workings to derive the number of months for the EDATE function in cells D13 to H13.

Again, you add the initial cash flow and the result is 7502.58, which compares with the previous answer of 7511.85.

XNPV and EDATE

Figure 2.31



TEXT AND UPDATED LABELS

You could improve the clarity of the model by allowing the labels to update and providing some text on the result. If the net present value is above the limit, then you could have a label informing the user. The Text sheet in the model provides two improvements:

- 1 it shows the discount rate in the label;
- 2 it provides feedback on the calculated net present value.

Cell B20 is now an updated label. The Text function converts numbers to text following the number formats. This will display the percentage to two decimal places. The ampersand (&) is used to join or concatenate the text strings.

=NPV at "&TEXT(C31,"0.00%")

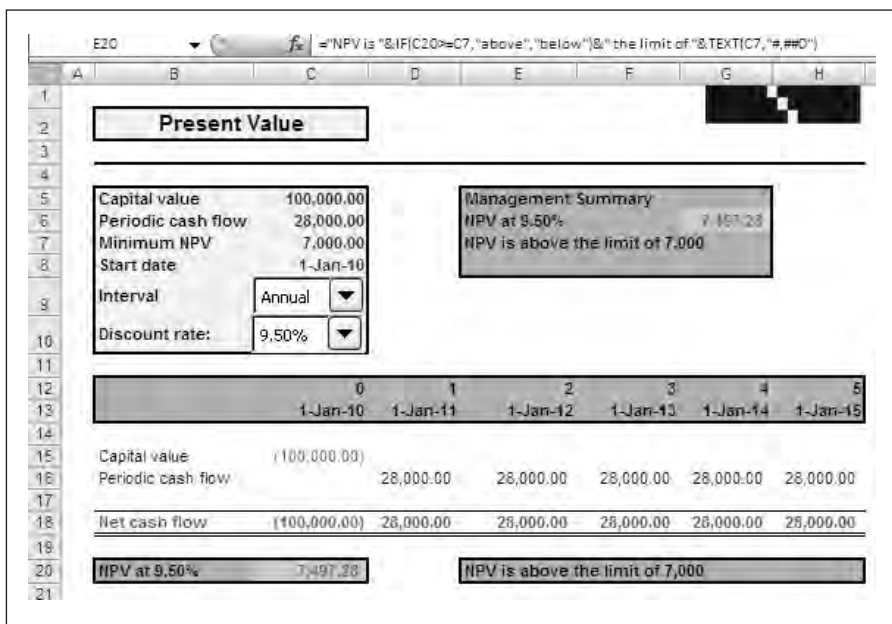
The management feedback uses an IF function to display one text string if the project is above the limit and another if it is below. In order to reduce the code, the IF statement substitutes a zero above or below depending on the net present value.

=NPV is "&IF(C20>=C7,"above","below")&" the limit of
 "&TEXT(C7,"#",##0")

The spreadsheet will now inform the user of the discount rate used and provide a comment of the answer (see Figure 2.32). Excel takes the decision rather than the user having to spend time reviewing the result.

Figure 2.32

Text labels

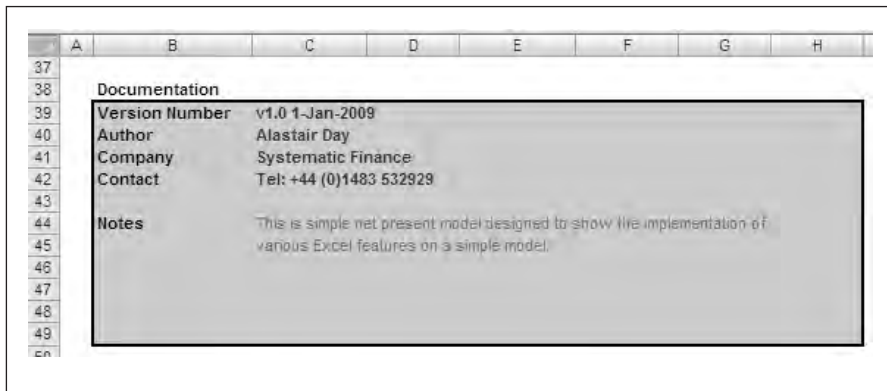


RECORDING A VERSION NUMBER, AUTHOR, ETC.

As detailed in Chapter 1, there should be some documentation as part of the model. With complex models, it is good practice to record version numbers, author name and contact details together with notes on how the model works. As a model develops over time, you can record the changes between one version and another. This is particularly important if you find a major error. In addition, it means that a version reference is at the top of every sheet that you printed out (see Figure 2.33).

This section could of course run to several pages with diagrams and notes. It is, of course, better to put the notes in the model and you can always hide a sheet by selecting *Format, Sheet, Hide*.

Documentation

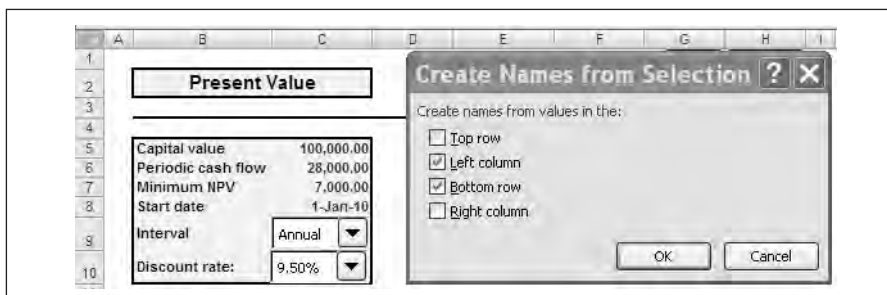
Figure 2.33


USING NAMES

Names can make formulas easier to understand: for example rather than using cell C28, you can have *PeriodInterestRate*. The standard cells above such as *Version*, *Author*, etc. would also be better standardized across all your models such that *=Version* will always insert the version number. The files with this book use several standard names such as *Author*, *Company*, *Version* and *Product*.

You can use *Formulas, Defined Names, Define Names* (Excel 2003 – *Insert, Name, Define*) to define names; alternatively, Excel will create multiple names using the labels to one side of the selected cells using *Create from Selection* (see Figures 2.34 and 2.35). This creates the names in the left-hand column (e.g. *Start_date*). The function is now easier to understand since it refers to the periodic interest rate in cell C20.

Create names

Figure 2.34


=XNPV(Int_Rate,C18:H18,C13:H13)

If you copy a sheet containing names, then the new sheet will continue to refer to the original sheet. Similarly, if you copy a sheet to a new workbook, Excel creates a link between the two workbooks. You can always check for links by selecting *Edit, Links*. If this is the case, you have to remove them manually and reinsert the cell formulas. To help with names, Excel 2007 has a more comprehensive Names manager, which allows you to manage them more effectively than in previous versions.

Figure 2.35

Name manager

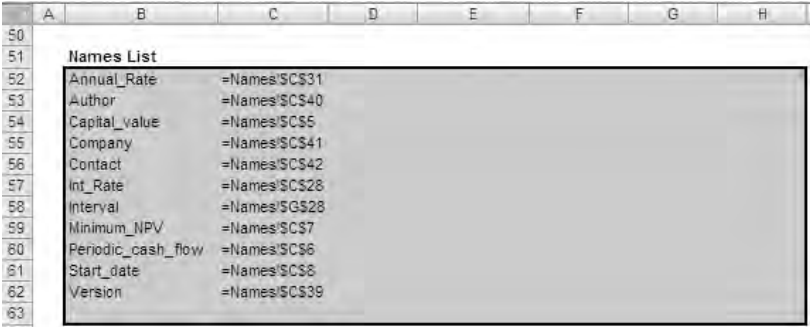


PASTING A NAMES TABLE

It is useful to paste a list of names as part of the documentation to provide an audit trail. Any deleted names should be removed so that all names are current and usable. You select *Formulas, Defined Names, Use in Formula, Paste Name, Paste List* (Excel 2003 – *Insert, Name, Paste, Paste List*). (See Figure 2.36.)

Names list

Figure 2.36



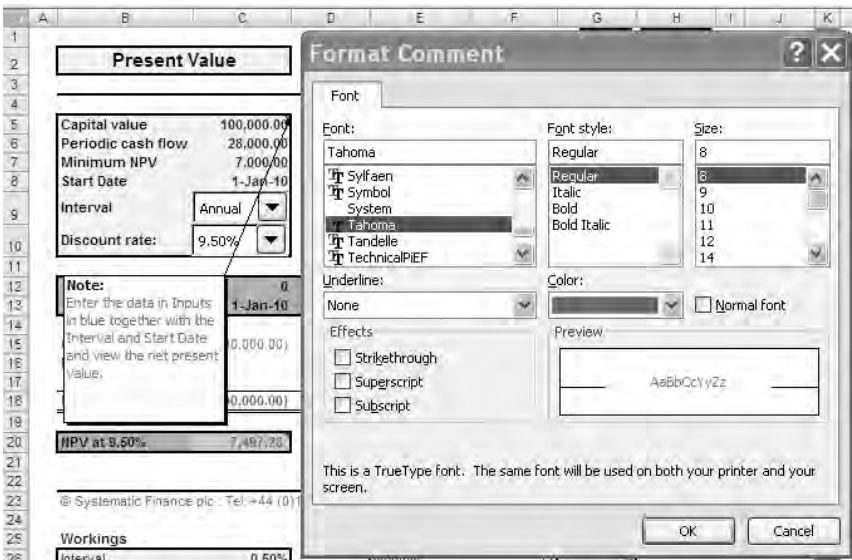
	A	B	C	D	E	F	G	H
50								
51		Names List						
52		Annual_Rate	=Names!\$C\$31					
53		Author	=Names!\$C\$40					
54		Capital_value	=Names!\$C\$5					
55		Company	=Names!\$C\$41					
56		Contact	=Names!\$C\$42					
57		Int_Rate	=Names!\$C\$28					
58		Interval	=Names!\$C\$28					
59		Minimum_NPV	=Names!\$C\$7					
60		Periodic_cash_flow	=Names!\$C\$6					
61		Start_date	=Names!\$C\$8					
62		Version	=Names!\$C\$39					
63								
64								

COMMENT CELLS

Commenting cells allow notes to be placed against cells to provide background or help the user. Go to *Review, Comments, New Comment* (Excel 2003 – *Insert Comment*) or right mouse click on a cell. Enter a text message and then format the font size and colours (see Figures 2.37 and 2.38).

Comments

Figure 2.37



The screenshot shows an Excel spreadsheet with a 'Present Value' calculation. A comment is attached to the cell containing the start date '1-Jan-10'. The 'Format Comment' dialog box is open, showing the following settings:

- Font:** Tahoma
- Font style:** Regular
- Size:** 8
- Underline:** None
- Color:** (Default)
- Effects:** Strikethrough, Superscript, Subscript (all unchecked)
- Preview:** AaBbCcYyZz

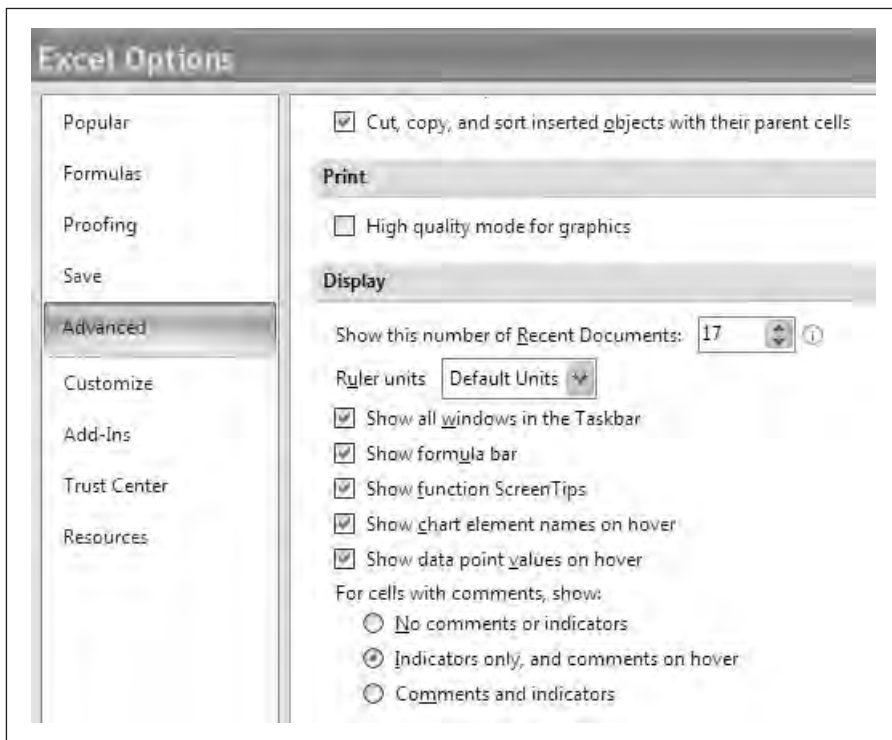
The spreadsheet data is as follows:

	A	B	C	D	E	F	G	H	I	J	K	
1		Present Value										
2												
3												
4												
5		Capital value	100,000.00									
6		Periodic cash flow	28,000.00									
7		Minimum NPV	7,000.00									
8		Start Date	1-Jan-10									
9		Interval	Annual									
10		Discount rate:	9.50%									
11												
12		Note:	0									
13		Enter the data in Inputs	1-Jan-10									
14		in blue together with the										
15		Interval and Start Date	0,000.00									
16		and view the net present										
17		value.	0,000.00									
18												
19												
20		NPV at 9.50%	7,497.28									
21												
22												
23		© Systematic Finance plc : Tel: +44 (0) 1234 567890										
24												
25		Workings										
26		Interval	0.50%									

You can control how Comments are viewed using Office Button, Excel Options, Advanced, Display (Excel 2003 – Tools, Options, View). You can turn them off, show the indicator or have the comment permanently visible. In the second case, the cell displays a red triangle at its top right-hand corner. Again, comments can assist in explaining important formulas or telling the user what to do. For example, some people use numbers for percentages and then divide by 100 in code. A comment could inform a user to insert a number rather than a percentage.

Figure 2.38

Comments options

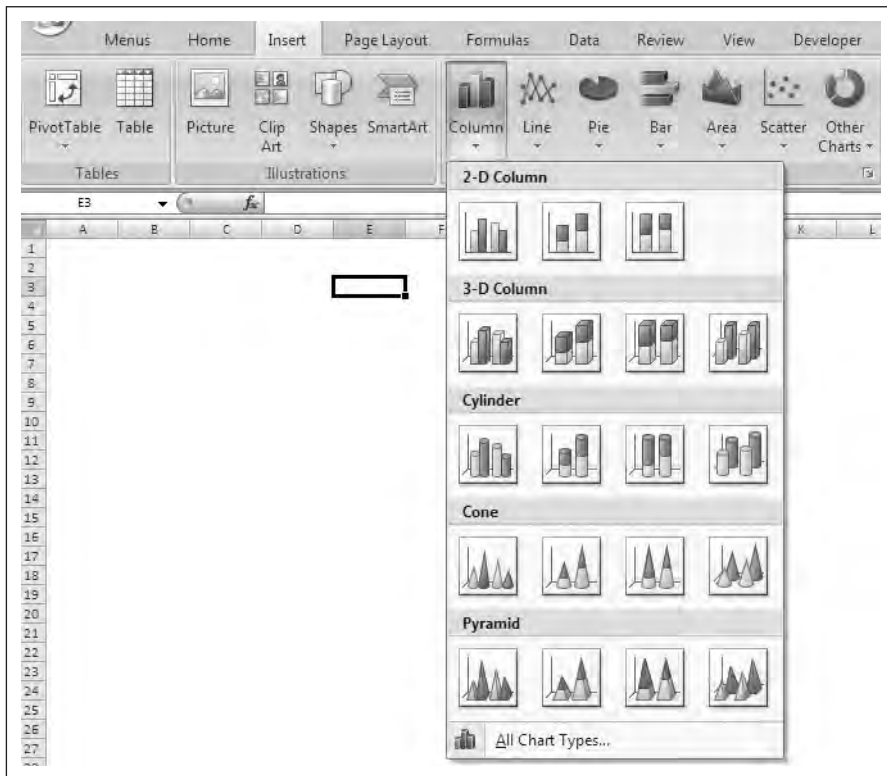


GRAPHICS

Graphics assist in management reporting and showing a user important results. The example now adds a cumulative cash flow and graphs the cash flow. You can use Insert, Chart, Chart Type (Excel 2003 – Insert Chart). (See Figure 2.39.)

Chart types

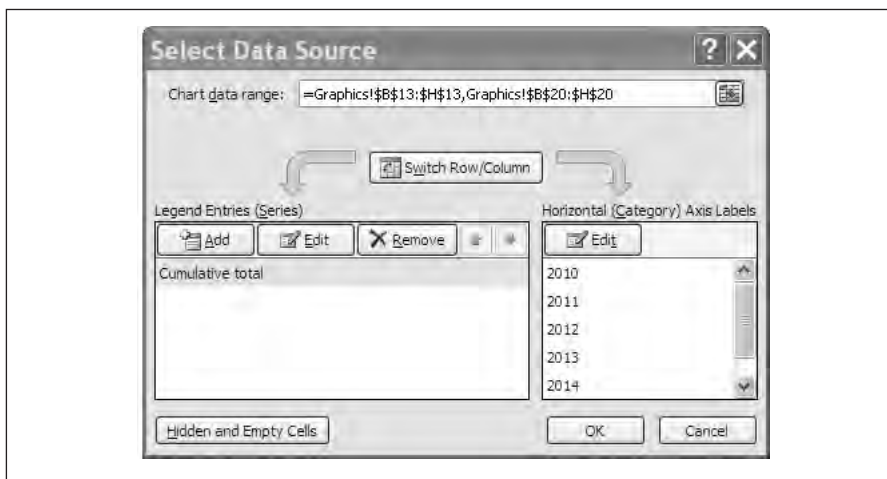
Figure 2.39



This is just charting a single series and so a column graph will produce a clear printout. You can right click the series and review the source data. Each series should consist of a reference for the names, X and Y axis (see Figure 2.40).

Source data

Figure 2.40



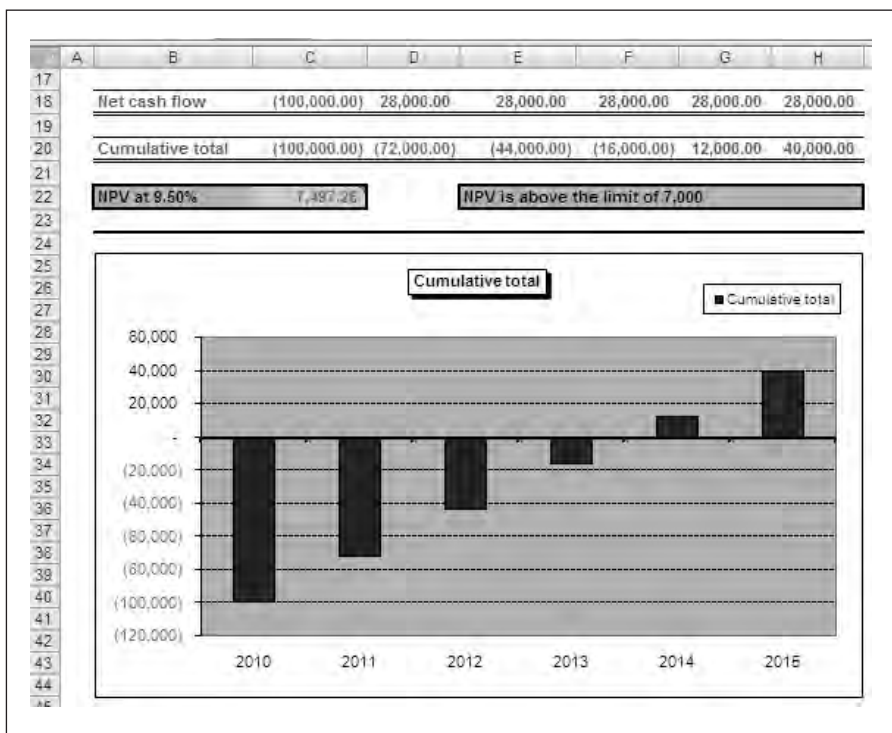
This will plot the cumulative cash flow values with the dates as the X labels across the chart (see Figure 2.41). The name is also in code as Graphics!\$B\$20. If you click on Next, the chart title and legend titles are displayed. Excel will not allow you to enter a cell reference against the name, but you can do this when you have finished the Wizard.

If you right click the X axis, it can be formatted so that the tick marks are low as an option in Patterns. The chart title is entered as =Graphics!\$B\$20 so that it updates itself. This is important since you do not want labels to be 'hard-wired'. The objective is always to reduce the hard coding and allow changes to cascade.

Payback is a non-time value of money method of investment appraisal. Essentially, you check how long it takes to get your money back. Figure 2.41 shows clearly that this will happen in year four.

Figure 2.41

Cumulative chart



DYNAMIC GRAPHS TO PLOT INDIVIDUAL SERIES

A single chart is very useful, but a dynamic graph would allow you to review any of the rows. This is a simple example but this approach would be useful for examining individual lines in a cash flow or company analysis.

Office 2007 – Developer, Controls, Insert, Form Controls (Office 2003 – View, Toolbars, Forms)

The steps are:

- Set up a combo box with the inputs as the labels to the individual lines and a cell link to update (F25).

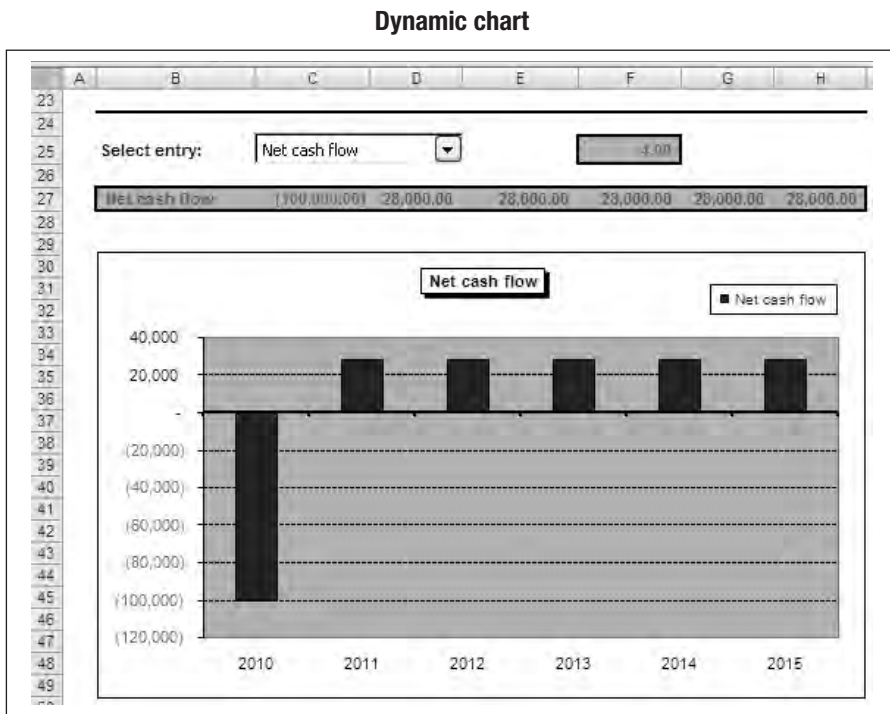


Figure 2.42

- Use an `OFFSET` function to look up the relevant line using the cell link from the control. The `OFFSET` function starts from row 14 and moves down by the number in cell F25.
- Point the chart at the look-up lines and ensure that the series and chart names are not hard-coded. The name of the series is cell B27 to ensure that it updates. The formula in cell B27 is:

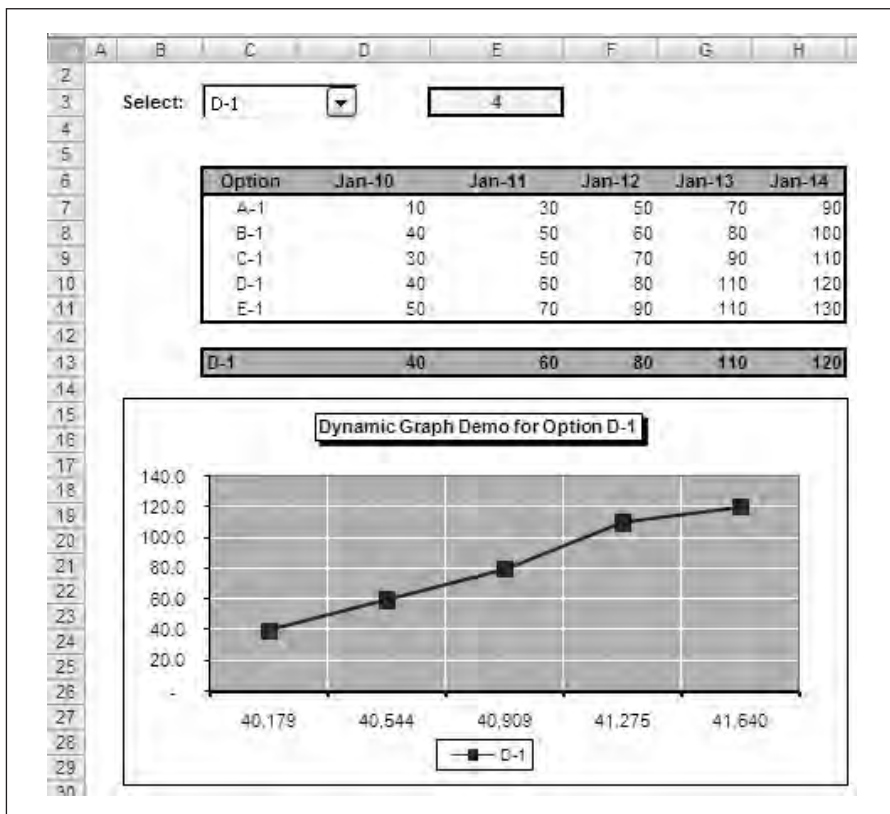
```
=OFFSET(B14, $F$25, 0)
```

Figure 2.42 displays the combo box with each of the available rows.

In the file, there is also a sheet called `Dynamic_Graph_Example`, which puts together a table of figures, a combo control, an `OFFSET` function and a graph to display the results (see Figure 2.43).

Figure 2.43

Dynamic graph



DATA TABLES

The model so far has produced a single-point answer: the capital and cash flows discounted at 9.5 per cent result in a net present value. The model would be more powerful if you could display the net present values for a range of discount rates simultaneously on the same sheet. This can be achieved by the array function Table, which can be found under Data, Data Tools, What-if Analysis (Excel 2003 – Data, Table).

The steps are:

- Set up a grid with an interval as an input.
- Enter the function.
- Graph the results.

The dynamic graph has been moved down on the Data_Tables sheet to make room for the data or Sensitivity table (see Figure 2.44). The grid consists of an interval and then a row of discount rates in line 29. The 9.5 per cent is an absolute and is marked as an input. The cells on either side are

plus or minus the interval. Cell B30 looks up the answer in cell C22. When complete the data table will show the net present value at each of these interest rates.

Sensitivity table

Figure 2.44

	0	1	2	3	4	5
	1-Jan-10	1-Jan-11	1-Jan-12	1-Jan-13	1-Jan-14	1-Jan-15
Capital value	(100,000.00)					
Periodic cash flow		28,000.00	28,000.00	28,000.00	28,000.00	28,000.00
Net cash flow	(100,000.00)	28,000.00	28,000.00	28,000.00	28,000.00	28,000.00
Cumulative total	(100,000.00)	(72,000.00)	(44,000.00)	(16,000.00)	12,000.00	40,000.00
NPV at 9.50%	7,497.28					

	8.50%	9.00%	9.50%	10.00%	10.50%	11.00%
NPV	7,497.28	10,324.40	8,896.15	7,497.28	6,127.00	4,784.57
Variance to 7,467		2,827.12	1,398.87		-1,370.28	-2,712.71

The next stage is to highlight the grid area and enter the data table (see Figure 2.45).

Table function

Figure 2.45

	8.50%	9.00%	9.50%	10.00%	10.50%	11.00%
NPV	7,497.28	10,324.40	8,896.15	7,497.28	6,127.00	4,784.57
Variance to 7,467		2,827.12	1,398.87		-1,370.28	-2,712.71

Cell C81 in this interim version is the periodic discount rate derived from the combo box. Excel inserts the figures in the grid and the answer of 7502.58 at 9.5 per cent is visible. This shows the sensitivity of the final answer to changes in the discount rate (see Figure 2.46).

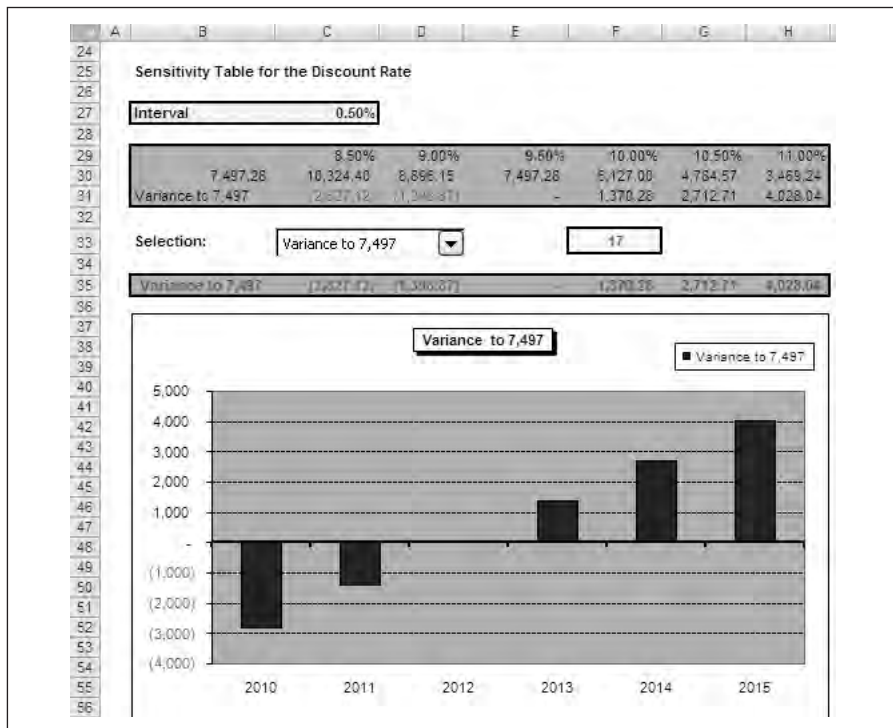
Table is an array function, which means that you cannot alter individual cells within the group. If you try to alter any of cells C31 to H31, you will get an error message. Similarly, if you copy a data table from one sheet to another, only the values will be pasted. You have to highlight the grid and reinput the table on the new sheet.

Rather than create a further chart, this example uses the existing 'dynamic graph' and increases the inputs to line 31. Line 31 is simply a variance to the original answer. The OFFSET function merely requires the rows to index down by and so no other programming changes are necessary.

Data tables can be single-dimensional, as above, or two-dimensional. There are often two dominant variables in a model and this approach allows you to 'flex' the variables. It is important to use a grid to set out the table and best not to hard code the interval. This means that you can always change the interval quickly and see on any printouts the interval used. In addition, it is best practice to input the current value for the variable in the middle so you can see the values on either side. Some applications with the book then use a macro to update the input values on the table by copying down the values from the inputs area.

Figure 2.46

Composite table



SCENARIOS

If there were several versions of this simple example project, producing multiple spreadsheets would be wasteful and potentially introduce errors. Similar spreadsheets tend to diverge over time and be more difficult to maintain. Scenarios provide the facility to ‘remember’ inputs so that you can load them at any time. As an added bonus, Excel will produce a management report based on the scenarios.

Scenarios are accessed using *Data, Data Tools, What-if Analysis (Excel 2003 – Tools, Scenarios), Add* (see Figure 2.47). There are saved cases on the Scenarios sheet.

Add scenario

Figure 2.47



You can select multiple cells by separating them with a comma (or a semi-colon in continental Europe). When you have selected them, Excel allows you to review the values in each of the cells before saving them. Press *Show* to display the scenario.

There are further examples on the sheet which vary only the capital value and periodic cash flow. If you press *Summary* as in Figure 2.47 and select

cells C22 and E22 as the result cells, Excel produces the management report shown in Figure 2.48.

It is always best to start from a Base Case and vary these inputs rather than developing further scenarios. Here Worst Case and Best Case vary only two cells from the original scenario. It is therefore clearer what exactly changes from the initial estimate.

Figure 2.48

Scenario report

	A	B	C	D	E	F	G
1							
2	Scenario Summary						
3			Current Values:	Base Case	Worst Case	Best Case	
4	Changing Cells:						
5		\$C\$5	100,000.00	100,000.00	103,000.00	99,000.00	
6		\$C\$6	28,000.00	28,000.00	27,000.00	28,500.00	
7		\$C\$7	7,000.00	7,000.00	7,000.00	7,000.00	
8		\$C\$8	1-Jan-10	1-Jan-10	1-Jan-10	1-Jan-10	
9		\$C\$27	0.50%	0.50%	0.50%	0.50%	
10		\$E\$29	9.50%	9.50%	9.50%	9.50%	
11		\$C\$61	0.50%	0.50%	0.50%	0.50%	
12		\$C\$62	0.08	0.08	0.08	0.08	
13		\$B\$62	300%	300%	300%	300%	
14		\$G\$61	4	4	4	4	
15	Result Cells:						
16		NPV	7,497.28	7,497.28	658.09	10,416.87	
17		Limit:	limit of 7,000	limit of 7,000	limit of 7,000	limit of 7,000	
18	Notes: Current Values column represents values of changing cells at time Scenario Summary Report was created. Changing cells for each scenario are highlighted in gray.						
19							
20							
21							

Only one cell is named on this sheet: this is Scenarios!\$C\$22, which shows as a name in line 17 rather than a cell reference. This is a static or values only report, which will not change if the underlying values change. If the model changes, you have to run the report again. It also acts like an audit trail since you could print this out and keep it in a file to show what inputs produce the range of results.

SPREADSHEET AUDITING

There are a number of techniques which can be used separately or together to check the inputs and calculations in a model. It is of course important that any model is free of errors which could arise from:

- technical design, such as high-level analysis of ideas or principles;
- conceptual errors, for example, flaws in logic, rationale or mechanisms;

- user errors, such as individual cell coding errors or overwritten cells;
- compounded errors, such as errors on errors, especially in distributed models.

The methods described below include:

- manual review
- show formulas (also known as formula auditing mode)
- audit toolbar
- pattern matching to ensure consistency
- FIND for hidden errors
- known test data
- data to all inputs
- chart – known patterns
- third party add-ins as described on the Links page at www.financial-models.com.

Using some of the design techniques earlier in the chapter reduces the opportunity for errors, for example:

- design method in segregating inputs and calculations;
- splitting out workings;
- keeping individual cell coding as simple as possible;
- self-checking, such as making sure a balance sheet adds up on both sides.

A manual review often reveals simple errors and other features such as the spell checker will show up text errors. Other methods involve other features in Excel.

Show formulas

Figure 2.49

The screenshot shows an Excel spreadsheet titled 'Present Value'. The spreadsheet is organized into several sections:

- Input Section (Rows 5-10):** Contains input fields for 'Capital value' (100000), 'Periodic cash flow' (28000), 'Minimum NPV' (7000), 'Start Date' (40179), 'Interval' (Annual), and 'Discount rate' (9.50%).
- Calculation Section (Rows 13-22):** Contains formulas for calculating the present value. Row 13 shows a timeline with values 0 and 1, and a formula for the start date: `=EDATE(C13,G83)`. Row 15 shows a formula: `=B5`. Row 16 shows a formula: `=B6`. Row 17 shows a formula: `=C5`. Row 18 shows a formula: `=SUM(C15:C17)`. Row 19 shows a formula: `=SUM(D15:D17)`. Row 20 shows a formula: `=C18`. Row 21 shows a formula: `=C20+D18`. Row 22 shows a formula: `=NPV at "&TEXT(C66,"0.00%")`.

View formulas

This function is called Show Formulas at Formulas, Formula Auditing (Excel 2003 – Tools, Formula Auditing, Formula Auditing Mode). Viewing formulas shows the formulas and if there are constant values these cells will not change (see Figure 2.49). You can select View Formulas in Excel 2003 at Tools, Options, View. Alternatively, you can press `Cntrl` and `'` to toggle between the two views. This is a good check on the quality of the underlying sheet and will reveal overwritten cells or inconsistencies.

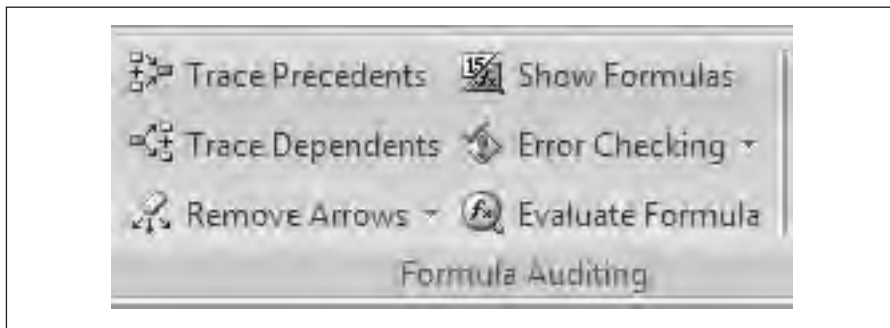
Using the above example, the errors again become apparent. The errors in cells G10 and H10 show up against cell F10, which contains the correct code.

Audit toolbar

The audit tools can be displayed by pressing Formulas, Formula Auditing (Excel 2003 – Tools, Auditing, Show Auditing Toolbar). The example shown in Figure 2.50 is in the data table sheet, which traces the derivation of the net present value.

Figure 2.50

Auditing toolbar



You can trace precedents and dependants for a cell (see Figure 2.51). The NPV at cell C22 is derived from the dates, cash flows and discount rate. The arrow from below refers to the frequency of the periods.

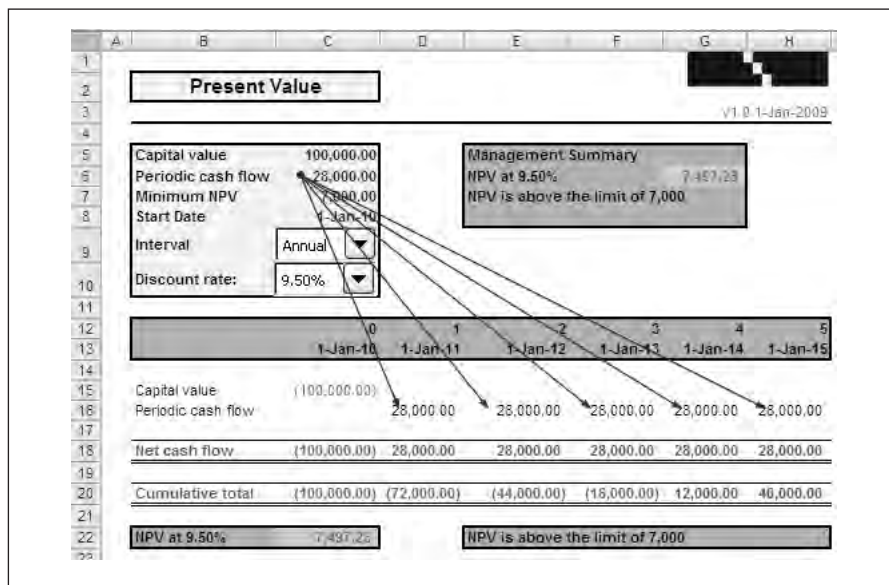
Pattern matching

Pattern matching allows you to search for constants, formulas, arrays, etc. In the above example, this would highlight the errors in the calculations. Select cell B15 to H20 and access Home, Editing, Find & Select,

Go To Special (Excel 2003 – Edit, Go To, Special) to display this dialog box (see Figure 2.52). Formula errors are shown in Figure 2.53.

Dependants and precedents

Figure 2.51



If you highlight formulas, Excel shows them. You would expect to see formulas in the cash flows rather than anything hard coded from above.

Use known data with an entry to every input cell

You need to enter data to every entry cell to ensure that the results are as expected. In an accounts spreading model, you could enter data to every possible cell and make sure that the balance sheet balances and that the cash flow agrees with the change in cash. With the current example, there is data in each of the inputs, but it is always a good idea to see what happens if unusual data were entered. Users can always be relied on not to follow instructions. Techniques such as data validation obviously help in avoiding ‘rubbish in, rubbish out’.

Graph or data ‘looks right’

The cumulative cash flow graph is smooth with no kinks as expected (see Figure 2.54). If the series were curved, then this could point to an error in the calculations. People are better in assessing pictures than grids of numbers and can ‘see’ errors more quickly.

Figure 2.52

Edit Go to Special

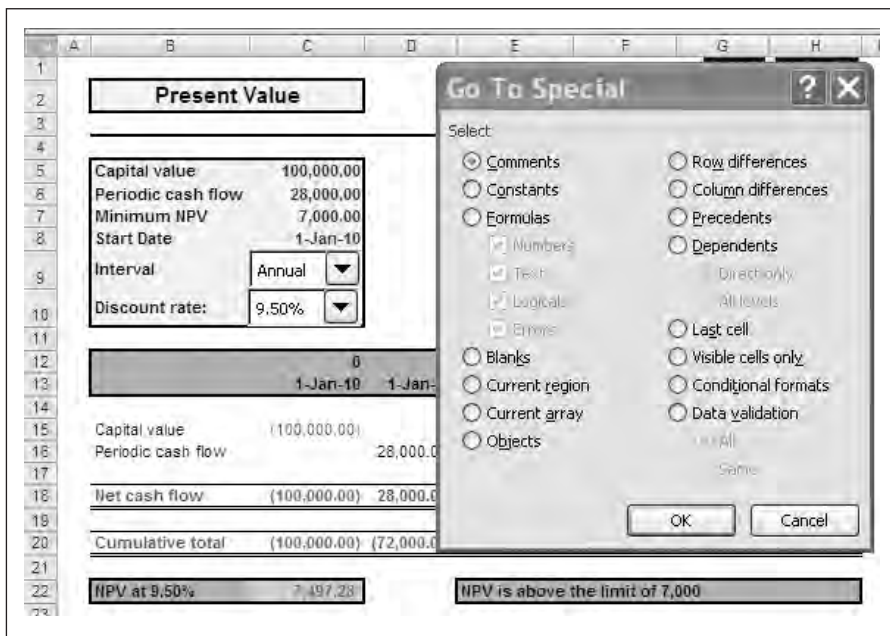
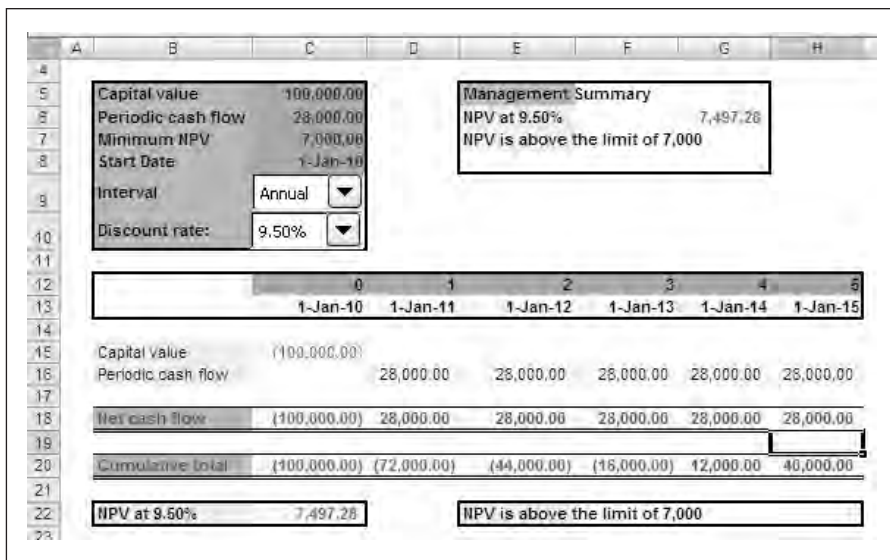


Figure 2.53

Formula errors



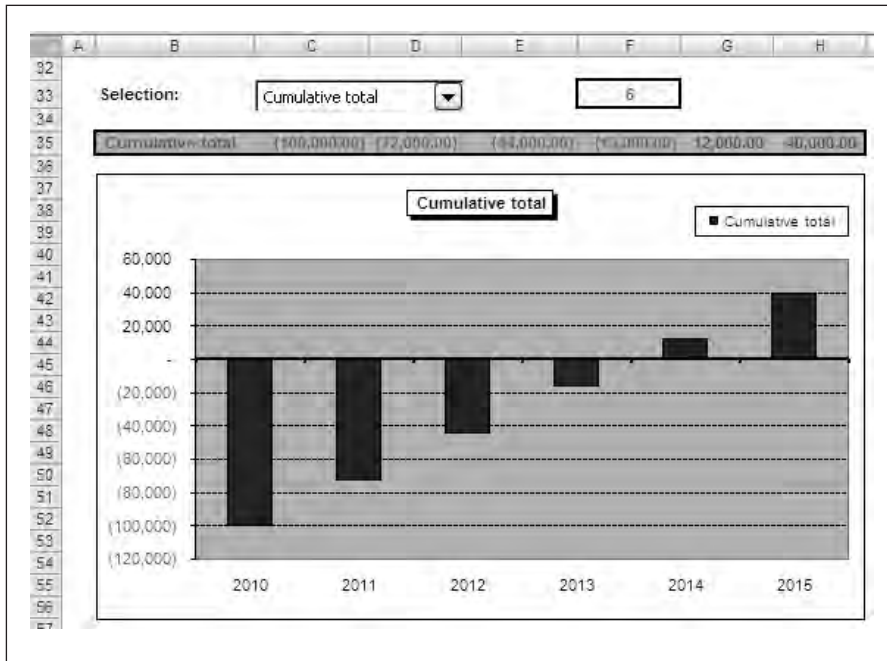
FIND for hidden errors

You can use Home, Editing, Find & Select (Excel 2003 – Edit, Find) to look for errors such as N/A or Div/0 since errors are not always

obvious. You could also do the same by choosing Home, Editing, Find & Select, Go To Special (Excel 2003 – Edit, Go To, Special, Formulas, Errors). While you should find errors by other means, this is useful for checking entire sheets and workbooks.

Graph check

Figure 2.54



Stress and range testing

You need to be sure that unusual inputs will not cause errors or answers which appear to be correct, but which are incorrect. Users are easily upset by a page of errors, which they have to audit. There are a number of things to look for:

- Extremes in range of inputs. This can be controlled through validation or using controls to limit the range of inputs.
- Test the likely range of results to make sure that the model can display them. For example, a column should be able to display the potential range of numbers.
- Negative numbers where positive numbers are expected.
- Text in place of numbers and vice versa.
- Large or small numbers to test the number of decimal places required.

- Decimals in place of integers to ensure validation and use by continental European versions of Excel.
- Numbers in place of decimals.
- Dates in wrong order (31/12/00, 12/31/00) to test for US and other date formats.
- Blank inputs and checks for subsequent errors in formulas. The function ISBLANK can help to identify problems and suppress errors.
- Zero inputs to correct #Div/0 errors. This can be rectified by ISERROR functions or IF statements such as: =IF(Income!J10<>0,(Income!J24/Income!J10)*100,0)

SUMMARY

This chapter reviews a distinct design method for spreadsheet applications known as Systematic Design Method. Models for distribution or use by third parties require a rigorous and disciplined approach and this chapter suggests a number of points for good design and a list of useful features. The application discussed in the chapter progresses using a number of features to show the importance of design. You will note that the quality of presentation and the management information produced progressively improves. Finally, there are a number of auditing techniques to ensure consistency in the design and coding of the model. It is important that models can be checked, and these techniques provide a basic framework for auditing.

Risk and uncertainty

.....
Introduction

.....
Risk

.....
Uncertainty

.....
Response to risk

.....
Methods

.....
Summary
.....

File: MRM2_03

INTRODUCTION

The methodology in the previous chapter suggests developing a single-point model and segregating areas of a workbook into:

- inputs
- calculations
- outputs.

Correct design ensures that all inputs are visible and all have been modelled. This means you can change the inputs and note the immediate effect on the output. What-if analysis is much more difficult without this organization. The next aspect to address is sensitivity to a change of key variables.

The simple model derives a single result and thereby limits the analysis. The result neither provides information on the potential variance nor backs up decision making. In business modelling, risk is always present since forecasts are inherently inaccurate. You can sub-divide risk into two components:

- 1 risk
- 2 uncertainty.

RISK

In corporate finance, you need to be able to explore the potential upsides and downsides, and to understand how the anticipated result could vary. With any project, you want to understand how likely you are to fail to reach a minimum target or, alternatively, the effect on the result of important variables.

Risk can be defined as the chance of making a loss; this could be making a loss on an asset sale or the possibility of machine failure. Alternatively, you could describe a risk in quantitative terms such as a 30 per cent possibility of a loss. In finance, you are normally more concerned with downsides since any upside always seems a remote possibility. In order to control risk, you first have to be able to describe and measure it and then decide if the anticipated return is worth the risk. Whilst some individuals may differ in the perceptions, it is usually assumed that decision makers are rational and weigh up the potential pros and cons. Here are some other definitions of risk:

- combination of the probability of an event and its consequences;
- symmetrical chance of a loss or a gain;
- probability of a different outcome;

- possibility of occurrence of undesirable contingency;
- possibility of loss;
- hazard;
- divergence of actual from expected results.

The Capital Asset Pricing Model (CAPM) is a useful example of risk and return. Portfolio theory shows how the risk in a portfolio can be mitigated by diversification based on standard deviation and correlation. The CAPM formula deals with individual risk and the beta score is a measure of individual stock risk against the market. The formula is:

$$Return = R_f + \beta * R_p$$

R_f = Risk free rate
β = Measure of risk
R_p = Risk premium

This formula defines the return that investors should demand and is defined by the excess return on the share against the market index. Investors can deposit funds at the risk-free rate or in a diversified portfolio at the market rate. This means that there is a basic return to be gained with no chance of a loss. The premium is therefore a measure of the extra return to be derived from taking the market risk. In the example below, a share with beta of one produces a result of 10 per cent.

$$R_f = 5\%$$

$$\beta = 1.0$$

$$R_p = 5\%$$

$$Return = 5\% + (1 \times 5\%) = 10\%$$

The variance is therefore the variability against the market: a beta of more than one indicates a greater than market risk and the opposite is true of a beta of less than one.

Figure 3.1 shows the prices for 10 shares over a five-year period against an index. The values are converted into logarithms and plotted against each other. The beta is therefore the correlation of the share's return with the market. The formula in cell E73 (see Figure 3.2) is:

$$= LN (D73 / D72)$$

Columns D and H can then be plotted as a scatter graph with a trend line through the series to illustrate the slope (see Figure 3.3).

Share (stock) prices

Figure 3.1

No.	Month	Index	AAA	BBB	CCC	DDD	EEE	FFF	GGG	HHH	III	JJJ
0	Jan-05	1,153.1	356.2	362.0	180.5	256.8	498.0	729.3	175.3	187.1	171.8	50.1
1	Feb-05	1,202.1	379.8	368.8	185.8	247.2	540.0	757.4	184.3	206.2	175.8	50.5
2	Mar-05	1,148.6	348.8	367.3	176.3	246.3	528.0	767.9	190.3	201.9	176.8	55.9
3	Apr-05	1,208.8	370.0	375.3	186.3	257.7	547.0	786.9	185.3	224.2	176.8	60.9
4	May-05	887.3	299.5	286.3	128.8	222.5	340.0	530.1	140.3	162.7	120.8	39.0
5	Jun-05	796.3	266.4	258.8	120.3	214.9	335.0	471.1	121.3	142.7	105.8	40.6
6	Jul-05	870.2	281.1	287.3	143.8	206.4	352.0	529.8	129.3	164.1	112.8	40.6
7	Aug-05	915.8	298.9	293.8	143.8	219.7	392.0	528.2	138.3	176.8	135.8	39.7
8	Sep-05	908.1	302.6	292.3	145.3	243.4	391.0	528.6	139.3	169.4	154.1	40.6
9	Oct-05	896.8	291.5	278.8	145.3	260.6	370.0	479.4	126.3	157.4	151.8	39.0
10	Nov-05	928.2	275.9	286.3	156.3	275.8	369.0	482.4	129.3	184.7	158.8	57.3

 β estimation

Figure 3.2

No.	Month	Index	Index Returns	Selection:	AAA	AAA Returns
0	Jan-05	1,153.10			356.18	
1	Feb-05	1,202.10	0.042		379.77	0.064
2	Mar-05	1,148.60	(0.047)		349.75	(0.082)
3	Apr-05	1,208.80	0.053		369.97	0.056
4	May-05	887.33	(0.309)		299.51	(0.211)
5	Jun-05	796.31	(0.108)		266.42	(0.117)
6	Jul-05	870.22	0.089		281.12	0.054
7	Aug-05	915.84	0.051		298.89	0.061
8	Sep-05	908.08	(0.009)		302.57	0.012
9	Oct-05	896.75	(0.013)		291.54	(0.037)
10	Nov-05	928.19	0.034		275.91	(0.055)

For company AAA, the slope of the trend line from the function SLOPE, is 1.06. It is highly correlated with market movements. The other shares in this example portfolio show a range of variance with the index. The beta table is shown in Figure 3.4.

The beta is therefore a historic score of risk, which shows that some shares in this collection have been more volatile than the market and therefore investors should, in theory, demand a higher return. Risk can therefore be measured and, in theory, the past should broadly equal the future.

Figure 3.3

β scatter chart

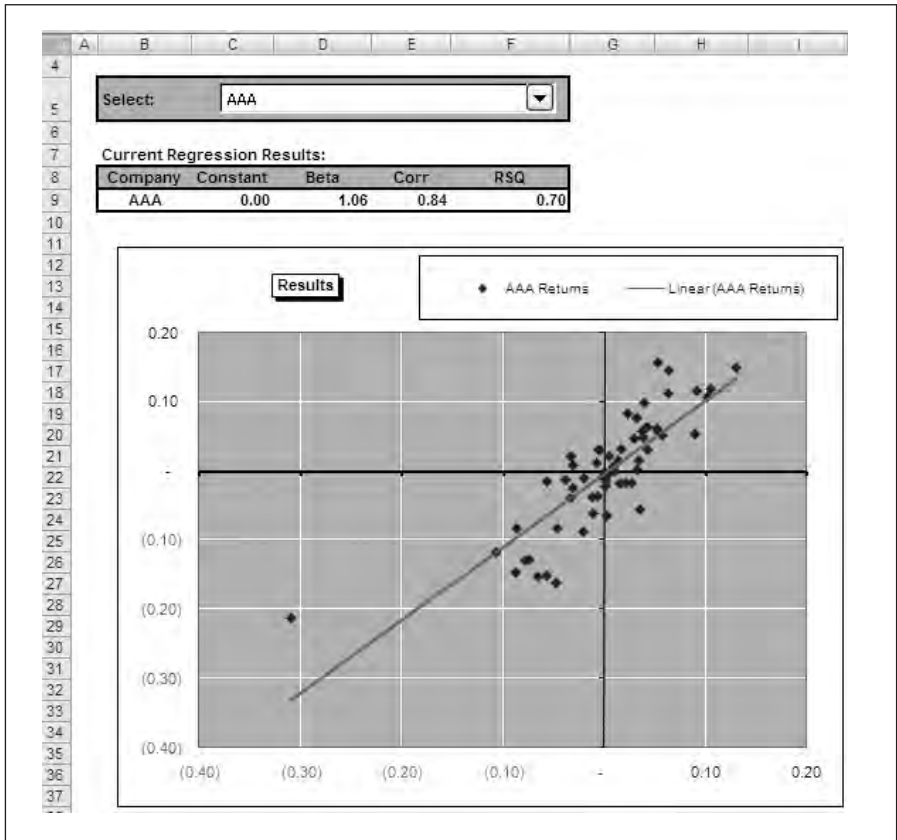
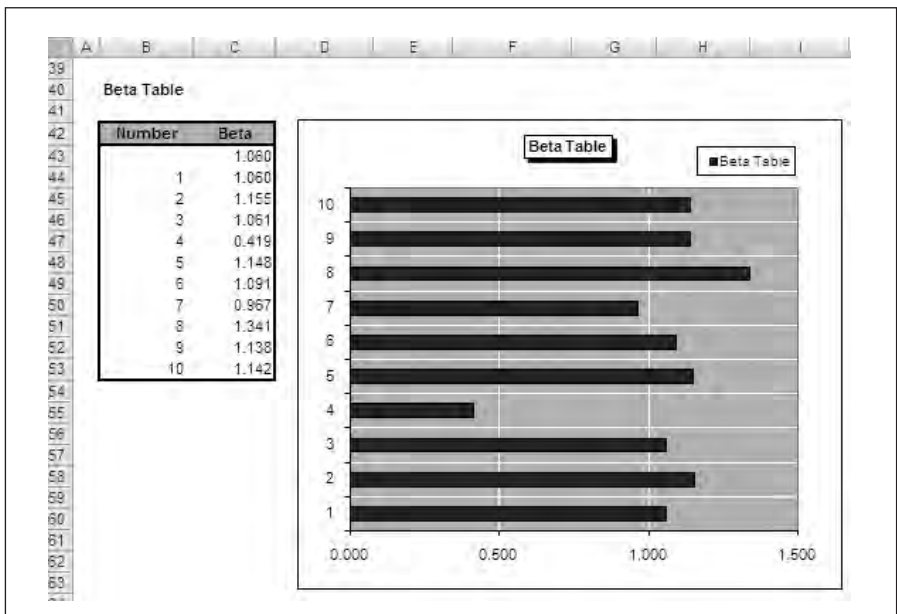


Figure 3.4

β table



The model sheet is a simple real estate model. This is a buy for let model where you invest in property and receive rental income. The first section shows all the variables where the cost inputs are percentages of the purchase price (see Figure 3.5).

Inputs

Figure 3.5

	A	B	C	D	E
4					
5				Inputs	Costs
6		Purchase Price	100,000.00		(100,000.00)
7		Stamp Duty / Tax	1.00		(1,000.00)
8		Other Costs	0.75		(750.00)
9		Reburbishment Costs	2.00		(2,000.00)
10		Letting Fees	1.175		(1,175.00)
11		Building Insurance	0.300		(300.00)
12		Gas Safety	0.050		(50.00)
13		Inventory	0.060		(60.00)
14		Maintenance	0.500		(500.00)
15		Assumed Rental per Month	666.67		
16		Capital Growth	4.00		
17		Voids %	10.00		
18		Mortgage Period (yrs)	25.00		
19		Interest Rate %	5.51		(5.51%)
20		Mortgage Percentage %	50.00		(2,750.00)

There are a significant number of variables which can be multiplied out to produce returns and profits. These include both the one-off costs of purchasing and refurbishing a property, but also the on-going costs of maintaining and letting it. Since the owners' funds will be leveraged through a form of loan or mortgage, the cost of borrowing is a significant cost to be placed against the gross rental yield. In addition, the percentage voids or rent-free periods could also be a significant factor. Lastly, property may afford the benefit of capital growth over and above the rental income.

The objective of the model is to calculate the projected annual income and the owners' return on the equity investment. The second profit measure includes the benefit of capital growth and there is an overall yield measure from income and capital.

The answer is a yield on income of 2.65 per cent or 10.10 per cent including capital growth (see Figure 3.6). Whilst there are financial and non-financial risks, property rental has inherent risks which could significantly lower the yield, for example:

- maintenance and other regular costs;
- assumed rental per month and the state of the rental market in the area;

- capital growth on the property;
- voids defined as the number of days when the property lies empty;
- interest rate to be paid on loans.

Figure 3.6

Estate schedule

	A	B	C	D	E	F	G	H	I
21									
22			Cost	Rental %	Gross Yield	Annual Rental	Annual Costs	Mortgage Per Annum	Net Rental Income
23									
24		Property Cost	(100,000.00)						
25		Initial Costs	(3,750.00)	0.6667	8.0000	8,000.04	(2,085.00)	(3,688.11)	2,226.93
26		Total Investment	(103,750.00)						
27		Plus Mortgage	50,000.00						
28		Voids				(800.00)			
29		Net Income				7,200.04	(2,085.00)	(3,688.11)	1,426.93
30									
31			Net	Yield %					
32		Net Investment	(103,750.00)						
33									
34		Net Letting Income	1,426.93	2.65					
35		Capital Growth	4,000.00						
36		Total Income	5,426.93	10.10					
37									

The model only allows single-point entry and the inputs are best guesses. Given the cyclical nature of the property market, it is fair to say that there are significant risks or, alternatively, variables not fully modelled. For example, interest rates could rise and rents fall in a depressed economy. This could make it hard to find suitable tenants and therefore voids could rise. These factors together would then significantly impact on the overall yield. Based on historic experience, it could be possible to plot both the average and variability in these factors in order to quantify the chance of a significant loss.

Figure 3.7

Probability

	A	B	C	D	E	F	G	H
7								
8		Return	A	B	Variance	Expected A	Expected B	
9	1.00	(50.00)	-	-	-	-	-	-
10	2.00	(40.00)	-	5.00	(5.00)	-	(200.00)	
11	3.00	(30.00)	-	5.00	(5.00)	-	(150.00)	
12	4.00	(20.00)	5.00	10.00	(5.00)	(100.00)	(200.00)	
13	5.00	(10.00)	10.00	10.00	-	(100.00)	(100.00)	
14	6.00	-	20.00	10.00	10.00	-	-	
15	7.00	10.00	30.00	10.00	20.00	300.00	100.00	
16	8.00	20.00	20.00	10.00	10.00	400.00	200.00	
17	9.00	30.00	10.00	10.00	-	300.00	300.00	
18	10.00	40.00	5.00	15.00	(10.00)	200.00	600.00	
19	11.00	50.00	-	15.00	(15.00)	-	750.00	
20		Total	100.00	100.00	-	1,000.00	1,300.00	
21								
22		Expected Return A	1,000.00					
23		Expected Return B	1,300.00					
24		Variance	(300.00)					

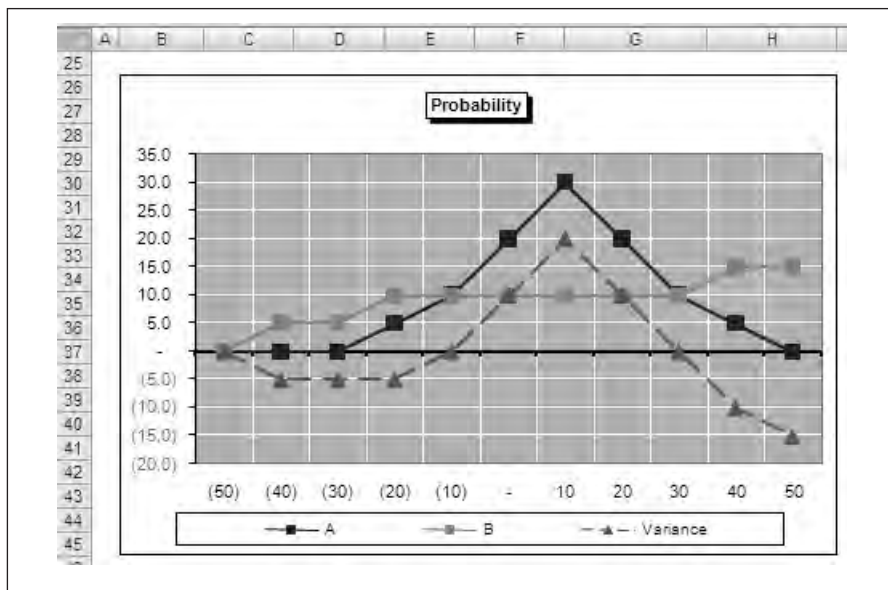
Risk is also allied to theories of probability. Suppose that an investor could invest in shares and over one year the expected probabilities and returns are shown in Figure 3.7.

Figure 3.7 shows the possible returns in column C and the expected probabilities for shares A and B in columns D and E. Columns G and H are the probability return for shares A and B multiplied by the return. Share B suggests a much wider range of returns than A and the higher adjusted return is a profit of 1300. Share A possesses a narrower range and therefore appears to present the less risk.

The range shows up clearly on a probability chart, where option B displays a flat distribution whereas A is a more normal bell curve distribution (see Figure 3.8). The profit or loss at each point is set out in Figure 3.9 and this shows the possibility of a significant loss on share B.

Probabilities

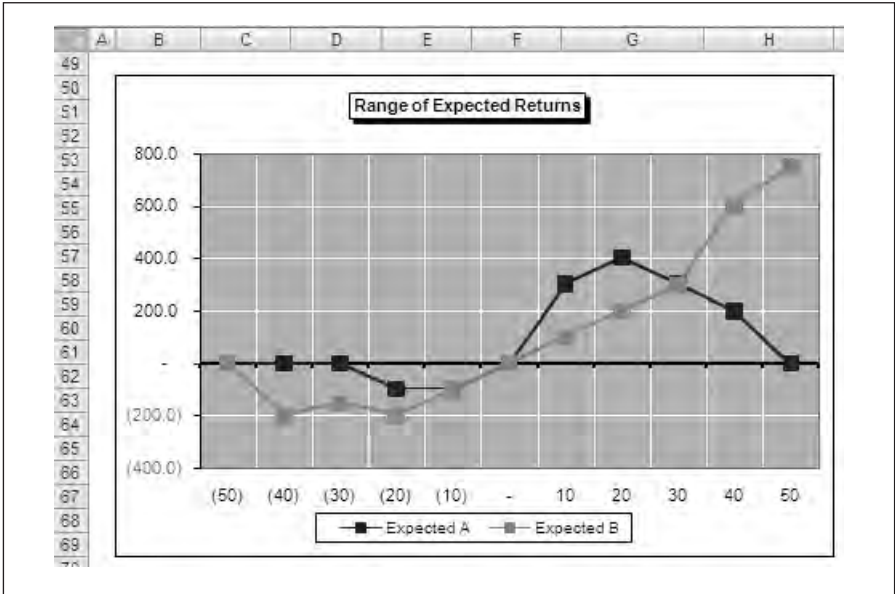
Figure 3.8



The return can therefore be expressed as an amount and a range or probability. There is always the option of not investing and the perception of risk and potential return may be important. In most situations, the outcomes are not completely clear and perception of risk is affected by subjective factors: for example, it depends on how you perceive losses or gains. In addition, the concept of risk adversity may not always be correct. Some individuals are risk takers while others will always opt for safety.

Figure 3.9

Range of expected outcomes



UNCERTAINTY

All the possible outcomes on a model cannot be predicted and there will always be uncertainty or randomness – which cannot be predicted exactly. There are two areas of uncertainty:

- 1 Random or unexpected events that are outside the control of the organization: for example, earthquakes or multiple occurrences, which are the result of chance and do not conform easily to probability distributions.
- 2 Ignorance about the variables or inputs to the model arising from a lack of understanding. Further analysis and information could reveal more factors for modelling and thereby increase the validity of the system.

The single-point model is the best guess, which may or may not occur. In the real estate model above, the future may not equal the past because of unforeseen events.

RESPONSE TO RISK

A generic model for responding to risk should:

- Identify sources of risk in a project or organization (see Figure 3.10), in particular the financial risks where an organization may be more skilled in dealing with this form of operational risk.

- Describe risks and how they impact on the organization using some form of probability impact diagram. The questions could be: why might it happen? and what would lessen the impact?
- Analyse and understand relative importance which could include risk mapping.
- Mitigate and control, through structuring or other changes to operations, to increase the controllable elements.
- Accept or reject residual or uncontrollable risk.
- Price accordingly in a credit or project model to ensure a 'correct' risk/return ratio.
- Build up a database, monitor and learn for the future.

Risk response

Figure 3.10



Risk mapping should reveal the potential severity and possible frequency with which potential problems could occur. The response on a project could be:

- Increase the size of the project as the original plan could be too cautious.
- Do nothing, since the potential cost of dealing with risk outweighs the perceived benefits.
- Collect more data on the problem to better understand the potential downsides.
- Add a contingency to the planning and thereby allow for risk.
- Reduce or build in an abandonment option as a less risky approach.
- Share the risk with a partner or contractor in return for lesser fees.
- Transfer risk through an insurance contract.
- Eliminate risks by redesigning the plan to reduce uncertainty.
- Cancel project or financing since the potential losses are perceived to be too high or uncontrollable.

The above list could give an organization the opportunity to examine the basis for trying to control risk and later chapters explore credit, project and other scenarios.

METHODS

The discussion of risk and uncertainty above shows that a single-point answer may not reveal the prospect of loss inherent in any business decision. The methods for dealing with risk can be summarized as follows:

- sensitivity analysis using data tables and charts;
- scenario analysis and scenario manager;
- manual scenarios using functions;
- decision trees;
- simulation.

Figure 3.11

Sensitivity table

	A	B	C	D	E	F	G	H	I	
38										
39										
40		Sensitivity Table to Voids % Across and Mortgage Percentage % Down								
41		Interval Across	2.50							
42		Interval Down	15.00							
43										
44			2.50	2.50	5.00	7.50	10.00	12.50	15.00	17.50
45		5.00	5.41	5.21	5.01	4.81	4.60	4.40	4.20	
46		20.00	5.06	4.82	4.58	4.35	4.11	3.87	3.63	
47		35.00	4.56	4.27	3.98	3.68	3.39	3.10	2.81	
48		50.00	3.77	3.40	3.03	2.65	2.28	1.91	1.54	
49		65.00	2.38	1.86	1.34	0.83	0.31	(0.21)	(0.72)	
50		80.00	(0.78)	(1.62)	(2.47)	(3.31)	(4.15)	(4.99)	(5.84)	
51		95.00	(14.77)	(17.06)	(19.34)	(21.63)	(23.91)	(26.20)	(28.48)	

Sensitivity analysis

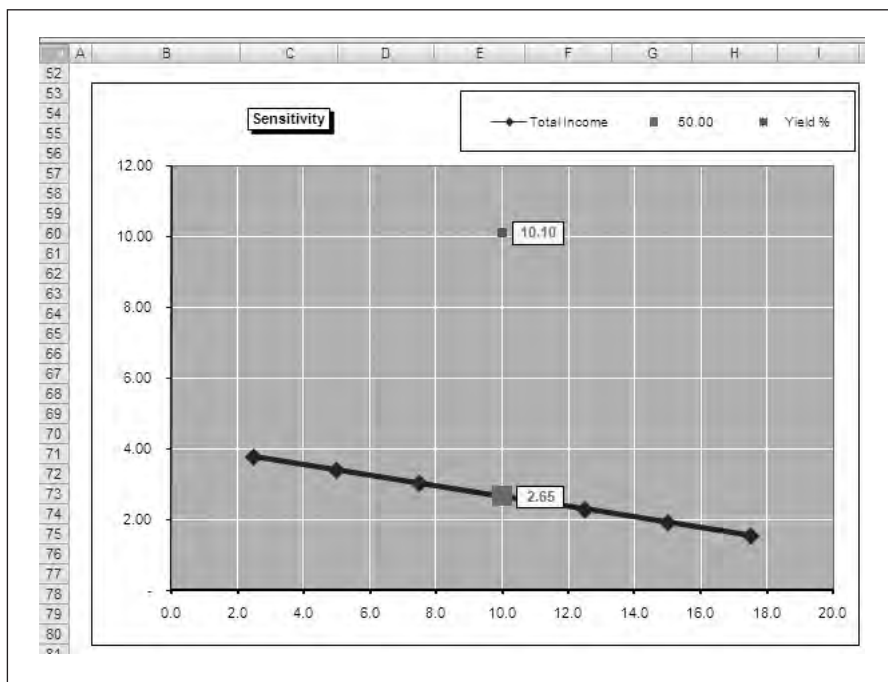
This technique uses data tables in Excel as one- or two-dimensional grids to show multiple answers on the same sheet. In the real estate example, the percentage of voids is plotted against the degree of leverage. This helps to show the effect on the yield before capital growth.

Office 2007 – Data, Data Tools, What-if Analysis (Excel 2003 – Data, Table)

Figure 3.11 illustrates the losses increasing with leverage as the percentage of voids increases. Tables of numbers are not easy to interpret and therefore a chart always helps to show the degree of change. Figure 3.12 demonstrates the gross and net yield and the line series is the middle row in the table.

Sensitivity chart

Figure 3.12



Scenarios

Scenario planning can be a powerful tool for 'thinking the unthinkable'. There are always different views of the future and history reminds us that the future cannot be fully explained or controlled.

Office 2007 – Data, Data Tools, What-if Analysis (Excel 2003 – Tools, Scenarios)

There are many techniques for gaining ideas, such as:

- brain storming;
- mental mapping;
- panels of experts such as in the Delphi technique.

Figure 3.13

Scenario Manager



Within Excel, the built-in Scenario Manager allows for different views to be held and loaded at will (see Figure 3.13). You can use it to save an audit trail of previous inputs or as a considered view to different futures. Saving the inputs means that you can always get back to the same answer. This can be useful in ensuring the integrity of a previously created model. For example, you can test the model at a future date and ensure that it has not been corrupted by comparing answers with the scenario summary. An audit trail is useful and scenarios also reduce the requirement for multiple copies of the same model.

There are three saved scenarios in the model to show the effect of a poor or growth economy on the result. This focuses the decision makers' attention on the possibility of falling rents, lowered occupancy and increased borrowing costs. The Summary button produces a management report of the inputs and outputs.

The report provides a concise report and in this case demonstrates how an adverse economy removes any possibility of a positive return on the investment (see Figure 3.14).

Scenario report

Figure 3.14

	A	B	C	D	E	F	G
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
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23							
24							
25							
26							
27							
28							
29							
30							
31							
32							
33							
34							

Scenario Summary				
	Current Values:	Base Case	Poor Economy	Growth Economy
Changing Cells:				
Purchase_Price	100,000.00	100,000.00	100,000.00	100,000.00
Stamp_Duty_Tax	1.00	1.00	1.00	1.00
Other_Costs	0.75	0.75	0.75	0.75
Reburishment_Costs	2.00	2.00	2.00	2.00
Letting_Fees	1.175	1.175	1.175	1.175
Building_Insurance	0.300	0.300	0.300	0.300
Gas_Safety	0.050	0.050	0.050	0.050
Inventory	0.060	0.060	0.060	0.060
Maintenance	0.500	0.500	0.500	0.500
Assumed_Rental_per_Month	675.00	666.67	600.00	675.00
Capital_Growth	5.00	4.00	2.00	5.00
Voids	7.50	10.00	20.00	7.50
Mortgage_Period_yrs	25.00	25.00	25.00	25.00
Interest_Rate	5.50	5.51	7.00	5.50
Mortgage_Percentage	50.00	50.00	50.00	50.00
\$P\$7	0	0	0	0
\$C\$41	2.50	2.50	2.50	2.50
\$C\$42	15.00	15.00	15.00	15.00
\$F\$44	7.50	10.00	20.00	7.50
\$B\$48	50.00	50.00	50.00	50.00
Result Cells:				
Net_Invested	(53,750.00)	(53,750.00)	(53,750.00)	(53,750.00)
Net_Income	1,722.98	1,426.93	(585.68)	1,722.98
Yield	3.21	2.65	(1.05)	3.21
Income_after_Growth	6,722.98	5,426.93	1,434.32	6,722.98
Net_Yield	12.51	10.10	2.67	12.51

Notes: Current Values column represents values of changing cells at time Scenario Summary Report was created. Changing cells for each scenario are highlighted in gray.

Manual scenarios

You can also use functions such as `OFFSET`, `CHOOSE` or `LOOKUP` to load different sets of variables. The advantage is the visibility of all the variables. The example on the `Manual_Scenarios` sheet uses a combo box to generate the index number in cell H5 (see Figure 3.16). Row 16 contains `OFFSET` functions to look up the rows above based on the index number.

Decision trees

Decision trees are used to select the best course of action in situations where you face uncertainty, and many business decisions fall into this category. You face a complex problem that seems to make it impossible to choose the right option. Although you do not know the exact outcome, you may have some

information about the range of possible outcomes and how likely each is to occur. This information can be used to select the option that is most likely to yield favourable results. Modelling provides the framework to consider the quantitative factors and uses Bayes theorem to apply the probabilities.

Figure 3.15

Scenario comparison

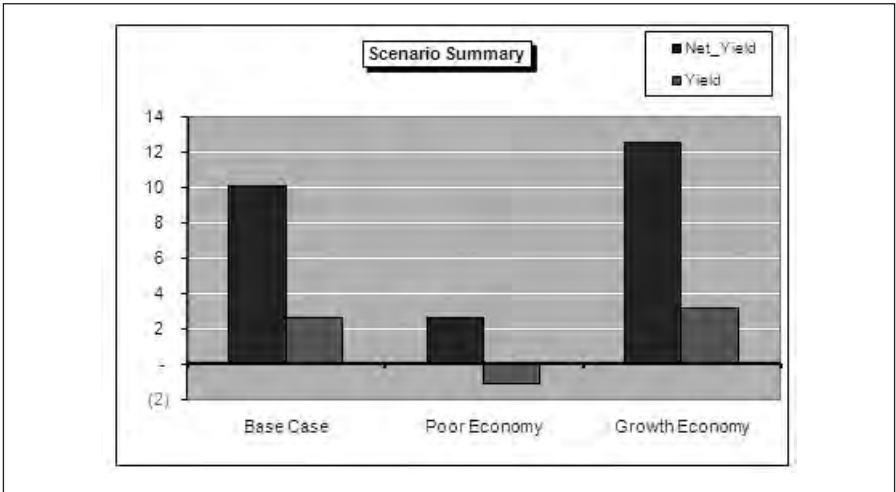
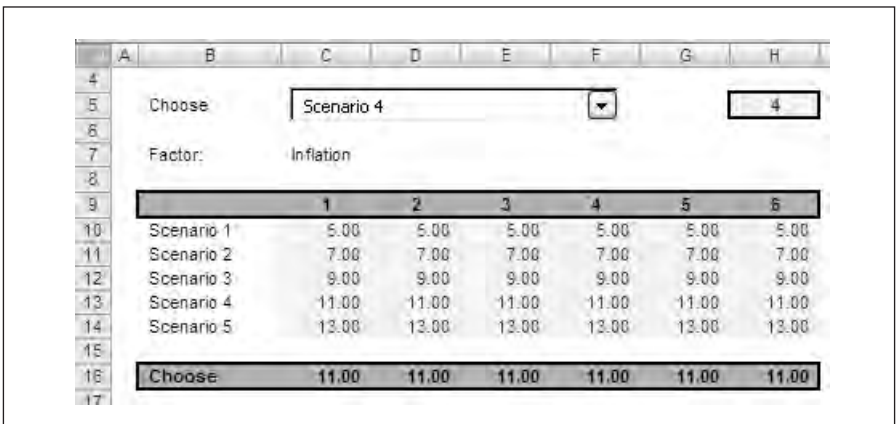


Figure 3.16

Manual scenarios



Simulation

Scenario analysis allows you to keep different views of the world on the same sheet. You can load, for example, base case, optimistic and pessimistic. While this offers advantages over a single answer, there are times when there are significant elements of risk to be captured in a model. In the real

estate model, there are single inputs such as voids or the mortgage percentage for deriving the expected yields.

For each variable you could probably define a minimum, maximum and most likely, as in a triangular distribution. If there are 10 variables, then there are 10^3 possible states and therefore it quickly becomes impossible to model all possibilities. Another example is a bonds portfolio of 100 instruments where there could be eight possible credit states for each bond on expiry of a time period. Again, there could be 100^8 possible combinations on expiry.

In a simulation model, you specify the probability distribution of each uncertain variable. The model generates random numbers within the distribution and produces a large number of possible scenarios. You could plot the number of results between intervals and the resulting histogram of results provides information on the mean score, standard deviation, percentiles and other statistics. Simulation is dealt with in more detail in Chapter 5.

SUMMARY

The presence of risk in business underlines the need for initial analysis and identification of all key variables in a business problem. The problem should drive the modelling and not the other way around. Objectives should be clear to allow for risk identification, assessment, mitigation and inclusion. Simple techniques include tables and scenarios for identifying a range of possible outcomes.

Project finance

.....
Introduction

.....
Requirements

.....
Advantages

.....
Risks

.....
Risk analysis

.....
Risk mitigation

.....
Financial model

.....
Inputs

.....
Sensitivity and cost of capital

.....
Construction, borrowing and output

.....
Accounting schedules

.....
Management analysis and summaries

.....
Summary

File: MRM2_04

INTRODUCTION

This chapter introduces a project finance model as an example of the design method outlined in Chapter 2 and an illustration of the range of risks associated with financing a project. The text below outlines the risk process in financing and then provides a generic model for projects. The aim is to show the process of identifying the sources of risk and the modelling approach as a complete model. The eventual model is complete with all the elements of a finished model and aims to illustrate both the types of risks and also the modelling approach including all the possible variables.

Project finance is the creation of a separate entity for a project that can stand apart from the sole business of the sponsor and the debt providers. The brief could be to design, construct and operate, for example, a power station or infrastructure improvement. Generally, the future cash flows can be forecasted and used as the sole security for the project financing. The objectives are:

- to establish a vehicle to receive capital in the form of equity and debt;
- to expend the funds on constructing assets;
- to generate a revenue stream to pay back the loans; and
- to provide an acceptable return to the equity participants and demonstrate the security in the project to debt participants.

REQUIREMENTS

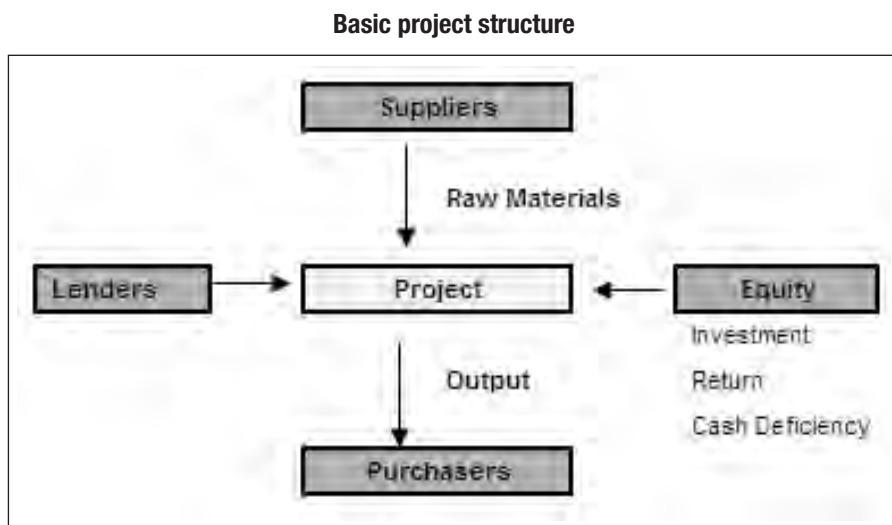
The difference between project finance and a traditional loan is that the former depends on the ability of the project to generate sufficient funds for loan repayment. Usually the loans are without recourse to the sponsor's balance sheet. In a traditional loan the borrower is responsible for repayments, whereas the project vehicle is 'ring fenced' from other assets from the sponsors.

Therefore, project finance is a means of raising finance, which seeks to bring together specialist parties and allocate risk and reward in accordance with the level of each participant's involvement. Financial engineering and capital structuring seeks to allocate the potential gains and losses between the parties. Funders need to examine carefully the sources of risk since there is no diversification of risk as there would be when a company undertakes a range of projects. The key objective is to assess the project's ability to repay debt from cash flow. In addition, projects are typically sizeable and perhaps too large for one participant to accept all the risk. The key elements are as follows:

- a stand-alone vehicle to hold all the contracts and manage the project;
- long-term contracts to purchase outputs to act a security for debt;
- contracts for the design, construction and operation of project assets;
- a market for the output (e.g. electricity from a power station and road tolls from a road construction);
- mechanisms and covenants for injecting further funds in the event of future financial problems or regulating cash distributions.

The basic project structure is shown in Figure 4.1.

Figure 4.1



Whilst a company seeking a loan can show the bank an operating history and annual reports, a project plan can only point to future profitability and cash flow. The funds are required today in anticipation of positive cash flows in the future based on use of the assets. There are a number of feasibility factors to take into account, for example:

- technology and implementation of technical processes;
- economic factors to allow a project to generate sufficient cash flow, and there may be factors such as political upheavals which cannot be anticipated;
- availability of raw materials and other inputs together with effective management.

ADVANTAGES

Project financing arrangements usually include mutual interests in structuring over and above separate financing for allocating risk and reward. Advantages include:

- pooling of benefits between the interested parties;
- means of spreading risk among specialists in particular fields (e.g. financiers, constructors and operators);
- a fixed life arrangement releasing excess cash flow to equity participants after debt servicing has been covered, which could allow higher returns than from traditional financing;
- the project vehicle manages the cash flows to lenders, equity participants and sponsors to ensure that debt providers are paid directly from project flows without recourse to a stand-alone company;
- increased debt capacity and increased gearing possible by securing the projected cash flows;
- lower cost of capital than traditional finance because of increased leverage and risk premiums;
- economies of scale greater than two corporations acting separately;
- contractual arrangements for resolving disputes and potentially lower legal costs.

RISKS

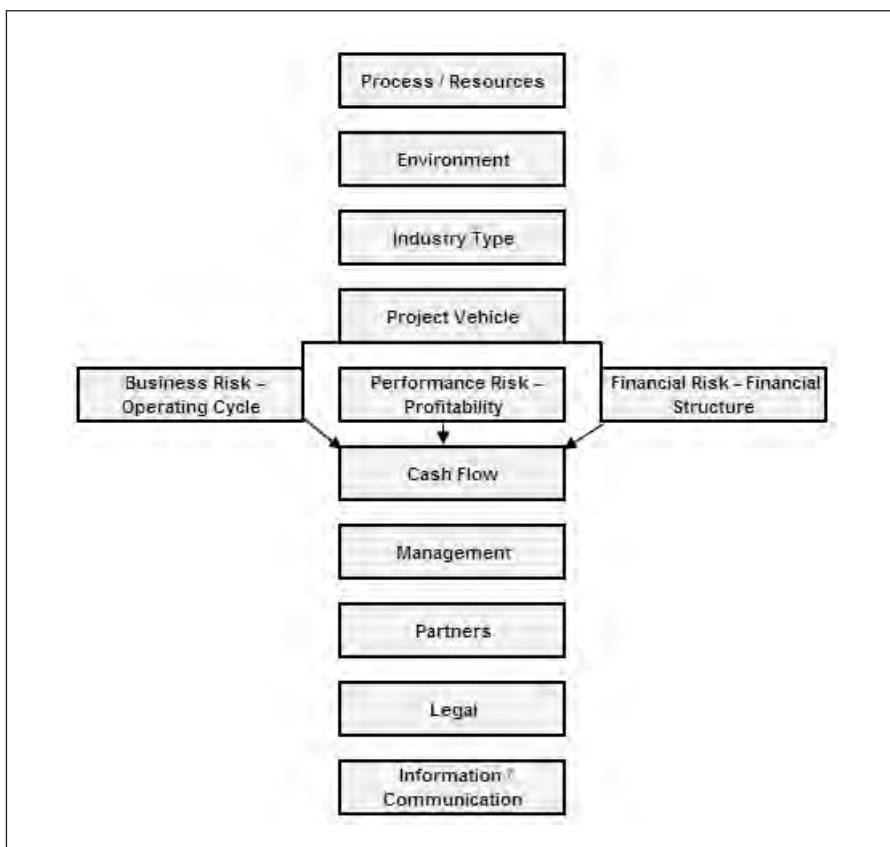
Figure 4.2 summarizes the sources of risk in an example project.

The methodology is initially to describe risks in order to analyse and then mitigate the risk through structuring and other methods. This list details some of the elements to be modelled, which are in effect the key elements of credit analysis:

- Environment and macro factors are those that an organization cannot directly control. A simple model is the STEEPV model (see Figure 4.3). In a long-term project shifts in politics, taxation or other factors can have profound effects on demand and cash flow. These factors are a source of uncertainty:
 - social and lifestyle developments that affect demand and costs;
 - technological changes, where an industrial process can be rendered expensive or unsustainable in the face of advances in technology.

Figure 4.2

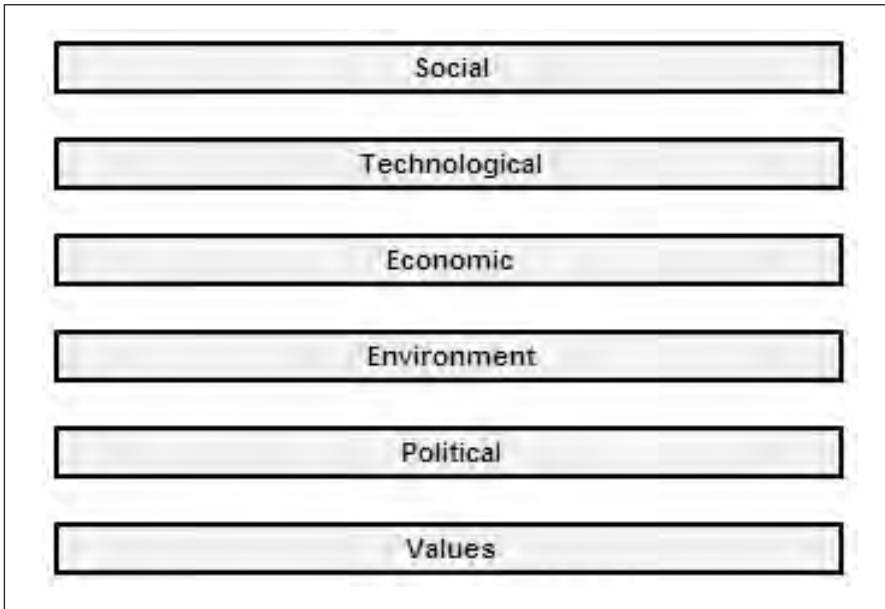
Project risks



- Economic and activity cycles, which affect future demand for goods and services and the availability of raw materials.
- Environmental factors especially for power and oil and gas projects. This is important during the project’s life and demands are made upon the operators to clean up sites on expiry of the project.
- Political climate and support through changes of government both at home and in any country where the project operates (e.g. changes in tax methods, rates of corporate tax and environmental legislation).
- Values and other ‘soft’ factors, which develop over time. Each decade exhibits certain values, such as the ‘green 1990s’.
- Industry type, since each industry exhibit different risk factors in its ability to insulate itself against future change. A road scheme and an industrial plant require a different approach, and demand for product can vary over time.

STEEPV

Figure 4.3



- Choice of project vehicle could be important. There are advantages to limited companies, unlimited and limited partnerships, joint interest ownership or an off-balance-sheet vehicle. Each method has tax, accounting and legal consequences. The elements are:
 - Business risk is efficiency in the operating cycle. Ratios such as debtor, creditor or inventory days demonstrate the measure of management control over working capital. It is obviously important that a project can generate cash in order to service the loans.
 - Performance risk means profitability and margin such as gross and net profit margins. Profit is dependent on accounting standards and conventions and therefore it is important to review accounting policies, such as the depreciation period for assets. For example, long depreciation periods enhance earnings in the early stages. Other return ratios combine the balance sheet and the income statement, such as the return on equity, return on assets or return on investment.
 - Financial risk emanates from the financial structure and the level of debt to equity. Since interest has to be paid on debt, whereas dividends can be suspended, higher leverage brings more financial risk. Similarly, a company needs working capital and the structure of the balance sheet should provide for both short- and long-term capital.

- Cash flow should be evident if business, performance and financial risk are controlled. A company producing profits should also produce cash. It is also important that there is both volume and a lack of volatility in cash flow in order to meet commitments.

Sample ratios are set out in Figure 4.4, which lists analysis ratios for each of the factors above.

Figure 4.4

Sample ratios

Generic Project : Evaluation Model 1				
Line	Year	2012	2013	2014
		1	2	3
Core Ratios				
R-10	Return on Sales (NPAT/Sales %)	2.30	7.75	12.04
R-11	Asset Turnover (Sales / Total Assets)	0.69	0.84	0.96
R-12	Asset Leverage (Total Assets/Equity)	2.29	2.27	2.16
R-13	Return on Equity (NPAT/Equity %)	3.64	14.72	24.99
Profitability				
R-17	Gross Profit / Sales (%)	57.14	56.12	55.36
R-18	Net Operating Profit / Sales (%)	9.80	16.59	21.68
R-19	Profit before Tax / Sales (%)	3.28	11.08	17.20
R-20	Profit after Tax / Sales	1.59	6.48	11.59
R-21	Return on Capital Employed (ROCE)	7.53	15.71	24.60
R-22	Return on Invested Capital (ROIC)	6.72	12.36	17.91
R-23	Return on Assets (ROA)	6.80	13.88	20.87
Operating Efficiency				
R-27	Inventory Days	-	-	-
R-28	Trade Receivables (Debtor) Days	91.25	91.25	91.25
R-29	Creditors Days	110.16	101.21	94.77
R-30	Funding Gap Debtors+Inventory-Creditors	(18.91)	(9.96)	(3.52)
Financial Structure				
R-34	Current Ratio	2.18	2.60	2.68
R-35	Quick Ratio (Acid Test)	2.18	2.60	2.68
R-36	Working Capital (Thousands)	13.80	22.56	32.10
R-37	Gross Gearing (%)	108.17	103.86	91.59
R-38	Net Gearing (%)	99.02	82.55	56.01
R-39	Gearing - Debt to Equity Ratio	51.54	50.12	45.36
R-40	Solvency (Interest Coverage)	150.34	300.69	483.35
R-41	Debt Service Ratio	3.29	3.67	4.24

Other factors are less easy to quantify, especially over time, but nevertheless these factors have to be considered for their impact on the overall plan:

- Management makes all the strategic decisions rather than the banks. In a structured finance transaction, depth of management is important and must have all the necessary skills to deliver on the covenants. There is, of course, the truism that managements rather than companies fail.
- Partners may also provide future instability, given that many projects last for 10 or 20 years. In a co-generation scheme, there are sponsors, construction companies and other specialists, banks, equity investors, raw material suppliers and customers for the generated power. The cash flows are only as sound as the partners' ability to manage all the processes.

- Legal considerations are always a factor across national borders and therefore the documentation should confirm the understanding of all parties and deal with all ambiguities in order to reduce the latitude for interpretation. The contracts must not only be in place, but also be capable of enforcement through the courts. This is especially true of acceptance, cost and negligence clauses.
- Information, knowledge management and communication are becoming more important as a separate area, since most companies depend on management information systems and their ability to leverage knowledge into competitive advantage. This is also true of a project, especially in cost control and gaining a deep understanding of the underlying business.

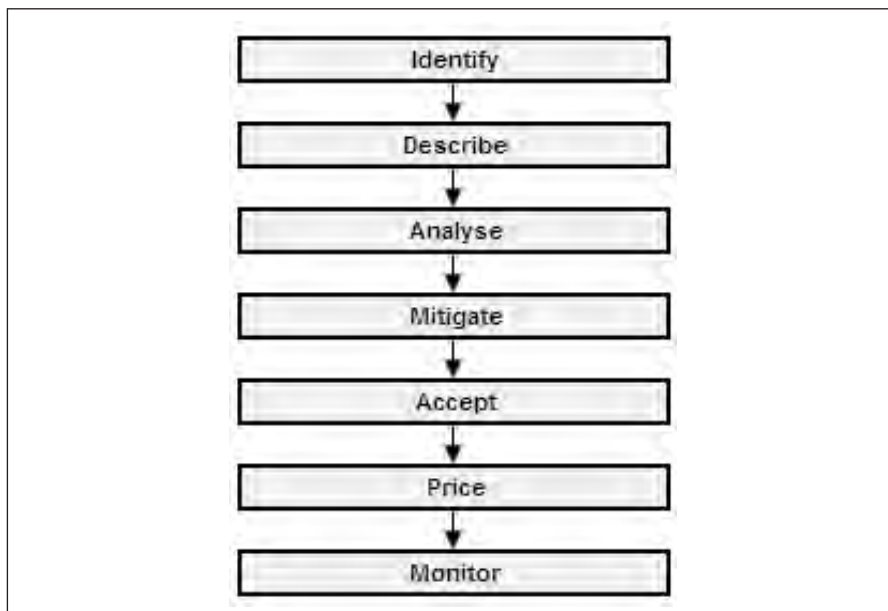
Analysis of the above factors should reveal the list of factors which will eventually become inputs for a financial model. The aim is to investigate, as thoroughly as possible, all the variables to save revisions to the financial model at a later stage. Key considerations are:

- the significant sources of risk and uncertainty associated with each stage of an investment;
- the causes of each risk;
- any links between factors and how risks could be grouped for classification and analysis.

Figure 4.5 shows the response sequence.

Response sequence

Figure 4.5



Only risks that are identified can be evaluated and then managed. Risk matrices are helpful in assessing the impact and probability and highlighting factors for subsequent sensitivity analysis (see Figure 4.6). Whilst there are a large number of inputs and rule to the model, there are usually a small number of input variables, which are clearly significant. For example, what happens to financial ratios and benefits of the project if construction were delayed by six months? Experience from earlier projects can help to outline difficulties and areas of concern.

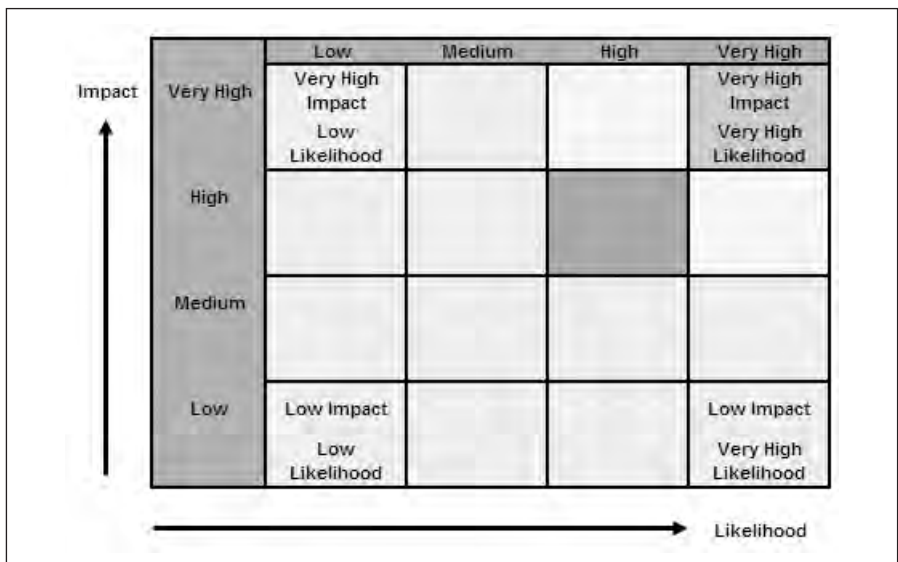
RISK ANALYSIS

Analysis of significant risks can take qualitative and quantitative forms using some of these methods:

- likelihood or frequency of occurrence per year or 100 years as a way of expressing likelihood;
- potential consequence (with respect to one or more of the factors or related cash flows) if the risk occurs;
- most likely frequency of the risk occurring during the whole lifetime of the project;
- possible timing of the risk's impact;
- risk scores.

Figure 4.6

Impact – likelihood 4x4 matrix



It is sometimes beneficial to allot a score for the likelihood and one for the impact and then combine the figures as a score. Risk with the highest scores can then be identified by these two factors and selected for further analysis. Combinations of risks can be evaluated together as one factor. Examples of occurrences are:

- once and for all chance of occurrence;
- average rate of occurrence over the duration of the project;
- variable rate of occurrence;
- extent of occurrence (e.g. per kilometre of road);
- probability of each of a series of possible values or ranges of values over the life of the investment (i.e. a probability distribution).

RISK MITIGATION

Project modelling assists with the risk analysis by providing a closed system for evaluating the inputs and likely outputs. All the costs and likely revenues can be calculated and then ‘stress-tested’ to see if the results are acceptable. Example outputs are:

- net present value (NPV);
- internal rate of return or modified internal rate of return;
- payback or discounted payback;
- cover ratios on the funding to ensure that there are sufficient funds to repay debts;
- maximum borrowing and other financial covenants;
- maximum possible tariff or optimum tariff required to cover debt and produce returns.

There are various phases to any project through construction, commissioning, operation and closure, and with long-term cash flows the level of error increases over time. Risk mitigation could include a number of techniques, such as:

- insurance;
- risk sharing through partnerships;
- structuring;
- financial engineering.

The above discussion seeks to demonstrate the degree of complexity in a project model and the risk faced at each stage of the process. The next section outlines the Excel model.

FINANCIAL MODEL

The file, MRM2_04, is an example feasibility model which brings together the main variables in a project with the objective of providing two key results: cover ratios and returns. The model contains a construction schedule to be funded through debt equity and then repayments against a forecast revenue and cost structure. Investors need to be certain of a return on their investment, while bankers need reassurance that loans can be repaid in full and on time. The audience is therefore a range of stakeholders with different agendas and varied risk appetites, and the model needs to be flexible enough to incorporate all the variables so that their contribution can be tested. By performing stress or sensitivity analysis, the model should reveal more information on the sources of risk and uncertainty, and assist with the structuring of the equity and debt injection.

It is assumed that analysis has been carried out and reveals areas for further research which are:

- plant completion date and the time required to rise to peak production;
- interest costs and loan structure, where interest rates are higher than planned;
- equity/debt gearing percentage;
- cost of construction rising in local currency;
- contingencies and possible overruns in construction and other costs adding to the strain on cash and the loans to be serviced, especially in the early stages, thereby reducing the cash available to investors;
- tax rates and retrospective changes in the nature and timing of tax payments;
- other costs, such as management fees;
- production volumes and selling prices failing to meet initial expectations;
- costs of raw materials altering drastically owing to economic shock or times of political instability;
- overhead costs rising above planned levels;
- escalators and inflation rates over the period reducing the selling price in real terms.

The model needs to be able to incorporate all these factors and store a number of individual cases. The organization must develop a number of individual scenarios to be considered and tested rather than adopt a solitary view of the future. Experience shows that macro (external) factors increase in importance over time together with the possibility of seemingly random events.

Therefore, the cases have to encompass both a poor and a more positive economic outlook. The result of each case will be a cash flow with related financial statements and ratio analysis in order to assess:

- NPV of the project at the risk-adjusted weighted average cost of capital or a nominated hurdle rate;
- internal rate of return to investors;
- debt service capacity of the project.

The organization of the model naturally splits into a number of sheets or areas. This makes it easier for co-workers and other users to understand and will make maintenance easier in the future. Adding more schedules will not require a fundamental redesign of the underlying workbook. The schedules are:

- menu;
- control area to look up individual scenarios from input sheets;
- input sheets for construction, timing, production, costs, contingencies and all the other variables;
- financial schedules – income statement and balance sheet;
- analysis – cash flow, ratios and sensitivity;
- management analysis – dynamic chart for line-by-line examination;
- management summary – annual summary and single-page report;
- explanation, user help and notes.

Figure 4.7 shows a model structure.

The only inputs allowed are on the Control, Inputs and Sensitivity sheets, and these are always marked in blue on the screen following the Systematic Design Method. The model is based on the App_Template and follows exactly the same style and design method (see Figure 4.8). This includes:

- use of colour – green for headings and totals, red for negative numbers, black for positive numbers;
- formats such as the use of a dash for zero;
- borders to break up sections of the schedule and highlight totals and answers;
- version numbers, units and project title in the same positions on each schedule.

Figure 4.7

Model structure

<p>Menu Control/Inputs Inputs - Scenarios Production Scenarios</p>	<p>Menu sheet – macro driven Inputs and assumptions Individual scenarios Production scenarios</p>
<p>Construction Borrowing Project Output</p>	<p>Capital expenditure Loan and equity requirement Quantity, revenue and costs</p>
<p>Income Statement Balance Sheet</p>	<p>Profit and loss Balance sheet</p>
<p>Cashflow Dividend Cashflow Ratios Sensitivity</p>	<p>Derived FRS-1 cashflow Annual ratio analysis WACC calculations Sensitivity tables and charts</p>
<p>Management Analysis Schedule</p>	<p>Dynamic charts for any line on any schedule Data only – do not delete</p>
<p>Management Summary Annual Summary</p>	<p>Single page flash report Summary of cash flows for each year</p>

Figure 4.8

Layout

	A	B	C	D	E	F
1						
2		Title				
3						vt.0 1-Jan-2000
4						
5		Inputs	100.00		Generic Project : Evaluation Model	
6			50.00		Units HK\$ '000,000	
7			25.00			
8			10.00			
9			5.00			Management Summary
10						
11						
12		Calculations				
13						
14						
15						
16						
17						
18		Answer	100.00			
19						
20						
21						
22		Sensitivity or Graphics				
23						
24						
25						
26						
27						
28						© Systematic Finance : Tel +44 (0)1483 532829
29						
30		Workings				
31						
32						
33						
34						

INPUTS

It is important to adopt a consistent style for spreadsheet models and all the models in this book follow the same pattern. This makes them easier to understand and faster to develop with fewer errors. The menu sheet below includes a combo control and assigned macro to access any sheet on the list. This is called `GetSheetNames`, which loops through and updates the list of sheets starting at row 50 and then selects the sheet number from the combo box. Excel uses index numbers internally so that `Worksheets(1)` is the first sheet in the workbook. This is the text of the macro:

```
Sub GetSheetNames()

Dim Number, Counter, SheetName(25)
Dim IndexNumber
On Error GoTo Error:

Application.Calculation = xlCalculationManual
Application.ScreenUpdating = False 'Turn off screen updating
Worksheets(1).Select 'Select first sheet - always the menu
Range("B51:B69") = "" 'Zero existing list

Range("B50").Select 'Start at the top of the
list
Number = ActiveWorkbook.Sheets.Count 'Count number of sheets in book
For Counter = 1 To Number 'Loop through each sheet

SheetName(Counter) = Worksheets(Counter).Name
'Put in the name of the sheet

ActiveCell.Offset(1, 0).Range("A1").Select
ActiveCell.FormulaR1C1 = Worksheets(Counter).Name
Next Counter

Error:
Range("A2").Select
On Error Resume Next
IndexNumber = Range("C50") 'Access the sheet number you selected
Sheets(IndexNumber).Select
Range("A2").Select
Application.ScreenUpdating = True 'Turn on screen updating

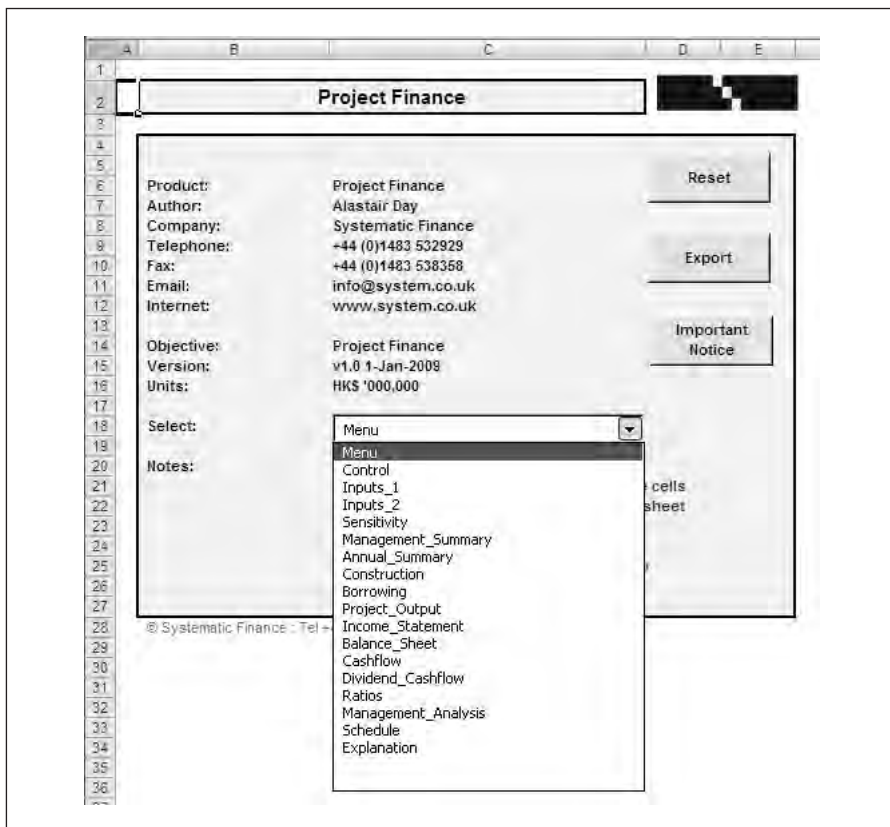
Application.Calculation = xlAutomatic End Sub
```

Figure 4.9 shows a project menu. The menu also contains a number of standard inputs such as the name of the application and the author. Again, these are standard names that are used on all workbooks developed by the author.

- Version = Menu!\$C\$15
- Product = Menu!\$C\$6
- Author = Menu!\$C\$7
- Company = Menu!\$C\$8
- Telephone = Menu!\$C\$9
- Fax = Menu!\$C\$10
- Email = Menu!\$C\$11
- Web = Menu!\$C\$12
- Objective = Menu!\$C\$14
- Contact = Menu!\$B\$28

Figure 4.9

Project menu



There are a large number of inputs for this model in order to provide future flexibility:

- Basic inputs – project name, revision, dates, currency, units (millions, thousands, etc.).
- Funding costs, period, fees and degree of leverage (debt to equity split). Since the model will produce the cash available to debt and equity, the degree of leverage may be important in increasing the NPV of the project.
- Escalators for future costs and revenues since prices are expected to rise.
- Predicted products, output quantities and sale price per unit.
- Costs for materials and establishment divided up into individual costs.
- Capital expenditure split into construction and subsidiary costs together with potential cost overruns and an option to include or discard. There are also inputs for post-completion capital expenditure.
- Cash and other starting balances for the balance sheet and cash flow. These would normally remain at zero.

The Control sheet uses a combo box at the top to look up information on the Inputs_1 and the Inputs_2 sheets which hold up to ten scenarios. This means that the individual scenarios are always visible. Whilst you can use the Scenario Manager in Excel, this method is often used on project models for the individuals cases.

Office 2007 – Data, Data Tools, What-if Analysis (Excel 2003 – Tools, Scenarios)

The control workings are at the bottom on Inputs_1 and the cell link is named Scenario_No. The data is derived from the cell inputs across the top entered by the user and looked up using the TRANSPOSE array function. The formula is as below and entered as an array function using Control, Shift and Enter together.

```
{= TRANSPOSE ($D$9:$M$9) }
```

OFFSET functions are used to collect the data from the Inputs sheets with a changing starting point and the same column offset number from the named cell Scenario_No. For example in cell D8:

```
= OFFSET (Inputs_1!C8,0,Scenario_No)
```

The Control sheet incorporates problems such as delays and contingencies so that the effects can be tested at a later stage. Similarly, there is a choice of funding out of cash or using an annuity method (see Figure 4.10).

Figure 4.10

Inputs

Select Scenario:		Evaluation Model 1
Key Inputs & Results		
Client	Generic Project	
Reference	Evaluation Model 1	
Start Date	1-Jan-10	
Company Year End	31-Dec-10	
Years to Operation	2.0 years	
Currency	HK\$	
Units	Millions	
Rates		
Interest Rate Loans	10.00%	
Debt Funding (% of total)	50.0%	
Dividend Payout	50.0%	
Project Delay (% of Yr up to 1 year)	0.0%	
Equipment Life (8-12 years)	10.0 years	
Corporate Tax	30.0%	
Management Fees	5.00%	
Loan Repayment Method		
% Cash Flow Dedication	Cash	50.0%
Annuity	Annuity	10.0 years
Number of Years	Years	10.0 years
CAPEX Percentage in First Year	75.0%	
Loan Repayment Method	Cash 50.0%	
Selected	Cash	
Cash Flow Dedication to Servicing Loan	50%	

The construction table uses combo boxes for contingencies and provides totals with and without cost overruns (see Figure 4.11).

Figure 4.11

Expenditure

Item	Amount	Contingency 20.0%	Total
Property, Plant & Equipment	50.00	No	50.00
Construction Costs	25.00	No	25.00
Infrastructure	10.00	No	10.00
Legal Costs	0.50	No	0.50
Establishment Costs	0.50	No	0.50
Pre-Completion Capex Over/Under Run	20.0%		
Total Capital Cost - No Increase	86.00		
Total Capital Cost with Contingency	86.00		

It is important to be able to review answers on an input sheet so that you do not have to tab to the other end of the model every time you change an entry. This summary table provides the main return numbers from the cash flow (see Figure 4.12). There are also minimum and maximum rules for

return and gearing, and the model uses an IF statement and conditional formatting to show up the answer.

Summary

Figure 4.12

	E	F	G	H	I	J	K	L	M	
7	Results: Leveraged IRRs					Equity NPV after Tax				
8	Equity Div before Tax	R51		183.2%			10%	\$32	98.6	
9	Equity after Tax	R52		28.4%			15%		58.6	
10	Project after Tax	R53		19.3%			20%		36.6	
11	Project before Tax	R54		24.4%			25%		23.8	
13	WACC								17.6%	
14	Net Present Value								25.26	
17	Management Tests									
18	Min Interest Cover Ratio		1.00		1.33	Pass				
19	Minimum NPV at 17.60%		25.00		25.26	Pass				
20	Maximum Gearing		75.00		61.54	Pass				
21	Min After Tax Equity Return		20.00		28.37	Pass				

The formula in K16 is = IF(J16<I16,"Fail","Pass") and column J uses MAX or MIN functions to select a case for cover, gearing and NPV.

Inputs_1 sheet is set out in columns to mirror the first page of the Control sheet whereas Inputs_2 sheet is in rows to accommodate the extra expenditure during the operating period (see Figure 4.13).

Inputs sheet

Figure 4.13

	A	B	C	D	E
5	Selected Scenario Evaluation Model 1				
7	Key Inputs & Results		1	2	
8	Client		Generic Project	Generic Project	
9	Reference		Evaluation Model 1	Evaluation Model 2	
10	Start Date		1-Jan-10	1-Jan-10	
11	Company Year End		31-Dec-10	31-Dec-10	
12	Years to Operation		2.0 years	2.0 years	
13	Currency		HK\$	HK\$	
14	Units		Millions	Millions	
17	Rates				
17	Interest Rate Loans		10.00%	10.00%	
18	Debt Funding (% of total)		50.0%	55.0%	
19	Dividend Payout		50.0%	55.0%	
20	Project Delay (% of Yr up to 1 year)		0.0%	0.0%	
21	Equipment Life (8-12 years)		10.0 years	10.0 years	
22	Corporate Tax		30.0%	30.0%	
23	Management Fees		5.00%	6.00%	
25	Loan Repayment Method				
26	% Cash Flow Dedication	Cash	50.0%	60.0%	
27	Annuity	annuity	10.0 years	10.0 years	
28	Number of Years	Years	10.0 years	10.0 years	
29	CAPEX Percentage in First Year		75.0%	80.0%	
30	Loan Repayment Method		Cash 50.0%	Cash 60.0%	
31	Selected		Cash	Cash	
32	Cash Flow Dedication to Servicing Loan		50%	60%	

SENSITIVITY AND COST OF CAPITAL

The Sensitivity schedule calculates a weighted average cost of capital (WACC) for the project using the Capital Asset Pricing Model (CAPM). The procedure is as follows:

- input for the risk-free rate, risk premium, historic equity beta, historic debt equity ratio, any extra hurdle rate premium, tax rate and predicted debt equity ratio;
- the model un-leverages the equity beta by multiplying the beta by $(1 - \text{debt}/\text{equity ratio})$;
- the resulting asset beta is divided by $(1 - \text{forecast debt}/\text{equity ratio})$;
- the cost of equity can then be calculated from $\text{extra hurdle rate} + \text{risk free rate} + \text{risk premium} * \text{equity beta}$;
- the cost of debt is the cost multiplied by $(1 - \text{tax rate})$;
- the WACC is then the cost of equity multiplied by its weighting plus the cost of debt multiplied by its weighting;
- there is also the option of including inflation in the calculation using the Fisher formula: $[(1 + \text{interest rate}) * (1 + \text{inflation})] - 1$.

In this example, the cost of capital is 17.60 per cent to reflect the risk on the organization in the beta; leverage in the debt/equity ratio, inflation and a hurdle premium to incorporate the extra risk in the project relative to the organization (see Figure 4.14).

Figure 4.14

Cost of capital inputs

	A	B	C
4			
5		Risk Free Rate	6.00
6		Risk Premium	5.00
7		Historic Debt / Equity Ratio	50.00
8		Equity Beta	1.20
9		Manual Extra Hurdle Rate	5.00
10		Marginal Tax Rate	30.00
11		Project Debt / Equity Ratio	50.00
12		Average Cost of Debt	10.00
13			
14		← →	
15			
16		Asset Beta [Beta / (1+Historic Debt %)]	0.80
17		Rev. Equity Beta [Beta * (1+Forecast Debt %)]	1.20
18		Capital Asset Pricing Model (CAPM) %	17.00
19		Net of Tax Cost of Debt %	7.00
20		Inflation %	5.00
21		WACC based on historic D/E ratio %	9.50
22		Inflation Adjusted WACC %	17.60
23			
24		Net Present Value on FCF	25.26
25		Internal Rate of Return %	21.38
26			

Office 2007 – Developer, Controls, Insert, Form Controls (Excel 2003 – View, Toolbars, Forms)

The slider control updates the forecast debt/equity ratio and is linked to a macro to update the inputs for the data tables shown in Figure 4.15. This is an alternative to the button at the top of the page since the outputs below are axes for the data tables further down the sheet:

- equity beta
- project debt/equity ratio
- inflation adjusted WACC percentage.

Data table

Figure 4.15

Sensitivity of Net Present Value on FCF to Project Debt / Equity Ratio Across and Equity Beta Down		Project Debt / Equity Ratio - Across				
Interval Across	5.00	Equity Beta - Down				
Interval Down	0.10					
		25.25	25.00	40.00	45.00	50.00
	0.90	23.38	23.38	25.93	28.71	31.71
	1.00	21.02	23.62	26.45	29.51	
	1.10	18.75	21.38	24.24	27.38	
	1.20	16.54	19.19	22.09	25.26	
	1.30	14.39	17.06	20.00	23.22	
	1.40	12.30	14.99	17.95	21.22	
	1.50	10.26	12.97	15.96	19.27	

The other tables display the sensitivity of the WACC to the project debt/equity ratio and the beta together with the effect on the NPV of the WACC.

CONSTRUCTION, BORROWING AND OUTPUT

The construction amounts, borrowings capacity and output are laid out in the Control schedule. These sheets show the workings on a periodic basis where the phasing of the construction affects the requirement for borrowings. After construction, there is also some new minor expenditure for repairs, maintenance and additions.

The depreciation per annum is an input cell on the Control schedule and the total capital for the period is depreciated at the rate. In the example, the rate used is 10 per cent per annum since the equipment life is 10 years (see Figure 4.16).

Figure 4.16

Construction schedule

Line	Year	Reference	2010	2011
			-2	-1
Capital Expenditure			75.00%	25.00%
CP-11	Property, Plant & Equipment	CN79	37.5	13.1
CP-12	Construction Costs	CN80	18.8	6.6
CP-13	Infrastructure	CN81	7.5	2.6
CP-14	Legal Costs	CN82	0.4	0.1
CP-15	Establishment Costs	CN83	0.4	0.1
CP-16	Total before Contingency		64.5	22.6
CP-18	Contingency	CP16*CN42	-	-
CP-19	Management Fees	(CP16+18)*CN23	3.2	1.1
CP-20	Total after Contingency		67.7	23.7
CP-22	CAPEX Adjustment/Saving	CP27*CN29	-	-
CP-23	Total CAPEX (Unescalated) - Pre Completion		67.7	23.7
Capital Cost Schedule - Post Completion				
CP-26	CAPEX - before Contingency	CN89*(1+CN35)*CN51	-	-
CP-27	Contingency	CP26*CN42	-	-
CP-28	Management Fees	(CP26+27)*CN23	-	-
CP-29	Total CAPEX - Post Completion/Contingency		-	-
CP-31	Total Project Capital Cost		67.7	23.7

The borrowings and equity ratio are fixed so that the construction determines the capital requirement. Interest during construction is capitalized on the Loan sheet to form the total requirement. The debt percentage is subject to a loan over 10 years. The objective is to allow the debt requirement and equity to cascade through the model based on the construction costs. The model uses equity first and then loans, but a model could be made more complex with different loan facilities offering varied expiry dates and interest rates. Other methods of equity injection could include:

- percentage of total capital (debt and equity);
- equity injected into the capital as required;
- equity paid at certain times such as completing milestones or key stages;
- percentage of construction costs after escalation and contingencies.

In the extract from the Loan funding schedule, the debt/equity split of 50 per cent is maintained and repayments are scheduled on a cash or annuity basis (see Figure 4.17). The interest rates come from the Control sheet so that the schedule calculates the key information:

- interest payable both pre- and post-completion;
- principal repayment;
- cash flow available to repay interest and principal;
- balance carried forward to the next period.

Borrowings schedule

Figure 4.17

Line	Year	Reference	2010	2011	2012
			-2	-1	1
Funding Required during Construction					
L-10	Pre Completion Capital Costs	CP23	67.7	23.7	-
L-11	Interest During Construction or Delay	L10*CN17	3.4	8.0	-
L-12	Facility and Commitment Fees	(L10:11)*CN30+((L10:11)-L31)*CN31	1.2	0.1	0.1
L-13	Increase in Working Capital	B40	-	-	10.0
L-14	Startup/Delay Expenses	S18	-	-	-
L-15	Total Funding Required		71.1	31.7	10.0
L-17	Provided by Debt	50.0%	35.6	15.8	5.0
L-18	Provided by Equity	50.0%	35.6	15.8	5.0
Loan Drawdown/Repayment Schedule					
L-21	Opening Balance	L26	-	35.6	51.4
L-22	Add Loan Drawdowns	L17	35.6	15.8	5.0
L-23	Closing Balance - Total		35.6	51.4	56.4
L-25	Less Principal Repayment		-	-	-
L-26	Closing Balance - Total		-35.6	51.4	56.4

This model is limited to two products denoted on the Control schedule. The purpose of this sheet is to provide a link between the initial inputs and the accounting sheets. The figures are presented without escalators to show an excess or deficit from the basic revenue and costs. The revenue is simply the number multiplied by the price per unit. At the bottom, the costs are escalated based on the increases in the Control sheet and the period number (see Figure 4.18).

ACCOUNTING SCHEDULES

All the schedules so far provide the data for the accounting schedules for presenting the likely profitability, net worth, cash flow and financial analysis. These schedules use standard layouts which could also be incorporated into budget, loan analysis, equity valuation, management buy-out and other models involving forecasts and accounting statements, such as:

- income statement
- balance sheet
- ratios
- cash flow.

Figure 4.18

Output

	A	B	C	D	E	F	G	H	I
5		Generic Project : Evaluation Model 1							
6		Line	Year	Reference	2010	2011	2012	2013	2014
7					-2	-1	1	2	3
8									
9		Revenue Schedule - No Inflation							
10	PJ-10	Product 000	CN54*(1-CN20)				100	150	200
11	PJ-11	Product 111	CN55*(1-CN20)				100	100	100
12	PJ-12	Total Output					200	250	300
13									
14	PJ-14	Price per Unit - Product 000	PJ10		0.3	-	0.3	0.3	0.3
15	PJ-15	Price per Unit - Product 111	PJ11		0.5	-	0.5	0.5	0.5
16	PJ-16	Total Revenue			-	-	75.0	87.5	100.0
17									
18		Cash Operating Schedule - No Inflation							
19	PJ-19	Fixed Labour Expenses	CN65				7.5	7.5	7.5
20	PJ-20	Variable Labour Expenses	CN66				5.0	6.3	7.5
21	PJ-21	Materials	CN67				20.0	25.0	30.0
22	PJ-22	Corporate Overheads	CN68				0.3	0.3	0.3
23	PJ-23	Insurance	CN69				3.7	3.4	3.0
24	PJ-24	Land Rates & Taxes	CN70				0.2	0.2	0.2
25	PJ-25	Administration	CN71				1.5	1.5	1.5
26	PJ-26	Marketing	CN72				1.5	1.5	1.5
27	PJ-27	Repairs and Maintenance	CN73				1.9	1.7	1.5
28	PJ-28	Input Materials	CN74				7.0	7.0	7.0
29	PJ-29	Utilities	CN75				10.0	10.0	10.0
30	PJ-30	Contingency Items	PJ20:29	0.0%			-	-	-
31	PJ-31	Cash Expenses after Contingency					58.6	64.2	69.9
32									
33	PJ-33	Excess / (Deficit)			-	-	16.4	23.3	30.1

Each of the lines is labelled with its source and uses data from loan and cost schedules. The result from the income statement is the accounting profit in each of the periods (see Figure 4.19). Workings at the bottom show the calculation of tax for both the income and cash flow schedules.

Figure 4.19

Income statement

	A	B	C	D	E	F	G	H	I
5		Generic Project : Evaluation Model 1							
6		Line	Year	Reference	2010	2011	2012	2013	2014
7					-2	-1	1	2	3
8									
9	P-09	Revenues	PJ40				82.7	101.3	121.6
10	P-10	Less: Fixed Labour Expenses	PJ19				7.9	8.3	8.7
11	P-11	Variable Labour Expenses	PJ20				5.6	7.2	8.1
12	P-12	Materials	PJ21				22.1	28.9	36.5
13	P-13	Corporate Overheads	PJ22				0.8	0.3	0.3
14	P-14	Insurance	PJ23				4.1	3.8	3.6
15	P-15	Land Rates & Taxes	PJ24				0.2	0.2	0.2
16	P-16	Administration	PJ25				1.7	1.7	1.8
17	P-17	Marketing	PJ26				1.7	1.7	1.8
18	P-18	Repairs	PJ27				2.1	-2.0	1.8
19	P-19	Input Materials	PJ28				7.7	8.1	8.5
20	P-20	Utilities	PJ29				11.0	11.8	12.2
21	P-21	Contingency	PJ30				-	-	-
22	P-22	Depreciation	CP42				10.4	10.5	10.7
23	P-23	Total Operating Costs			-	-	74.6	84.5	95.2
24									
25	P-25	Operating Profit			-	-	8.1	16.8	26.4
26									
27	P-27	Less: Interest Expenses	L34				5.4	5.6	5.5
28	P-28	Profit before Tax			-	-	2.7	11.2	20.9
29									
30	P-30	Less: Corporate Tax	P41				0.6	3.4	8.3
31	P-31	Net Profit after Tax			-	-	1.9	7.9	14.6
32									
33	P-33	Dividends	C30				8.2	6.6	9.5
34	P-34	Retained Earnings			-	-	(4.3)	1.3	5.2

The balance sheet self-checks at the bottom and demonstrates the accounting valuation for the project at each period end (see Figure 4.20). The income statement and balance sheet are linked since increased loans feed through to higher interest payment in the income statement, less profit to pay dividends and therefore less cash and net worth in the balance sheet.

Balance sheet

Figure 4.20

Line	Year	Reference	2010	2011	2012	2013
			-2	-1	1	2
B-09	Cash/Bank	C31	(1.2)	(1.4)	4.8	11.4
B-10	Accounts Receivable (Debtors)	B37	-	-	20.7	25.3
B-11	Total Current Assets		(1.2)	(1.4)	25.4	36.7
B-13	Fixed Assets - Equipment	CP40	72.4	104.2	104.2	105.4
B-14	Depreciation				10.4	21.0
B-15	Fixed Assets - Written Down Value		72.4	104.2	93.7	84.4
B-17	Total Assets		71.1	102.8	119.2	121.1
B-18						
B-19	Accounts Payable (Creditors)	B38	-	-	10.7	12.3
B-20	Current Portion Long Term Debt	L29	-	-	0.9	1.8
B-21	Provision for Tax	P30-C19	-	-	-	-
B-22	Total Current Liabilities		-	-	11.6	14.1
B-24	Non Current Liabilities					
B-25	Long Term Debt	L28	35.6	51.4	56.4	53.6
B-26	Total Liabilities		35.6	51.4	67.1	67.7
B-28	Equity - Shareholders' Equity	L39	35.6	51.4	56.4	56.4
B-29	Retained Earnings	L47	-	-	(4.3)	(5.0)
B-30	Total Equity		35.6	51.4	52.1	53.4
B-32	Total Liabilities and Equity		71.1	102.8	119.2	121.1
	Checksum No Errors		=	=	=	=

There are two cash flow statements. The first restates the income statement and balance sheet in the standard annual accounts format. This divides trading from non-trading cash and displays totals for the net operating cash flow and the cash inflow or outflow before financing. New capital as debt or equity is isolated and the statement reconciles back to the change in cash on the balance sheet. The second cash statement calculates the cash available for paying dividends, which is set in the Control schedule as 50 per cent of the cash available. The elements are shown in Figure 4.21. Again, the schedule self-checks to the change in bank on the balance sheet.

Figure 4.21

Dividend cash flow

Line	Year	Reference	2010 -2	2011 -1	2012 1	2013 2	2014 3
C-09	Operating Profit	P25	-	-	8.1	16.8	26.4
C-10	Add back Depreciation/Amortisation	CP42	-	-	10.4	10.5	10.7
C-11	Operating Cash Flow (EBITDA)		-	-	18.5	27.3	37.0
C-13	Less: Increase in Working Capital	B40	-	-	10.0	3.0	3.3
C-14	Capex - Pre Completion	CP23	67.7	23.7	-	-	-
C-15	Capex - Post Completion		-	-	-	1.2	1.3
C-16	Interest - Pre Completion	L11	3.4	8.0	-	-	-
C-17	Interest on Debt		-	-	5.4	5.6	5.5
C-18	Establishment/Commitment Fees	L12	1.2	0.1	-	-	-
C-19	Corporate Tax		-	-	0.8	3.4	6.3
C-20	Net Operating Cash Flow		(72.4)	(31.8)	2.3	14.2	20.7
C-22	Financing Sources - Debt	L17	35.6	15.8	5.0	-	-
C-23	Financing Sources - Equity	L18	35.6	15.8	5.0	-	-
C-24	Total Financing Sources		71.1	31.7	10.0	-	-
C-26	Financing Uses - Loan Principal Repmt	L25	-	-	-	0.9	1.8
C-27	Net Financing Cash Flow		71.1	31.7	10.0	(0.9)	(1.8)
C-29	Cash Flow available for Dividend	C20-C27	(1.2)	(0.1)	12.3	13.2	18.9
C-30	Less Dividend 50.0%		-	-	6.2	6.6	9.5
C-31	Net Cash Flow		(1.2)	(0.1)	6.2	6.6	9.5
	Change in Bank	B9	-	(0.1)	6.2	6.6	9.5
	CheckSum: No Errors		-	-	-	-	-

The equity and debt providers need the financial analysis of the project. The equity providers need to know the returns relative to the risk. In particular, the key areas are:

- profitability and return such as return on equity, profit margin and return on assets;
- financial structure such as gearing, interest coverage and solvency;
- operating cycle such as working capital, debtors, creditors and inventory days;
- cash flow such as net operating cash flow to sales.

The model provides the standard ratios grouped around the core ratios. Again, all the derivations of the ratios are shown on the schedule (see Figure 4.22). The return ratios are calculated on a pre- and post-tax basis.

Figure 4.22

Ratios

	A	B	C	D	E	F	G	H	I
5	Generic Project : Evaluation Model 1								
6	Line	Year	Reference	2010	2011	2012	2013	2014	
7				-2	-1	1	2	3	
8									
9		Core Ratios							
10	R-10	Return on Sales (NPAT/Sales %)	P31/P9			2.30	7.75	12.04	
11	R-11	Asset Turnover (Sales / Total Assets)	P9/B17			0.69	0.84	0.96	
12	R-12	Asset Leverage (Total Assets/Equity)	B17/B30			2.29	2.27	2.16	
13	R-13	Return on Equity (NPAT/Equity %)	P31/B30			3.64	14.72	24.99	
14									
15									
16		Profitability							
17	R-17	Gross Profit / Sales (%)	(P9-(P10:12))/P9			57.14	56.12	55.36	
18	R-18	Net Operating Profit / Sales (%)	P25/P9			9.80	16.59	21.68	
19	R-19	Profit before Tax / Sales (%)	P28/P9			3.28	11.08	17.20	
20	R-20	Profit after Tax / Sales	P31/B17			1.59	6.48	11.59	
21	R-21	Return on Capital Employed (ROCE)	P25/(B30+B25)			7.53	15.71	24.60	
22	R-22	Return on Invested Capital (ROIC)	(P25-P30)/(B25+B20+B30)			6.72	12.36	17.91	
23	R-23	Return on Assets (ROA)	P25/B17			6.80	13.88	20.87	
24									
25									
26		Operating Efficiency							
27	R-27	Inventory Days	B13/P11			-	-	-	
28	R-28	Trade Receivables (Debtor) Days	B10/P9*365			91.25	91.25	91.25	
29	R-29	Creditors Days	B19/(P10:12)			110.16	101.21	94.77	
30	R-30	Funding Gap Debtors+Inventory-Creditors	R27+R28-R29			(18.91)	(9.96)	(3.52)	
31									
32									
33		Financial Structure							
34	R-34	Current Ratio	B11/B22			2.18	2.60	2.68	
35	R-35	Quick Ratio (Acid Test)	(B11-Inv)/B22			2.18	2.60	2.68	
36	R-36	Working Capital (Thousands)	B11-B22			13.80	22.56	32.10	
37	R-37	Gross Gearing (%)	(B20-B25)/B30			108.17	103.86	91.59	
38	R-38	Net Gearing (%)	(B20-B25-B9)/B30			99.02	82.55	56.01	
39	R-39	Gearing - Debt to Equity Ratio	B25/(B25+B30)			51.54	50.12	45.36	
40	R-40	Solvency (Interest Coverage)	P25/P27			150.34	300.69	483.35	
41	R-41	Debt Service Ratio	(P25+C10-P30)/(C17+C26)			3.29	3.67	4.24	

Debt providers may be more interested in cover ratios. The financial model needs to derive the maximum amount of debt that the project cash flow could safely support. The important ratios here are:

- Gross gearing (%) $(B20 + B25)/B30$
- Net gearing (%) $(B20 + B25 - B9)/B30$
- Gearing – debt to equity ratio $B25/(B25 + B30)$
- Solvency (interest coverage) $P25/P27$
- Debt service ratio $(P25 + C10 - P30)/(C17 + C26)$

There are variants of these ratios. For example, earnings before interest, taxation, depreciation and amortization (EBITDA) or net operating cash flow could be used instead of operating profit for interest coverage. The project must be able to demonstrate both quantity and quality of cash flow and therefore in its simplest form must cover the interest payments. Debt providers also require repayment of principal, and the debt service ratio includes both interest and debt in the formula:

$$\frac{(\text{Operating profit} + \text{Depreciation} + \text{Amortization} - \text{Dividends})}{(\text{Interest} + \text{Principal repayment})}$$

An alternative formula is:

$$EBITDA / (Interest + (Principal / (1 - Tax\ rate)))$$

Where any of these ratios fall below one, the project is not generating sufficient cash to service its debts. A good model should survey the data and include decision making. The extract from the Control sheet shown in Figure 4.23 includes individual coverage tests to ensure that the model ‘passes’ at each stage. The minimum or maximum is extracted using the functions MIN and MAX to highlight the periods where coverage is at a minimum. Since forecasts notoriously become less accurate the further into the future you project, it is obviously important to critically review the coverage and returns from the later periods. The model therefore assists in demonstrating the key ratios for the client, advisers, debt and equity providers. This extract is on the Control sheet.

Figure 4.23

Return ratios

	E	F	G	H	I	J	K	L	M	
6										
7										
8		Results: Leveraged IRRs					Equity NPV after Tax			
9		Equity Div before Tax	R51	183.2%		10%	S32	98.5		
10		Equity after Tax	R52	28.4%		15%		58.6		
11		Project after Tax	R53	19.2%		20%		36.6		
12		Project before Tax	R54	24.4%		25%		23.8		
13										
14		WACC		17.6%						
15		Net Present Value		25.26						
16										
17		Management Tests								
18		Min Interest Cover Ratio	1.00	1.33	Pass					
19		Minimum NPV at 17.60%	25.00	25.26	Pass					
20		Maximum Gearing	75.00	51.54	Pass					
21		Min After Tax Equity Return	20.00	28.37	Pass					
22										

MANAGEMENT ANALYSIS AND SUMMARIES

The complete model is included in this chapter to demonstrate the number of variables, possible inputs and therefore the level of risk to be borne by each party. On account of the detail, the model needs schedules to summarize and report on the findings. These schedules are called:

- Management Summary
- Annual Summary
- Management Analysis.

The Management Summary brings together the internal rates of return from the Control schedule together with the components of the weighted average cost of capital from the Sensitivity sheet (see Figure 4.24). The table of management tests is repeated to demonstrate the acceptability of the cash flows.

Management Summary

Figure 4.24

	A	B	C	D	E
6					
7		Results			
8		Equity Div before Tax	183.2%		
9		Equity after Tax	28.4%		
10		Project after Tax	19.3%		
11		Project before Tax	24.4%		
12					
13		Project Equity Beta	1.20		
14		Manual Extra Hurdle Rate	5.0%		
15		Project Debt / Equity Ratio	50.0%		
16		Capital Asset Pricing Model (CAPM) %	17.0%		
17		Net of Tax Cost of Debt %	7.0%		
18		WACC	17.6%		
19		Net Present Value	25,26		
20					
21		Management Tests			
22			Rule	Achieved	
23		Min Interest Cover Ratio	1.00	1.33	Pass
24		Minimum NPV at 17.60%	25.00	25.26	Pass
25		Maximum Gearing	75.00	51.54	Pass
26		Min After Tax Equity Return	20.00	28.37	Pass
27					

Figure 4.25 is a summary of the capital costs and the loans and equity mix. The construction requirements are matched by an equal amount of debt and equity.

The Sensitivity chart illustrates how the NPV of the project changes as the cost of capital increases or declines (see Figure 4.26). The slope of the lines gives a good indication of the responses since the NPV rises by 20 to around 50 if the cost of capital is reduced to 15 per cent. If the WACC rises above 21.5 per cent, then the project attains a negative NPV.

The Annual Summary picks key lines from the other schedules to summarize output, revenue, cash and ratios on a periodic basis (see Figure 4.27). This is a single-page report for showing exactly how the cash flows and how this affects the cover and return ratios.

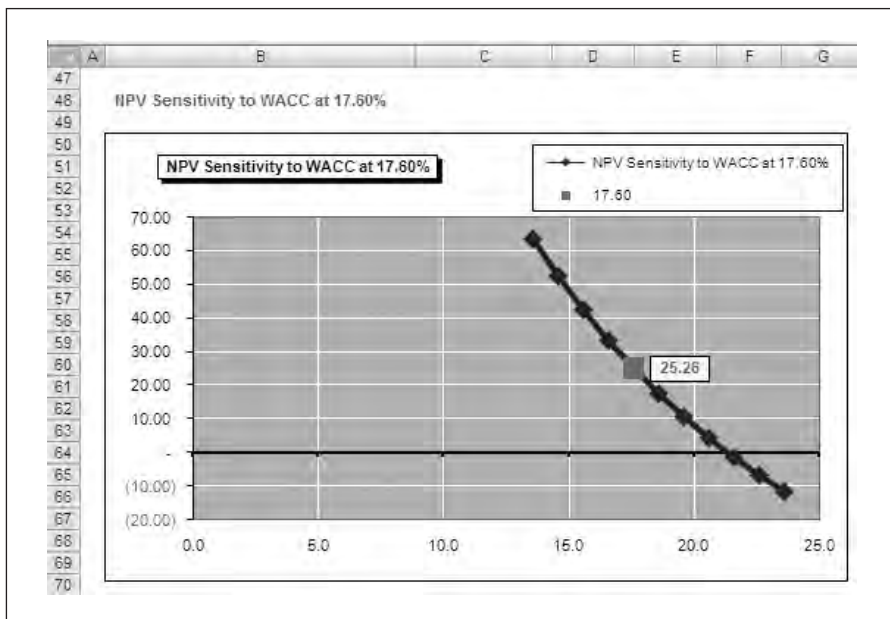
Figure 4.25

Capital Costs and Loan

	A	B	C
28			
29		Capital Costs and Loan	
30		Property, Plant & Equipment	50.63
31		Construction Costs	25.31
32		Infrastructure	10.13
33		Legal Costs	0.51
34		Establishment Costs	0.51
35		Management & Contingency	4.35
36		Interim Interest	11.34
37		Increase in Working Capital	9.98
38			
39		Total Required	112.75
40			
41		Loan	56.37
42		Loan Cost	10.00
43		Method	Cash 50.0%
44		Equity	56.37
45		Total Funding	112.75
46			

Figure 4.26

Sensitivity



Annual Summary

Figure 4.27

Line	Year	Reference	2010	2011	2012	2013
			-2	-1	1	2
S-08	Output Product 000				100.0	150.0
S-10	Output Product III				100.0	100.0
S-11	Total Output				200.0	250.0
S-13	Price Per Unit - Product 000	PJ14	0.3	0.3	0.3	0.3
S-14	Price per Unit - Product III	PJ15	0.5	0.5	0.6	0.6
S-15	Total Revenue				82.2	101.3
S-17	Operating Costs	PJ31	-	-	(11.6)	(89.5)
S-18	Operating Cashflow	S15-S17	-	-	8.1	16.8
S-19	Project Finance Loan	50%	35.6	15.8	5.0	
S-20	Equity Injection	50%	35.6	15.8	5.0	
S-21	Total Sources of Cash		71.1	31.7	18.1	16.8
S-23	Capital Expenditure	CP31	(67.7)	(73.7)	-	(1.2)
S-24	Capitalised Interest	L11	(6.4)	(6.0)	-	-
S-25	Working Capital	B40	-	-	(10.0)	(1.0)
S-26	Establishment/Commitment Costs	L12	(1.2)	(1.1)	(0.1)	-
S-27	Interest Payments	L34	-	-	(6.8)	(6.6)
S-28	Corporate Taxes	P53	-	-	(0.8)	(0.9)
S-29	Loan Repayments		Cash	-	-	(0.9)
S-30	Total Uses of Cash		(72.4)	(31.8)	(16.3)	(14.1)
S-32	Net Cashflow after Tax	S21-S30	(1.24)	(0.16)	1.78	2.67
S-33	Cumulative Cashflow		(1.24)	(1.39)	0.39	3.05
S-34	Cover Ratios - Interest	(S32-S27-S29)/S27			1.33	1.65
S-35	Principal Cover	(S29-S32)/S29			-	3.81
S-36	Debt Service Cover	(S32-S27-S29)/(S27-S29)			1.33	1.41
S-37	PV Cumulative Cashflows Cover	NPV/(CN16,L57/S19)			0.12	0.25

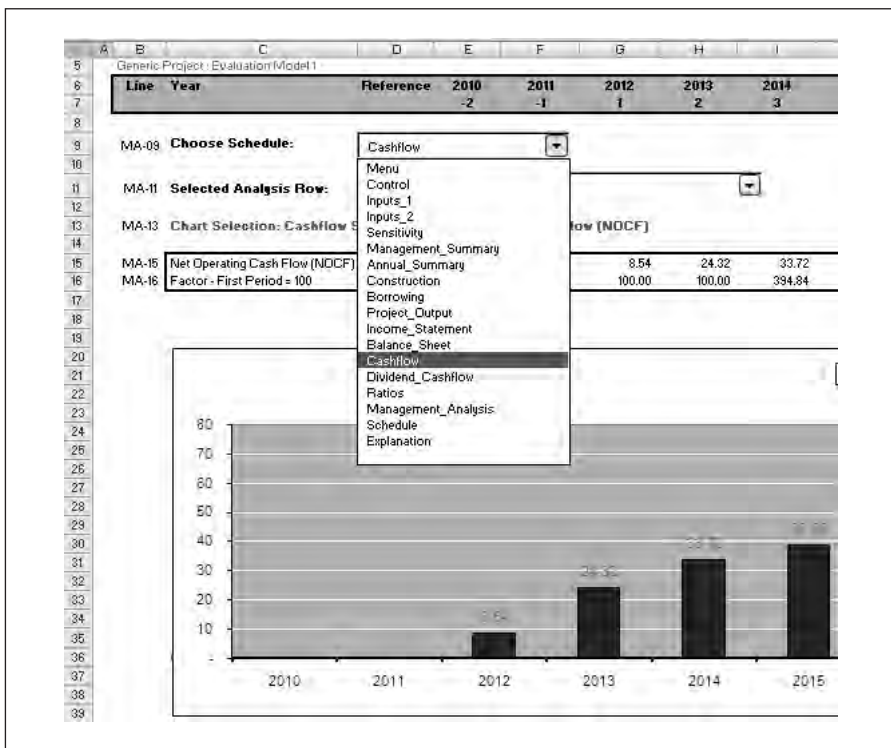
Schedules of figures are difficult to understand and therefore the model provides an additional method of reporting using a dynamic chart. The objective is to copy any sheet to the Schedule sheet and then look up these values on the Management Analysis sheet (see Figure 4.28). This saves producing multiple charts and provides the user with the flexibility of examining almost any line in the model.

The first stage is to choose a schedule using the control box and this updates the cell link at D61. There is a macro assigned to the control called CopyDataSheet. This performs the following:

- selects Management Analysis sheet;
- updates the sheet names at B50 on the Menu sheet;
- selects the sheet number selected by the control;
- copies rows 9 to 75 (since row 75 is the maximum row of any schedule);
- goes to the Schedule sheet and paste specials the values;
- pastes to A9 the name of the sheet that has been copied and pasted.

Figure 4.28

Management Analysis



The full text of the macro is as follows:

```

Sub CopyDataSheet ()
'
' CopyDataSheet Macro
' Macro developed by Alastair L Day
' Excel uses index numbers for sheets so this macro copies a sheet
number given by the control and paste specials the values into the
Schedule sheet
' The second control then selects a row on the Schedule sheet for a
chart

Dim Sheet_Selection
Dim Number, Counter, SheetName(25)
Application.ScreenUpdating = False
Application.Calculation = xlCalculationManual
Sheet_Selection =
Range("Management_Analysis!d61")
'Select Management Analysis sheet
    
```

```

'Update the sheet names at B50 on the Menu sheet
Worksheets(1).Select
'Update list of schedules on menu sheet
Range("B50").Select
Number = ActiveWorkbook.Sheets.Count

For Counter 1 To Number
SheetName(Counter) = Worksheets(Counter).Name
ActiveCell.Offset(1, 0).Range("A1").Select
ActiveCell.FormulaR1C1 = Worksheets(Counter).Name
Next Counter

'Select the sheet selected by the control
Application.Worksheets(Sheet_Selection).
Select

'Copy rows 9 to 75
Rows("9:75").Select
Application.CutCopyMode = False
Selection.Copy

'Go to the Schedule sheet and paste special the values
Range("b9").Select
Sheets("Schedule").Select
Range("A9").Select
Selection.PasteSpecial Paste:= xlValues, Operation:= xlNone,
SkipBlanks:= False, Transpose:= False

Range("A9").Select
Application.CutCopyMode = False

Range("b2") =
Application.Worksheets(Sheet_Selection).Name
'Paste to A9 the name of the sheet you just copied and pasted
Sheets("Management_Analysis").Select
Range("A9").Select

Application.StatusBar = False
Application.ScreenUpdating = True
Application.Calculation = xlAutomatic
End Sub

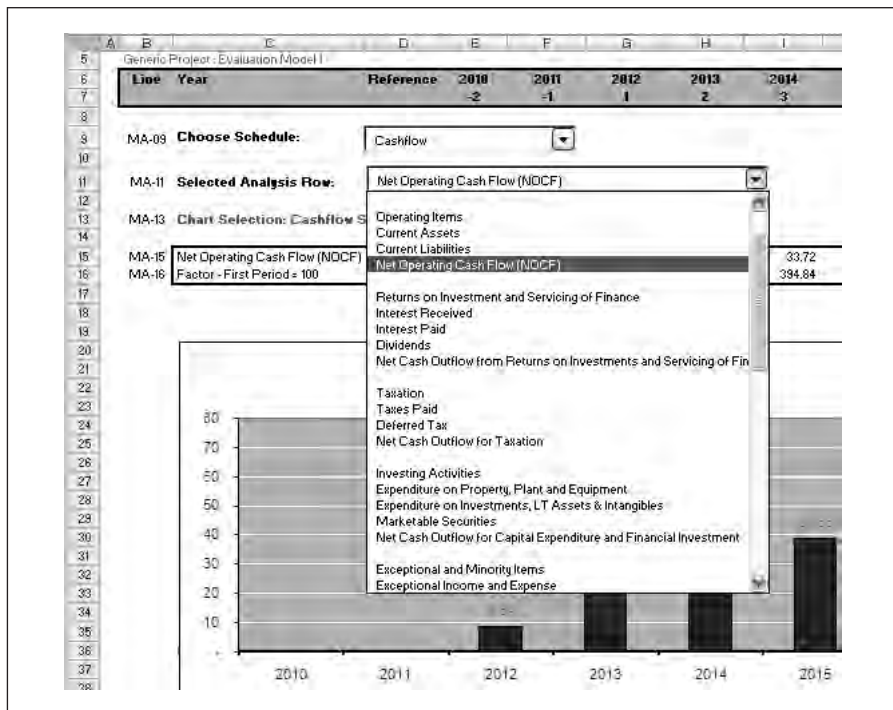
```

The second control then selects a line number on the Schedule sheet using a simple `OFFSET` formula based on the cell link at cell D63 (see Figure 4.29). Again, the user sees the actual line text and can decide easily which line is needed. This is the formula in cell G15:

```
= IF(ISERROR(OFFSET(Schedule!G8,$D$63,0)),0,OFFSET
(Schedule!G8,$D$63,0))
```

Figure 4.29

Select line



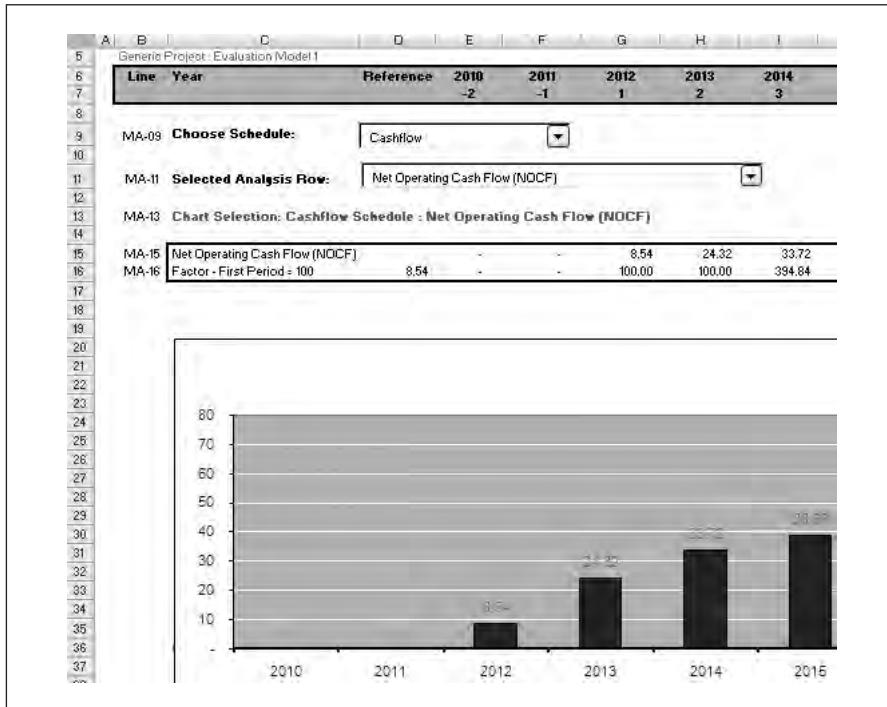
The data is changed on row 15, and row 16 includes a factor analysis. The first data point defaults to 100 and all subsequent points are restated as a factor. Minus 20 per cent would be 80 and plus 25 per cent would be 125. This is often a better way of presenting percentage changes than using just the percentage difference.

The finished Management Analysis chart shows the net operating cash flow from the cash flow schedule (see Figure 4.30). Here you can see the trend of the forecast results and examine the changes using multiple scenarios updated from the Control sheet.

You can select other schedules, and the text in the second control will automatically update if calculation is set to automatic. Since the macro suppresses the screen updates, you do not notice the macro running. Figure 4.31 shows the return on sales from the Ratios schedule.

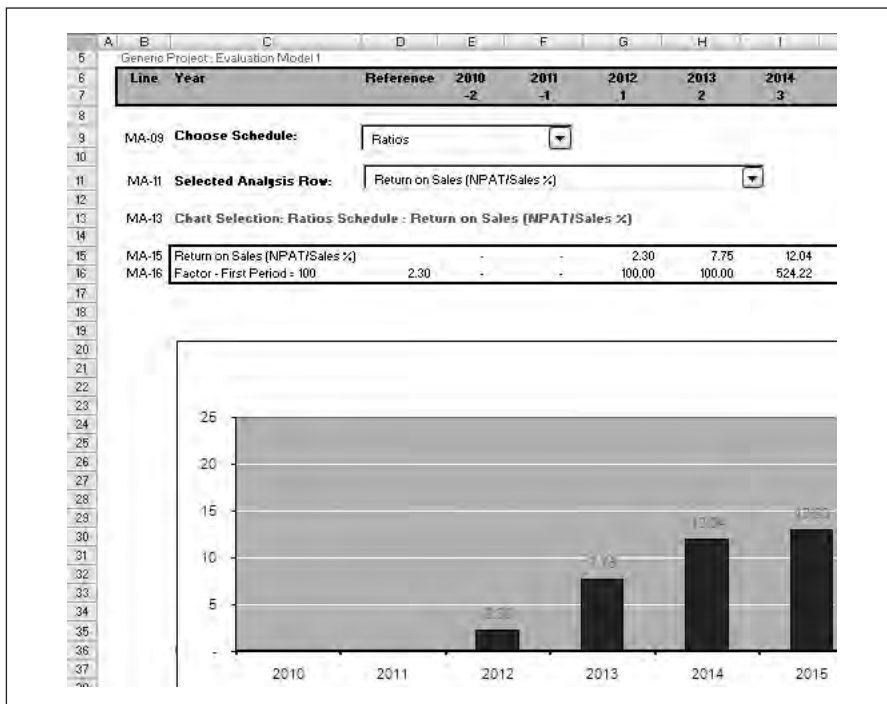
Management Analysis chart

Figure 4.30



Ratio analysis

Figure 4.31



Office 2007 – Office Button, Excel Options, Formulas, Calculation Options (Excel 2003 – Tools, Options, Calculations)

The Schedule sheet merely contains values correct to 13 decimal places, and the sheet always remains unprotected since the macro needs access to the sheet to update the values (see Figure 4.32).

Figure 4.32

Schedule values

Line	Year	Reference	2010	2011	2012	2013
Core Ratios						
R-10	Return on Sales (NPAT/Sales %)	P3/P9		2.30		7.75
R-11	Asset Turnover (Sales / Total Assets)	P3/B17		0.69		0.84
R-12	Asset Leverage (Total Assets/Equity)	B17/B30		2.29		2.27
R-13	Return on Equity (NPAT/Equity %)	P3/B30		3.64		14.72
Profitability						
R-17	Gross Profit / Sales (%)	(P9-(F10:12))/P9		57.14		66.12
R-18	Net Operating Profit / Sales (%)	P25/P9		9.80		16.59
R-19	Profit before Tax / Sales (%)	P28/P9		3.28		11.08
R-20	Profit after Tax / Sales (%)	P3/B17		1.59		6.48
R-21	Return on Capital Employed (ROCE)	P25/(B30*B25)		7.53		15.71
R-22	Return on Invested Capital (ROIC)	(P25-P30)/(B25*B20*B30)		6.72		12.36
R-23	Return on Assets (ROA)	F25/B17		6.80		13.88

SUMMARY

Project finance and its basic methodology allow risk to be shared amongst participants. The financial model sets out all the model sections together with the extra variables and contingencies to explore the potential cost overruns and other variables. Rather than just producing basic cover ratios, the model provides much more flexibility for examining up to 10 scenarios in the Control and Inputs schedules, and the variables cascade through the model. The Management Analysis and summaries provide the user with a means of extending the understanding of the risk inherent in the project. Macros and controls allow you to review multiple lines on all the schedules to demonstrate the potential downsides of the project.

Simulation

.....
Introduction

.....
Building blocks

.....
Procedure

.....
Real estate example

.....
Summary
.....

File: MRM2_05_01 and MRM2_05_02

INTRODUCTION

The project finance model in the previous chapter introduced a single-point model and then layered on scenarios and other risk techniques. Whilst you can add scenarios and multiply the answers by the assumed probability to derive a weighted outcome, there comes a point when it is inefficient to add more and more manual scenarios. The solution is to explicitly model uncertainty and build it into the model. The project model contained inputs for sales growth and demand as single points as a best guess. In the real world, you may be less certain about an exact figure, and the desired input could be a range or a distribution. The simulation on the Monte Carlo simulation model accepts distributions as inputs, runs the model through large numbers of theoretical scenarios and produces an output also as a distribution.

On the one hand, the single-point model produces answers such as the net present value (NPV) or the return to investors. On the other hand, the simulation model answers questions such as ‘How likely is the company to achieve cash flow covers on loan repayments of three times?’ or ‘What percentage chance is there that the unit will make a profit?’ This could be a great benefit since you do not have to build the physical system to understand the possible outcomes. The programming is often simpler than trying to model a number of discrete scenarios.

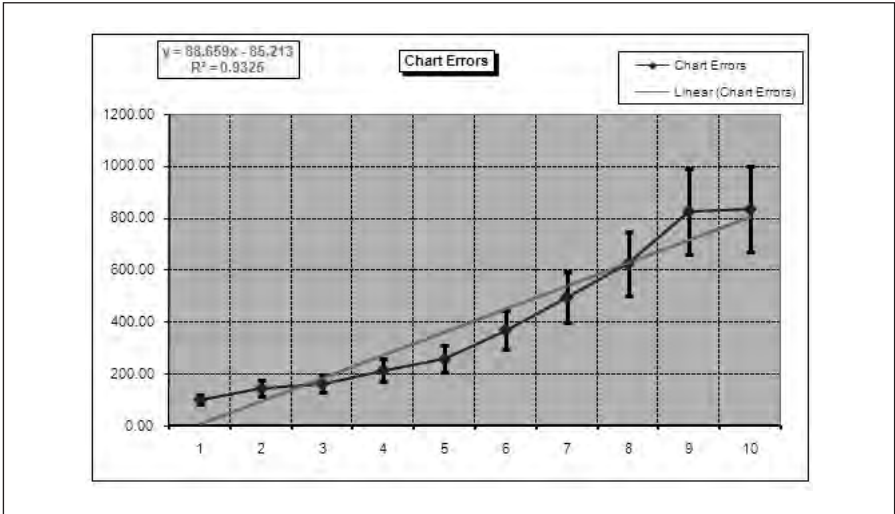
Uncertainty usually grows with time and estimating the interplay between variables using single-point models fails to take into account the potential forecasting errors. Potential errors normally increase with time as shown by the error bars. Figure 5.1 shows errors bars increasing with time. Similarly with time, factors may increase in importance or factors arise which have not been modelled. Therefore, a model which incorporates the uncertainty to be found in empirical situations may provide more management information about potential risks.

The structure of a simulation model is very similar to a single-point model and it is usual to build in simulation as an extra layer on the existing model. Most of the calculations and variables remain the same except that certain variables will now be represented by probability distributions instead of a single value.

Probability modelling is not a new concept. The mathematics behind Monte Carlo came out of the Manhattan Project to build the atomic bomb during the Second World War. The work is largely credited to Stanislaw Ulam, an Austrian-born mathematician, along with computer pioneer and scientist John von Neumann. Simulation models offered a way of arriving at approximate solutions to complex problems associated with the random neutron diffusion in nuclear weapons material. One report says that Ulam named the method ‘Monte Carlo’ after a relative fond of sneaking off to Monaco’s casinos. Nevertheless, the name does underline the fact that this is a probability and not a certainty model.

Figure 5.1

Chart errors



This chapter deals with simulation methods within Excel; however, there are a number of commercial add-ons to Excel for automating the process listed at www.financial-models.com, for example:

- @RISK at www.palisade.com
- Crystal Ball at www.crystalball.com
- Risk Solver add-in at www.solver.com.

BUILDING BLOCKS

There are several building blocks to simulation models consisting of random numbers and probability distributions. The golden rule is that all iterations generated by the model must be possible so that the model replicates possible events that could feasibly occur in the real world. The validity of the inputs is therefore essential. If you follow this rule, you will have a greater chance of producing a model that is both accurate and realistic. For example, a very common mistake is to produce a model that inadvertently calculates the mean of the answer, rather than developing a model that produces a large number of scenarios, from which the spreadsheet calculates the mean. For a simple illustration, consider the modelling of a variable (X) that has a 50 per cent chance of being Normal(100,33) and a 50 per cent chance of being Normal(70,5). A normal distribution can be described by its mean and standard deviation so that in the example above the mean is 100 and the standard deviation 33. This could be incorrectly modelled as follows:

$$X = \text{Normal}(100,3) * 0.5 + \text{Normal}(70,5) * 0.5$$

or correctly as a discrete distribution:

$$X = \text{Discrete}(\{\text{Normal}(100,3), \text{normal}(70,5)\}, \{0.5, 0.5\}).$$

The first formula is wrong because it generates values that could not occur and does not generate a lot of those that would occur. There is a 50 per cent chance of each discrete set of events with a different mean and standard deviation.

Random numbers

Excel is capable of generating random numbers between 0 and 1 using the RAND function. Alternatively, the RANDBETWEEN allows you to produce discrete numbers between a high and low figure. Note that the Analysis Toolpak should be installed as an add-in to use this function. Each time you press F9, the sheet updates with new values. With RAND, approximately 10 per cent of the numbers will be between 0 and 0.1 eventually, although smaller samples will give anomalies. More numbers will be generated in certain bins and you need larger samples to generate truer randomness. Two statistical theories underline the methodology in simulation.

Strong law of large numbers

This states that the larger the sample size the closer the distribution to the theoretical distribution. As you run more trials, then the randomness starts to disappear and the outliers become less important. The distribution starts to attain a much more concise shape.

Central limit theorem

This states that a mean of set of variables drawn independently from same distribution will be normally distributed. Based on the Strong law above, it means that if you take variables at random from a non-normal distribution, the selected values will be approximately normally distributed.

This can be expressed as formula where the mean of n variables (n should be large), with same distribution $f(x)$, will be normally distributed:

$$\bar{x} = \text{Normal}(\mu\sigma/\sqrt{n})$$

where m = mean and σ standard deviation of the $f(x)$ distribution from which the n samples are drawn. If you multiply both sides by n , then the

sum of n variables drawn independently from the same distribution is given by:

$$\Sigma = n\bar{x} = \text{Normal}(n\mu, \sqrt{n\sigma})$$

The file, MRM2_05_01.xls contains a sheet called Dice which reproduces throwing two dice up to 2000 times. The data are on the sheet called Dice_Data (see Figure 5.2). The combinations of scores range from 2 to 12, but numbers such as 7 are easier to attain since there are more combinations of dice that produce this result.

If you only create 50 trials, there are not enough trials to create the theoretical distribution under the two theorems above. Each time you press F9, you will obtain a different set of values. Figure 5.3 shows excess scores at the upper end of the scale. Further trials would improve the shape of the distribution since there should be a peak at seven as this is the most likely combination.

Figure 5.2

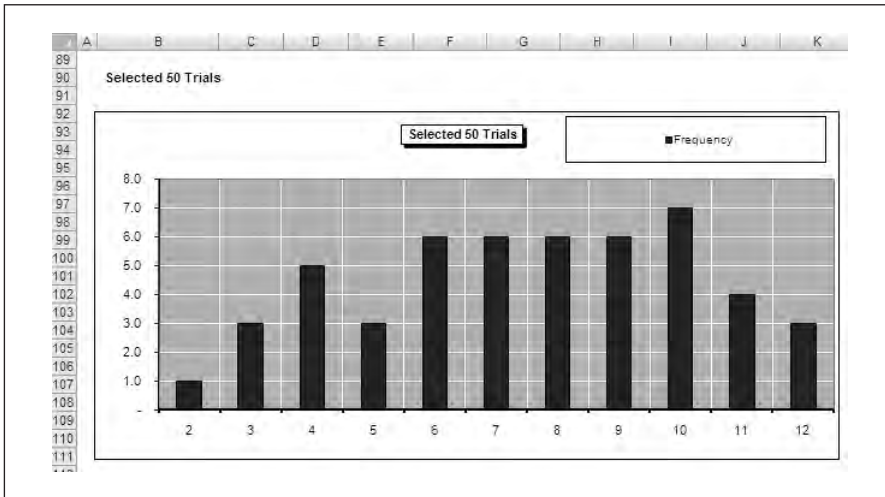
Dice data

	A	B	C	D	E	F	G
E							
6		No	First	Second	Total	Mean	Standard Deviation
7		1	3	3	6	6.0000	-
8		2	1	1	2	4.0000	2.8284
9		3	2	2	4	4.0000	2.0000
10		4	4	3	7	4.7500	2.2174
11		5	2	5	7	5.2000	2.1679
12		6	5	6	11	6.1667	3.0605
13		7	3	2	5	6.0000	2.8284
14		8	1	2	3	5.6250	2.8253
15		9	2	2	4	5.4444	2.6977
16		10	5	4	9	5.8000	2.7809
17		11	1	2	3	5.5455	2.7700
18		12	3	3	6	5.5833	2.6443
19		13	3	1	4	5.4615	2.5695
20		14	6	1	7	5.5714	2.5027
21		15	5	4	9	5.8000	2.5690

As you increase the number of trials the shape of the histogram changes until with 2000 trials the shape is closer to a normal bell curve. The histograms for 2000, 1000 and 50 trials are shown together represented as percentages of the total sample (see Figure 5.4). The larger sample clearly results in a more normal distribution and this is confirmed by the variance chart showing the difference of 50 and 1000 trials to 2000 trials (see Figure 5.5).

Fifty trials

Figure 5.3



Comparison of trials

Figure 5.4

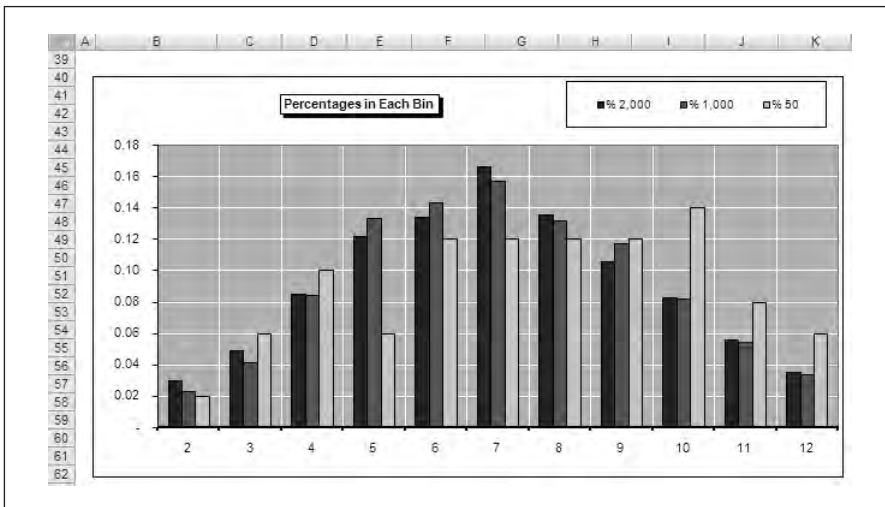
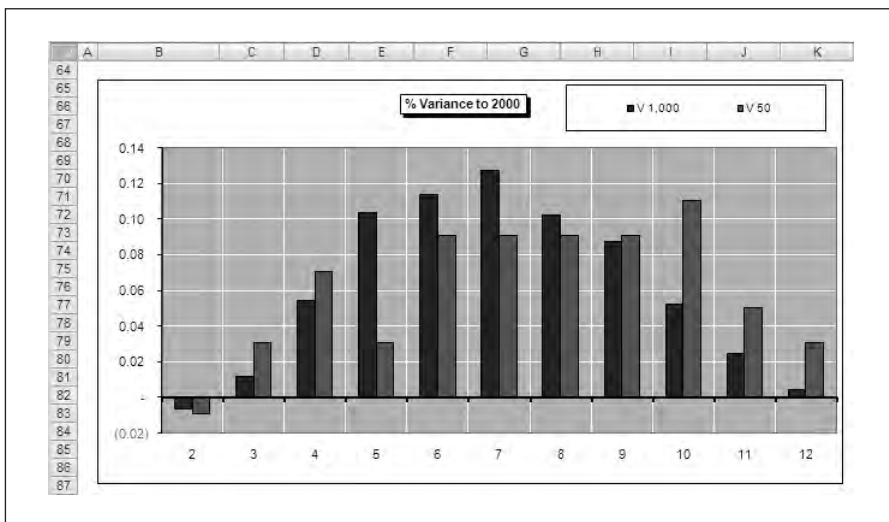


Figure 5.6 contains all the data for the histograms. The Dice_Data sheet produces the random numbers and scores which have to be counted and presented as frequency plots. There is also a requirement to show scores of less than 2000 to demonstrate how the distribution changes with more trials. Cell E7 contains an input for the row number. This is used in cell E10 to create an offset number for an average function. This means that you can look at any combination between 1 and 2000.

Figure 5.5

Variance to 2000 trials



```
E10 = AVERAGE(Dice_Data!E7:OFFSET(Dice_Data!E$7,
Dice!E$9-1,0))
```

Figure 5.6

Data

				% Variance to 2000					
				% 2,000	% 1,000	% 50	V 1,000	V 50	
Mean	7.0175	7.0530	7.5200				0.0405	0.5025	
Standard Deviation	2.4454	2.3909	2.6897				(0.0546)	0.2442	
Kurtosis	(0.6304)	(0.6264)	(0.9049)				0.0041	(0.2745)	
Skew	0.0430	0.0749	(0.1836)				0.0319	(0.2265)	
				Percentages in Each Bin			Variance % to 2000		
Combined Score	2,000	1,000	50	% 2,000	% 1,000	% 50	V 1,000	V 50	
2	59	23	1	0.0295	0.0230	0.0200	(0.0065)	(0.0095)	
3	96	41	3	0.0490	0.0410	0.0600	0.0115	0.0305	
4	170	84	5	0.0850	0.0840	0.1000	0.0545	0.0705	
5	243	133	3	0.1215	0.1330	0.0800	0.1035	0.0305	
6	268	143	6	0.1340	0.1430	0.1200	0.1135	0.0905	
7	333	157	6	0.1665	0.1570	0.1200	0.1275	0.0905	
8	271	132	6	0.1365	0.1320	0.1200	0.1025	0.0805	
9	211	117	6	0.1055	0.1170	0.1200	0.0875	0.0905	
10	185	82	7	0.0825	0.0820	0.1400	0.0525	0.1105	
11	112	54	4	0.0560	0.0540	0.0800	0.0245	0.0505	
12	70	34	3	0.0350	0.0340	0.0500	0.0045	0.0305	
Total	2000	1000	50	1.000	1.000	1.000	0.676	0.676	

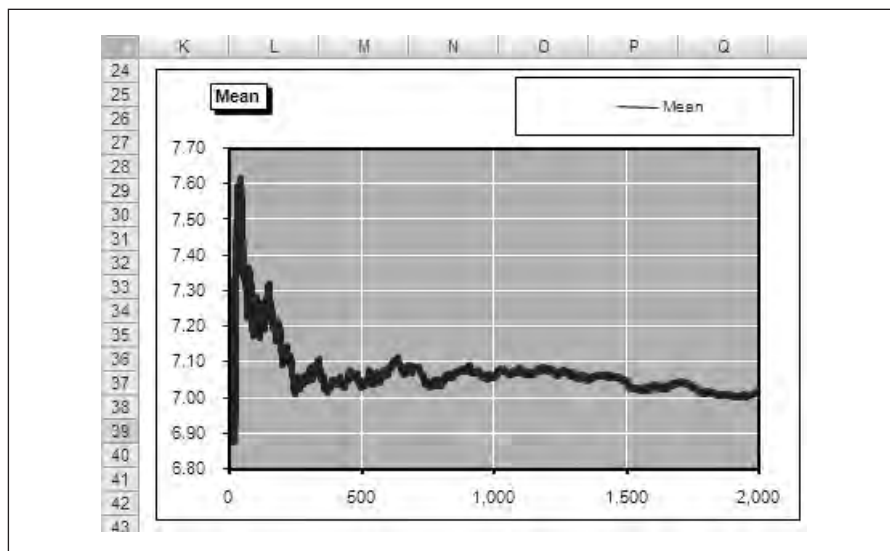
The same method is used to count the scores in the bins from 2 to 12 and create the data for the histograms.

```
E17 = FREQUENCY(Dice_Data!$E$7:OFFSET
(Dice_Data!$E$7,$E$9-1,0),$B$17:$B$27)
```

Figures 5.7 and 5.8 show how the mean and standard deviation develop during the 2000 trials. The initial variation disappears and the means and standard deviations move closer to their theoretical results.

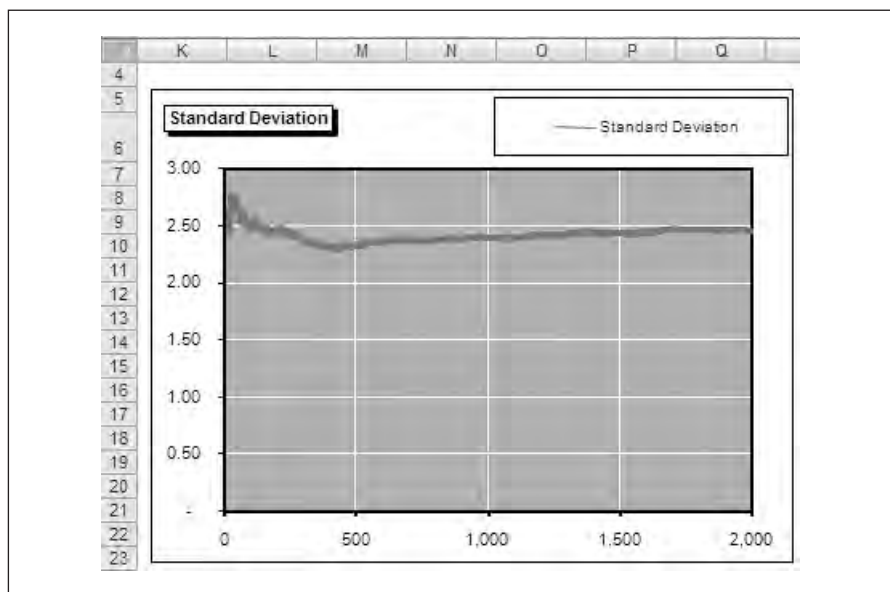
Mean

Figure 5.7



Standard deviation

Figure 5.8



PROCEDURE

The procedure is to decide on the structure of the model and the variables to be modelled. The example here is called Rental in the file

MRM2_05_02.xls. This file shows a simple, single-point model looking at the margin from renting housing units (see Figure 5.9). The maximum number of units for rent is 25 and the minimum 22. The average selected is 22 at a rental of 2000 per month. The expenses are 40000 and the resulting margin 4000.

The Sensitivity table shows the risk from renting fewer properties or an increase in costs (see Figure 5.10). If occupancy is lower at 20 units, the margin becomes negative. The problem is to understand the level of risk involved based on the two key factors of occupancy and expenses.

The stages in layering a simulation on to the model are:

- Decide on the probability distributions, their attributes and possible inter-relationships through past data or other research.
- Use random numbers to generate large numbers of possible scenarios.

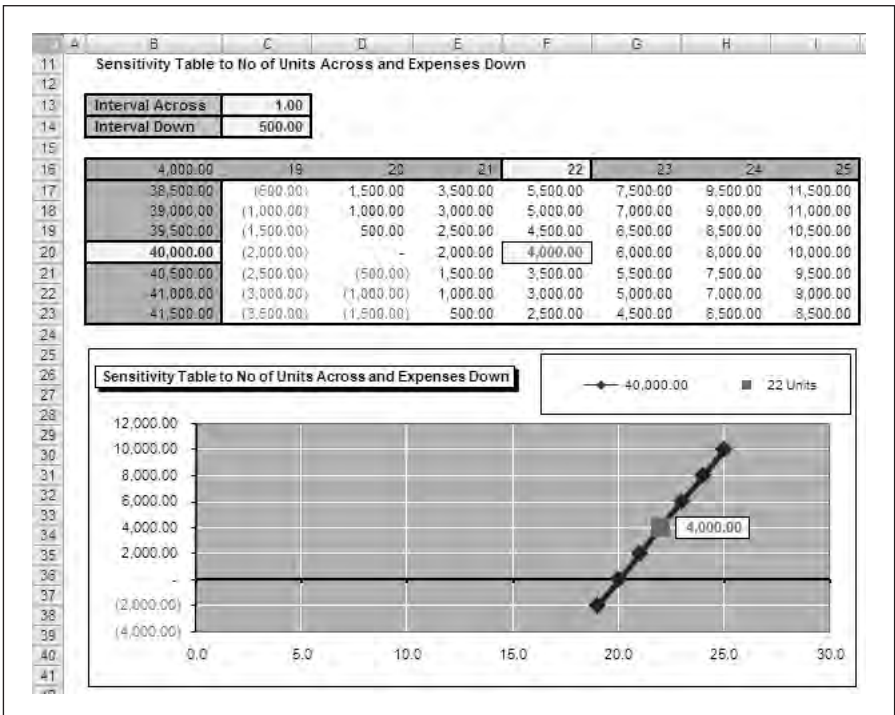
Figure 5.9

Inputs

	Start	Low	High	Result
No of Units	22 Units	20 Units	25 Units	
Rental per month	2,000.00			
Expenses	40,000.00	1,000.00		
Net Margin	4,000.00			

Figure 5.10

Sensitivity



- Draw a scatter chart of the data output.
- Count results in bins (ranges).
- Calculate the descriptive statistics of the distribution.
- Draw a histogram of the results.

In this case, there appears to be no historic pattern of occupancy and therefore a uniform distribution is used between the high and low figures. This can be generated in Excel using a `RANDBETWEEN` function. The expenses appear to have a mean of 40,000 and to vary by 1000 a month. This appears, on past experience, to be a normal distribution which can be modelled using the function `RAND`. The workings for the data are at the bottom of the sheet in Figure 5.10. Since these functions randomize the answers, the results will change every time the workbook is recalculated (F9). Therefore the currency results will vary from the graphics below.

Office 2007 – Formulas, Functions Library, Maths & Trig (Excel 2003 – Insert, Function)

The revenue is a random number between 20 and 25 multiplied by the rental per month.

```
=RANDBETWEEN($D$6,$E$6)
```

Column D generates a random number between 0 and 1 using `RAND`, and the costs are derived using the `NORMINV` function (see Figure 5.11). This takes the arguments of probability, mean and standard deviation. The last two are inputs and the probability is the random number. The margin is therefore the revenue minus the costs. This is repeated 100 times down the page to gain a sample of 100 scenarios.

NORMINV function

Figure 5.11

	A	B	C	D	E	F	G
111	Data for Simulation						
112							
113		Simulation	Random	Revenue	Random	Costs	Margin
114							
115		1	22	44,000.00	0.94	(41,526.03)	2,473.97
116		2	24	48,000.00	0.57	(40,178.56)	7,821.44
117		3	22	44,000.00	0.80	(40,854.72)	3,145.28
118		4	21	42,000.00	0.85	(41,043.26)	956.74
119		5	22	44,000.00	0.06	(38,480.21)	5,519.79
120		6	22	44,000.00	0.02	(37,858.58)	6,141.41
121		7	23	46,000.00	0.17	(39,055.25)	6,944.75
122		8	25	50,000.00	0.82	(49,316.78)	9,083.24
123		9	21	42,000.00	0.42	(39,809.26)	2,190.74
124		10	22	44,000.00	0.97	(41,868.80)	2,131.20

The next stage is to draw a scatter chart of the results using an XY scatter chart with a linear trend line through the data. This shows the relationship between increased occupancy and increased margin (see Figure 5.12). At each level of occupancy there is a spread of values reflecting the standard deviation of the costs.

Figure 5.12

Scatter chart

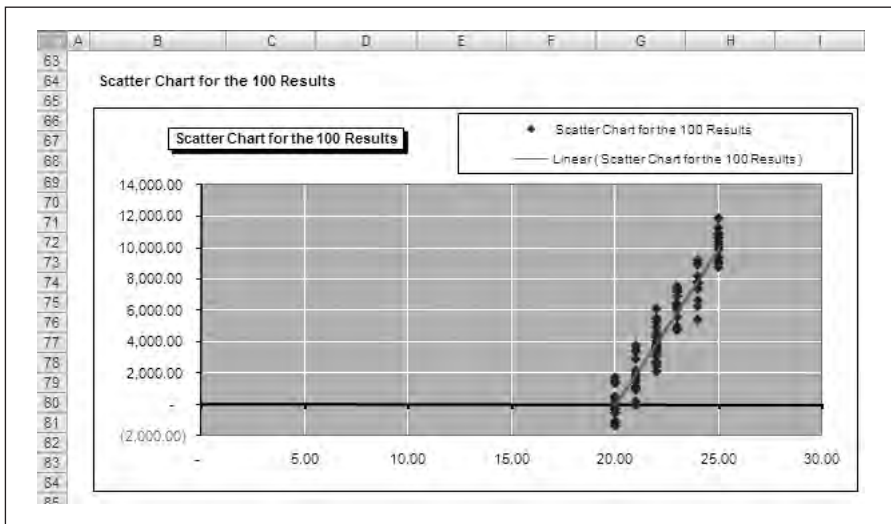
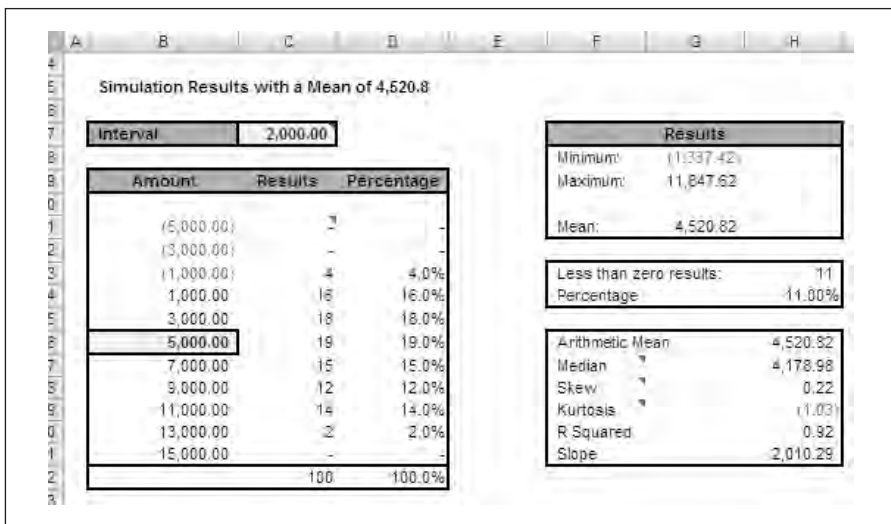


Figure 5.13

Frequency



Office 2007 – Insert, Charts, Scatter (Excel 2003 – Insert Chart, Chart Wizard)

The scatter chart only provides an idea of the results. The FREQUENCY function allows counting into bins. This chart shows a peak of margin between 5000 and 7000 which is higher than the single point answer (see Figure 5.13). This is because the input was 22 and the average of 20 to 25 is 22.50.

Other statistics are also available in Excel using functions shown in Table 5.1.

Function	Result
MIN	Minimum number in an array
MAX	Maximum number in an array
COUNTIF	Count if a condition is true – in this case less than zero to count the trials with no margin
AVERAGE	Arithmetic mean
MEDIAN	Middle result in an array
SKEW	Skew characterizes the degree of asymmetry of a distribution around its mean. Positive skew indicates a distribution with an asymmetric tail extending towards more positive values. Negative skew indicates a distribution with an asymmetric tail extending towards more negative values
KURT	Kurtosis of the distribution. Positive kurtosis indicates a relatively peaked distribution. Negative kurtosis indicates a relatively flat distribution.
SLOPE	Slope of the data using a linear trend line ($y = mx + b$)
RSQ	r^2 is the measure of fit between the linear regression line and the data. The r^2 value can be interpreted as the proportion of the variance in y attributable to the variance in x .

Table 5.1

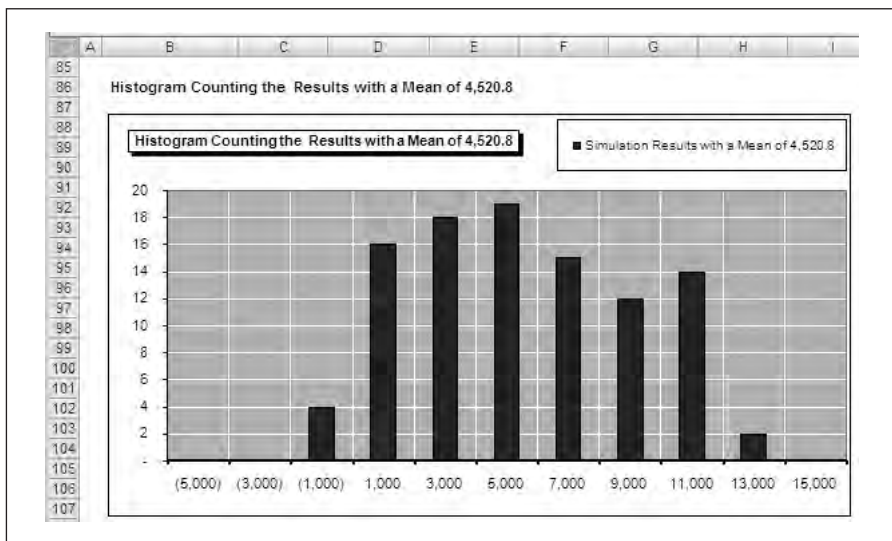
Office 2007 – Formulas, Functions Library, Maths & Trig (Excel 2003 – Insert, Function)

The counted results can then be plotted with the bins as the x -axis and the number of results as the y -axis.

The histogram shows the results of the FREQUENCY function (see Figure 5.14). Based on the inputs for occupancy and costs, the margin may not be as firm as 4000 as there are a number of results at around zero. The histogram demonstrates that the overall margin should be higher; however, percentiles would also show the range of values.

Figure 5.14

Histogram of results



The percentile takes the data array and the K value as its arguments. Figures 5.15 and 5.16 show that 50 per cent of the values fall below 4520.8.

```
=PERCENTILE($G$115:$G$214, K47)
```

The simulation model provides far more information than the single-point model about how the variables behave and therefore the inherent risk. Increasing the standard deviation of the costs will increase the range of possible outcomes. Similarly, increasing the lowest occupancy to 22 will reduce the range of revenue and therefore the spread of results.

REAL ESTATE EXAMPLE

This example revisits the real estate model in Chapter 3 to examine the factors voids and rental per month. The method uses a mean and a standard deviation for these two factors on the Simulation sheet which drive the inputs on the Model sheet. The random number generation is in Visual Basic code since models using tables become slower with more and more calculations. Here, the number of iterations is 1000 and it is sometimes easier to generate the data in code and then transfer it to Excel. The stages are:

- The model generates the numbers for a particular scenario.
- It transfers them to the Model sheet.
- It recalculates and then stores the numbers in an array.

Percentiles

Figure 5.15

	J	K	L	M
42	Percentiles			
43				
44	Interval	5.00%		
45				
46	Percent	Percentile	Increase	
47	-	(1,234.88)		
48	0.05	(199.23)	1,035.62	
49	0.10	343.88	543.09	
50	0.15	1,062.88	719.02	
51	0.20	1,534.67	471.79	
52	0.25	1,831.30	286.63	
53	0.30	2,372.21	540.91	
54	0.35	3,081.95	709.74	
55	0.40	3,933.84	851.89	
56	0.45	4,412.72	478.88	
57	0.50	4,951.05	538.32	
58	0.55	5,307.26	356.24	
59	0.60	5,961.71	654.43	
60	0.65	6,461.46	499.75	
61	0.70	7,031.31	569.85	
62	0.75	7,816.59	785.28	
63	0.80	8,344.74	528.15	
64	0.85	8,702.82	356.08	
65	0.90	9,583.38	880.57	
66	0.95	10,418.43	835.05	
67	1.00	11,814.04	1,395.61	

Percentiles chart

Figure 5.16

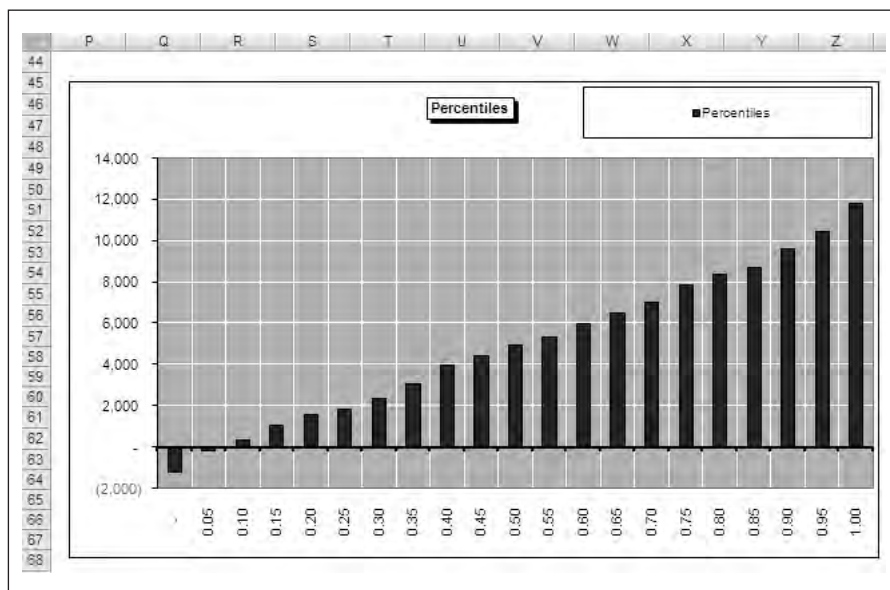


Figure 5.17

Real estate inputs

	A	B	C
5			
6	Purchase Price		100,000.00
7	Stamp Duty / Tax		1.00
8	Other Costs		0.75
9	Reburbishment Costs		2.00
10	Letting Fees		1.18
11	Building Insurance		0.30
12	Gas Safety		0.05
13	Inventory		0.08
14	Maintenance		0.50
15	Assumed Rental per Month		666.67
16	Standard Deviation		50.00
17	Capital Growth		4.00
18	Voids %		10.00
19	Standard Deviation		4.00
20	Mortgage Period (yrs)		25.00
21	Interest Rate %		5.51
22	Mortgage Percentage %		50.00

- It loops 1000 times and then pastes the results in a two-dimensional range J5:Q1005 on the Simulation sheet.
- It produces a scatter chart, frequency table, statistics, percentiles and a histogram.

The inputs in Figure 5.17 use the Base Case scenario on the Model sheet with the standard deviation for the monthly rental at 50 and 10 per cent for the percentage voids. The income after capital growth on the Model sheet is 2600.49 and the net yield percentage 4.84 for this initial case. The simulation layer therefore seeks to show the possible spread in the answers when the ranges of inputs are taken into account.

The code below declares the values and sets highs and lows for each of the factors. It starts a For Next loop, derives the values based on random numbers and the normal probability distribution, and transfers the values for calculation to the Model sheet. When it gets to the end of the loops, the code has built an array or grid of variables that is 1000 cells down by 7 across. Seven items of data are saved per scenario and these are then pasted on to the sheet at the end.

```

Sub Simulation()

Dim Result(1000, 7) 'Set up an array variable 1000 down by 7 across
Dim RandomFactorA, RandomFactorB, Count, ExistingValue1, ExistingValue2
Dim FactorA, FactorAHigh, FactorALow, FactorAStd,
FactorB, FactorBHigh, FactorBLow, FactorBStd
    
```

```

ExistingValue1 = Range("model!d15") 'Remember existing values
ExistingValue2 = Range("model!d17")
Range("Simulation_Results") = ""      'Zero existing results
Randomize

Application.Calculation = xlSemiautomatic 'Turn off calculation of
tables

Range("model!d15") = Range("simulation!c15")
Range("model!d18") = Range("simulation!c18")

Range("simulation!B75") =
(Int((Range("model!i10") * 10))) / 10 ' set centre of frequency table

FactorA = Range("simulation!c15")      'Rental
FactorB = Range("simulation!c18")      'Voids

FactorAHigh = FactorA + Range("simulation!c16")
'Range and StDev for A
FactorALow = FactorA - Range("simulation!c16")
FactorAStd = (FactorAHigh - FactorALow) / 4

FactorBHigh = FactorB + Range("simulation!c19")
'Range and StDev for B
FactorBLow = FactorB - Range("simulation!c19")
FactorBStd = (FactorBHigh - FactorBLow) / 4

For Count = 1 To 1000 'START OF LOOP
RandomFactorA = Rnd 'Find factor for A for this trial
Range("model!d15") =
Application.NormInv(RandomFactorA, FactorA,
FactorAStd)
randomfactorb = Rnd 'Find factor for B for this trial
Range("model!d17") =
Application.NormInv(randomfactorb, FactorB,
FactorBStd)
Result(Count, 0) = RandomFactorA
Random factor A
Result(Count, 1) = Range("model!d15")
'Rental per month
Result(Count, 2) = randomfactorb
'Random factor B
Result(Count, 3) = Range("model!d17")
'Voids
Result(Count, 4) = Range("model!I29")

```

```
'Gross margin
Result(Count, 5) = Range("model!c36") 'Net margin with capital growth
Result(Count, 6) = Range("model!d34")
'Gross yield
Result(Count, 7) = Range("model!d36") 'Net yield
Range("Simulation!f7") Count
Next Count END OF LOOP
Application.Calculation = xlAutomatic
Range("Simulation_Results") = Result 'Paste results
Range("model!d15") = ExistingValue1 'Put back existing inputs
Range("model!d17") = ExistingValue2
End Sub
```

The information saved is as shown in Figure 5.18.

Figure 5.18

Simulation results

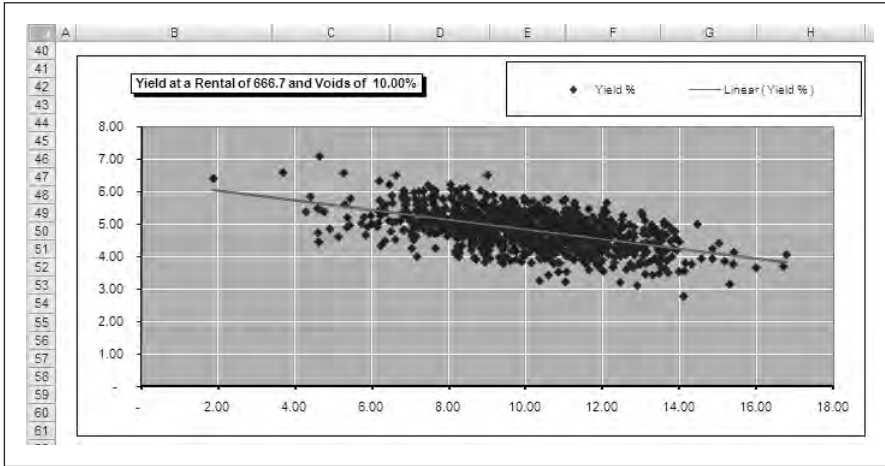
	Factor A	Rental	Factor B	Int Rate	Net Rental Income	Total Income	Yield %	Yield %
1								
2								
3								
4								
5								
6	0.4229	661.81	0.2095	8.38	(1,323.64)	2,676.36	(2.46)	4.98
7	0.0670	629.21	0.2802	8.84	(1,716.13)	2,283.87	(3.19)	4.25
8	0.9707	713.96	0.3465	12.04	(1,063.86)	2,936.14	(1.88)	5.46
9	0.5643	670.71	0.8131	11.78	(1,499.00)	2,501.00	(2.79)	4.65
10	0.5480	669.66	0.8367	11.96	(1,524.67)	2,475.33	(2.84)	4.61
11	0.6779	678.21	0.4696	9.85	(1,262.42)	2,737.58	(2.35)	5.09
12	0.8366	691.18	0.4467	9.73	(1,112.88)	2,887.42	(2.07)	5.37
13	0.6704	677.69	0.2746	8.80	(1,183.04)	2,816.96	(2.20)	5.24
14	0.3242	655.27	0.5262	10.13	(1,533.01)	2,466.99	(2.85)	4.59
15	0.0552	626.77	0.5001	10.00	(1,830.54)	2,168.46	(3.41)	4.04
16	0.7571	684.10	0.1485	7.91	(1,040.06)	2,959.94	(1.83)	5.51
17	0.6750	678.02	0.4310	9.65	(1,248.67)	2,751.33	(2.32)	5.12
18	0.8438	691.92	0.5011	10.01	(1,127.23)	2,872.77	(2.10)	5.34
19	0.0296	619.51	0.3801	9.39	(1,883.42)	2,136.58	(3.47)	3.98
20	0.2075	646.29	0.0264	8.13	(1,319.32)	2,680.68	(2.45)	4.99

The model then uses some of the code from the previous example to draw scatter charts and histograms (see Figure 5.19). As the percentage of voids rise, the overall yield declines. With 1000 trials there are still a number of data points outside the main concentration and running the model for more trials would increase the accuracy based on the Central Limit theorem.

The table uses FREQUENCY and other statistical functions to summarize and describe the distribution of results (see Figures 5.20 and 5.21). The majority of returns cluster between 4.3 and 5.8 per cent as shown in the left-hand table in Figure 5.20. The right-hand table in Figure 5.20 summarizes the input data for the monthly rental and the voids percentage, and then lists the mean and other statistics for the output distribution.

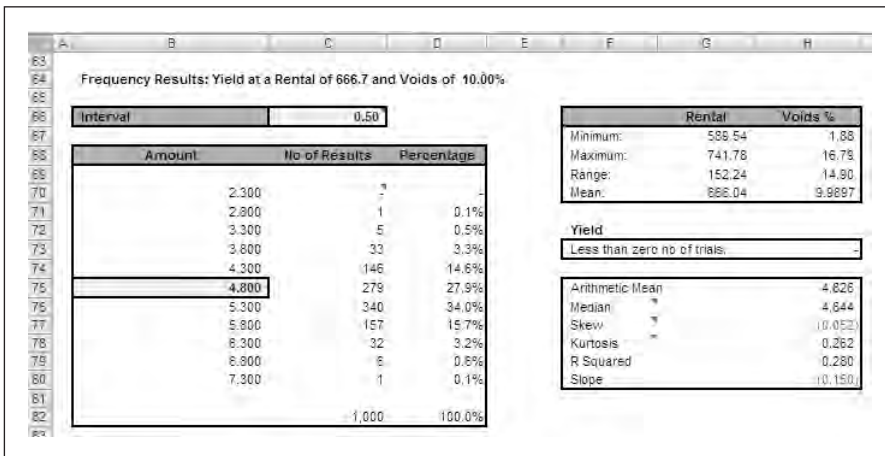
Scatter chart

Figure 5.19



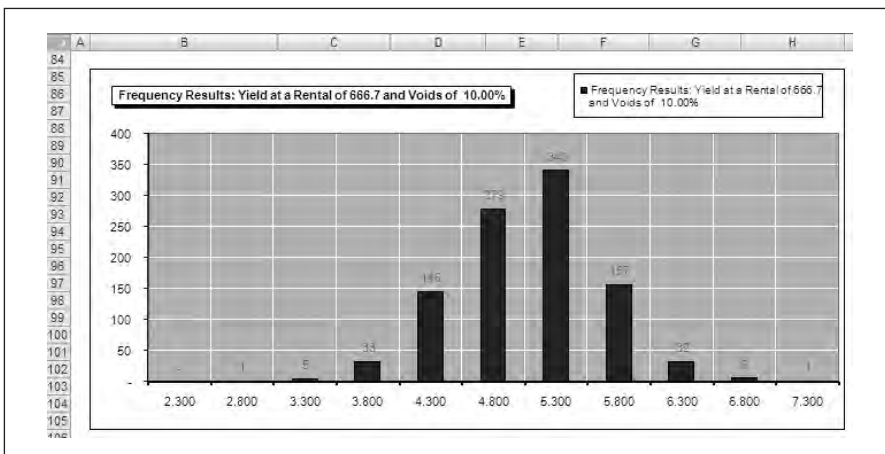
Frequency results

Figure 5.20



Histogram

Figure 5.21



Both the quartiles and percentiles are calculated so that you can see how many results provided low returns (see Figures 5.22 and 5.23). In this case, 25 per cent of the trials resulted in returns below 4.4 per cent and an income of 2381.52. Again, the simulation model provides more management information about the possible spread of answers. Several sets of scenarios could be run with differing distribution inputs to see the effect of flexing each of the variables.

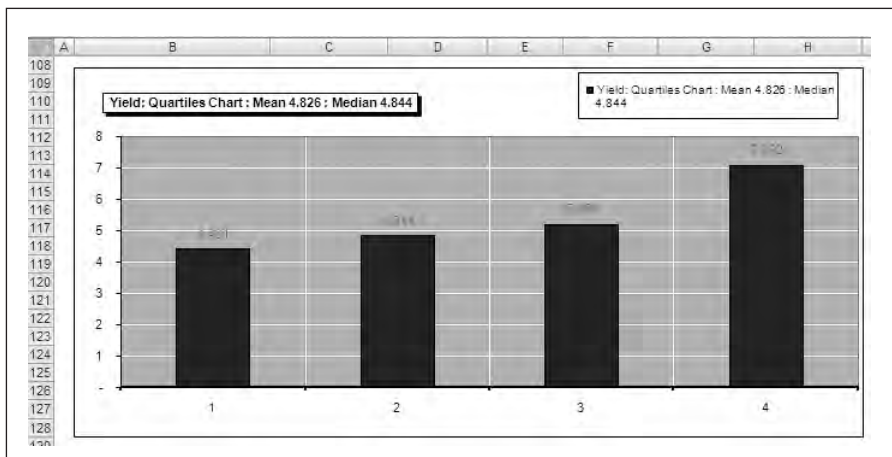
Figure 5.22

Frequency tables

Quartiles	Yield %	Count	Total Income	Count
0	2.765	1	1,486.39	1
1	4.431	249	2,381.52	249
2	4.844	250	2,603.47	250
3	5.209	250	2,800.06	250
4	7.093	250	3,812.56	250
Total Results		1,000		1,000
Range		4.328	2,326.17	
Mean		4.83		2,594.22
Median		4.84		2,603.47
Skew		(0.052)		
Kurtosis		0.262		0.262
Standard Deviation		0.29		308.80
Coefficient of Variation		0.060		0.119

Figure 5.23

Quartiles chart



SUMMARY

Simulation methods add another layer to financial models, allowing a range of inputs based on probability distributions. Running the model through a series of randomly generated possible scenarios provides an automated ‘what

if?’ analysis. It should be stressed that the outputs are entirely dependent on the input distributions and therefore the model is a probability and not a certainty model. In the real world, there are always events that have not been foreseen by the modeller, which can affect the simulation outputs. Nevertheless, this form of modelling adds another dimension to the information produced by financial models.

Financial analysis

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Summary

File: MRM2_06

INTRODUCTION

Financial analysis seeks to outline the main areas of risk highlighted by an organization's annual report. Recent company failures and the consequent tightening of corporate governance as defined by the Sarbanes–Oxley Act in the US mean that it is important to highlight possible areas of weakness and read the reported data correctly. Since calculating ratios or deriving cash flows with a pocket calculator is time consuming, a risk model can be an important tool for understanding the accounts.

Performance measurement in the form of 'what gets measured gets managed' can be summarized as:

- economy – how well the company buys in the factors of production (labour, materials, knowledge);
- efficiency – how well the company turns the 'raw material' into goods and services for sale;
- effectiveness – how well the company rewards the key stakeholders, including shareholders;
- environment – the company's responsibilities in the wider world;
- ethics – ethical goals such as corporate governance.

Analysis framework

Figure 6.1

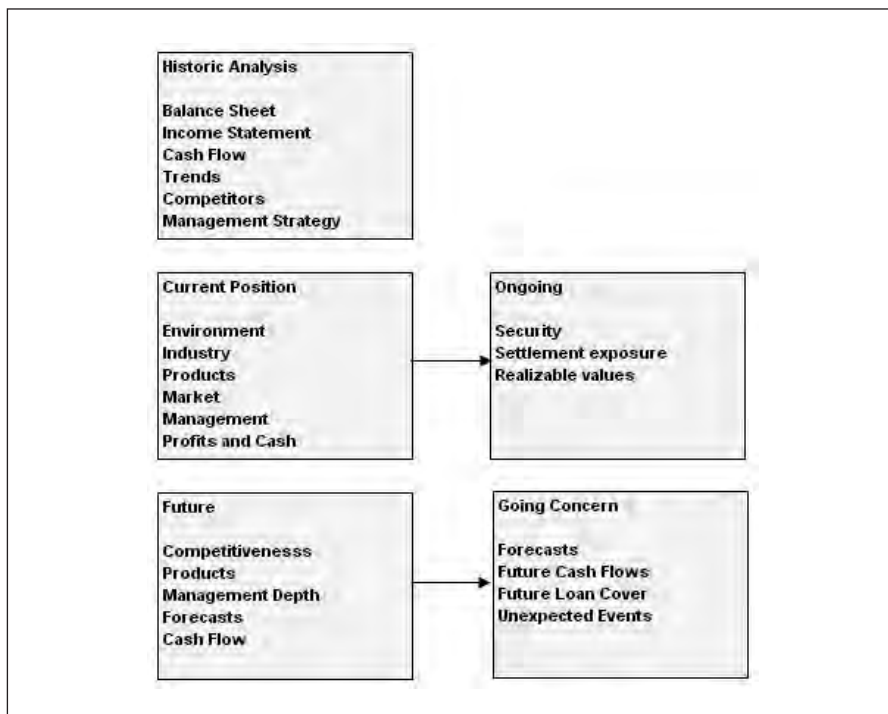


Figure 6.1 categorizes the banking analysis. First, the historic position outlines the quality of past decision making and the ability of the management to make and implement strategic decisions leading to an increase in the value of the company. Measures of success will vary by industry: for example, the value added by employees can be important in a service company whereas sales per square metre can indicate increased efficiency in a supermarket chain. For most companies, these are significant indicators of past success.

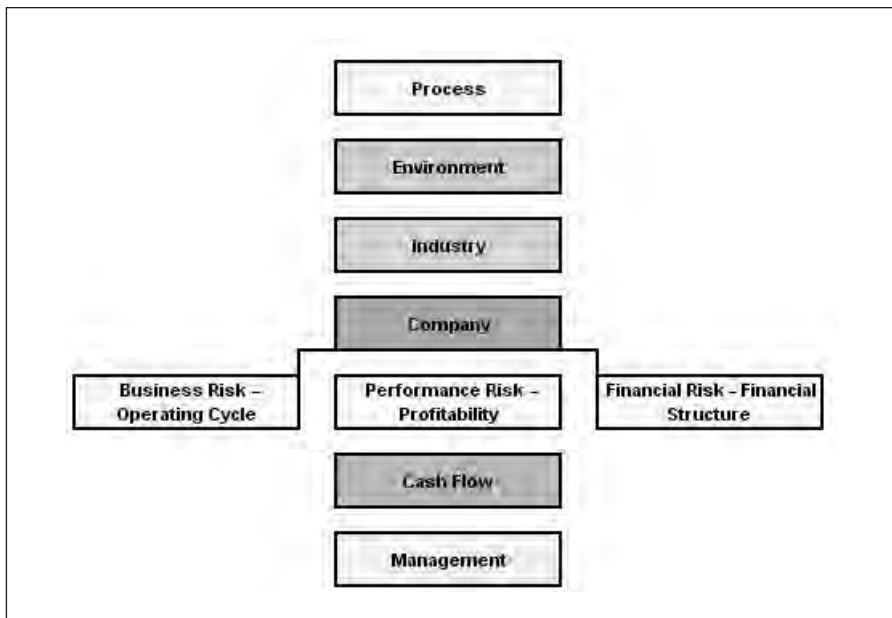
Past performance is not a guarantee of future success and, in assessing loans or financial commitment, analysis needs to switch to the current and forecast position. There are factors within and extra to the organization’s control in driving it forward and therefore analysis needs to include some assessment of future performance.

This chapter reviews the analysis from a risk perspective and Figure 6.2 demonstrates the main sources of risk:

- process – limitations of financial statements;
- environment – factors beyond the organization’s control;
- industry – competitiveness of the industry and reliability in producing returns;
- financial factors – operating cycle, profitability and financial structure;
- cash flow produced by the interlocking financial factors;
- management competence and depth.

Figure 6.2

Risk framework



PROCESS

The starting point is the annual report, which in the UK is drawn up based on the following four fundamental principles:

- 1 prudence means that doubtful revenues are not included while potential liabilities and losses are provided for;
- 2 consistency requires similar treatment from one accounting period to the next;
- 3 going concern assumes that the business will continue to operate;
- 4 matching or accruals means that costs should be matched as far as possible to applicable revenue in the same accounting period.

The above principles are augmented by financial reporting standards and conventions which seek to produce similarity in the way that organizations report their results. Internationally, the IAS standards provide a system of financial accounting standards and policies which result in Generally Accepted Accounting Principles (GAAP). Despite the rules on reporting, there are limitations to the financial information so that reports from different international companies are not always strictly comparable. For example, there are a number of methods for enhancing earnings which usually involve shifting cost from the income statement to the balance sheet. This could be achieved by adopting a longer depreciation period for fixed assets, capitalization of interest or research and development expenses. The intention here is not to provide a listing of the limitation of accounts but merely to point out that there is a risk in taking the figures as absolute values.

Other distortions could be created by the choice of year end or changes in the composition of group operations. Highly acquisitive companies are difficult to analyse since the figures are not always comparable across year ends. Similarly, changing year ends reduces the comparability of the figures to the point where trend analysis becomes more difficult.

ENVIRONMENT

The STEEPV model was outlined in Chapter 4 and is applicable here. Any analysis should begin with an assessment of the non-financial factors. These are factors beyond the organization's influence and any analysis should include an understanding of the forces operating on the environment, such as the following:

- Economic – economic cycles, interest and exchange rates, inflation both domestic and foreign. In the global economy, economic risks are always present whether an organization is an exporter or domestic service supplier.

- Demographics and demand in different age groups – Western Europe is an ageing population and this affects the demand for a wide range of products from care homes to nappies.
- Social – trends that have a medium- and long-term effect on demand.
- Technology – each industry is affected differently: some may benefit while others may not be able to change rapidly enough to remain competitive. For example, Psion pioneered the personal digital assistant (PDA) market but withdrew from the market owing to increased competition and falling prices.
- Government changes can change competitiveness. For example, the government has reduced the attractiveness of UK finance leases since 1997 by curtailing the tax depreciation benefits relative to operating leases and fixed-term rentals. Changes in the way that government acquires goods and services can also change the landscape such as with the private financing initiatives for the acquisitions of schools and hospitals.
- Ecology – this factor has assumed more importance with the rise of lobby groups and non-governmental organizations such as Greenpeace. Companies are judged on their ‘green’ credentials and those such as Shell and Norsk Hydro have been forced to change their policies.

If an environment appears to be stable, then predictions can be made on the basis of the past, but there can be unexpected changes (see Figure 6.3). Where there appears to be dynamic change, then projections of the future are likely to be useful in determining the key success factors and their sensitivity. Where change is both dynamic and complex, then the management ability assumes importance because of the requirement for a market-driven response to change.

Figure 6.3

Response to the environment

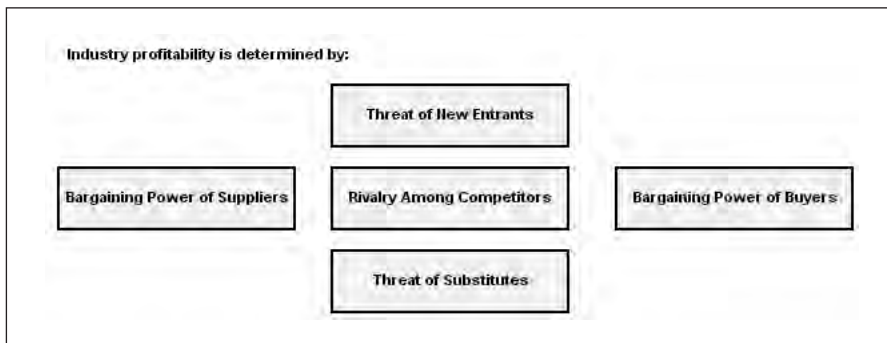
		Response to the environment	
		Simple	Complex
Stable		Gauge opinions and make predictions based on the past	Simulation and sensitivity model building
Dynamic		Focus on future projections. Examine management depth and competence	Simulation and sensitivity models coupled with assessment of quality and depth of management

INDUSTRY

The Michael Porter ‘five forces’ model (see Figure 6.4) provides a framework for understanding a company’s competitive position within an industry. As part of the qualitative analysis, an assessment is made of each of these factors and the impact on competition. Since the management and financial strategy should be coordinated, it follows that the industry characteristics influence the type of strategy adopted. The purpose is to try and achieve a ‘sustainable competitive advantage’ over the short and medium term. In analysis terms, this should mean a non-volatile cash flow and the ability to meet debts comfortably as they arise.

Porter five forces

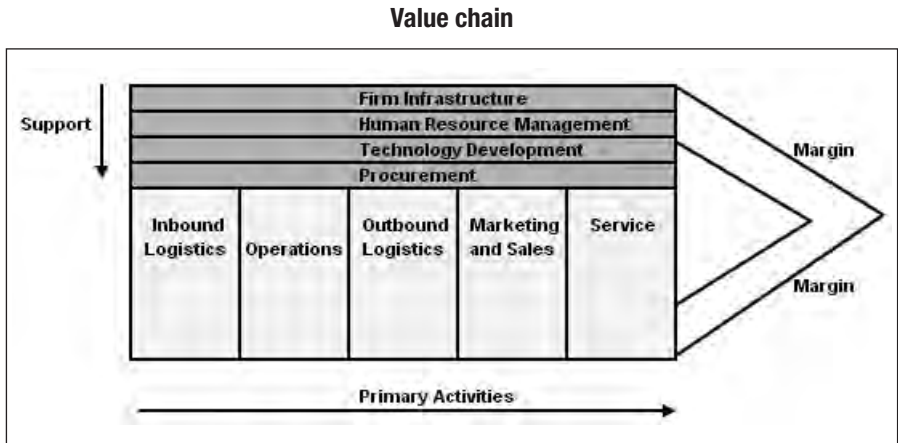
Figure 6.4



In the European airline industry, the threat of potential entrants is kept to a minimum by the high capital requirements and the difficulty of accessing new landing slots. National full-cost airlines typically have control over the hub and spoke networks used for intercontinental travel and appear to use their economies of scale to keep out competitors. There are few substitutes to using aircraft travel over longer distances, but other forms of travel such as car and rail, most notably the Channel Tunnel and high-speed rail networks, can offer equal benefits. The power of suppliers is great especially in the market for large jets. Lower down, there is a duopoly between Boeing and Airbus Industrie which limits airlines’ ability to choose. The power of buyers has been increased through deregulation and the rise of low-cost carriers based on the South Western Airlines model in the US. The ‘no frills’ package has been developed in Europe by Ryanair and easyJet to such an extent that the current market capitalization of Ryanair is greater than British Airways. AirAsia has also seen rapid growth in Asia. Therefore, the market has become more competitive and the airlines in Europe have a lesser grip, leading to reduced profits and prospects.

An alternative method would be to analyse the sources of value, and one model uses value chains to assess how a business unit adds value (see Figure 6.5). The key activities are inbound logistics, operations, outbound logistics, marketing and sales, and after service. These areas are supported by the infrastructure, human resources management, technology development and procurement. Business units can be compared to a peer group to assess the degree of success in these areas. The qualitative analysis leads to the modelling and an assessment of risk in the financial reports, and this initial review should provide questions for further considerations when the accounts are standardized as schedules.

Figure 6.5



FINANCIAL STATEMENTS

After consideration of the macro and industrial context, the model provides a standard method for reviewing companies and identifying trends. The basic question is whether risk is increasing or decreasing in the company. Trade credit tends to be fairly short term while bank loans usually entail a commitment over several years. Bear in mind also the time it takes after the year end to publish accounts. The model spreads the accounts into standard schedules and produces ratios and cash flows to assist with isolating weaknesses and identifying trends:

- ratios vary widely between different sectors such as retailers, manufacturers and service companies;
- trends need to be considered against the environment and industry sector;
- the absolute numbers are not relevant;
- ratios are backward looking and it usually takes companies some months to report and file accounts;

- analysis against a peer group or sector can highlight areas where the company is more or less efficient.

Most institutions have their own rules about how to treat intangibles or assets under constructions, and the spread format introduces a clear and concise method of combining the reported statements together with their notes. The three main areas of risk are:

- 1 operating efficiency – the operating cycle;
- 2 performance – profitability;
- 3 financial – financial structure and leverage.

In reviewing the above three risk sources, the model needs to address

- sales growth and its impact on working capital and cash;
- working capital and the availability of resources;
- cash flow performance, in particular the trading cash flow;
- profitability and the distribution of cost;
- return on capital for shareholders as their return for the risk of investing in the company;
- requirement for capital expenditure to fuel further growth in forecast periods;
- gearing and the proportion of the company funded by outside debt;
- debt repayment ability.

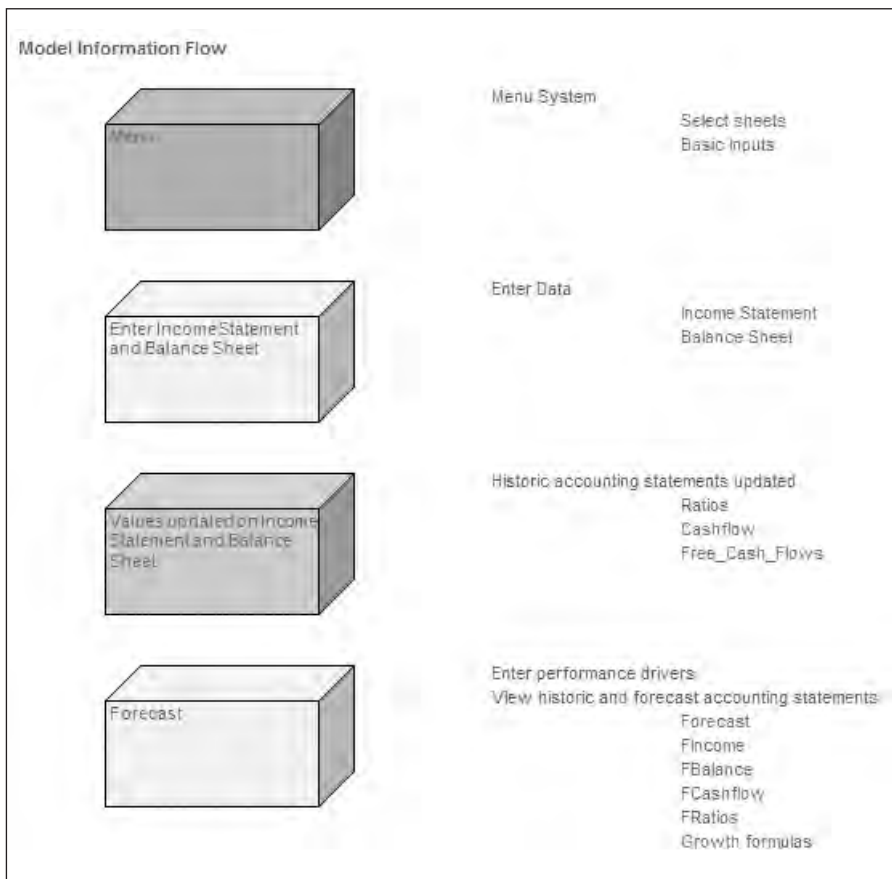
The model conforms to the structure shown in Figure 6.6 and is based on the standard Systematic application template. It is important that each schedule layout is consistent. The income statement and balance sheet are input schedules and these provide the information for the cash flow and ratio schedules. The forecast sheet uses key performance drivers to redraw the forecast schedules and these act as a basis for the next chapter. Here the emphasis switches to loan cover, sustainable growth and bankruptcy prediction models.

PROFIT AND LOSS

The structure of the profit and loss or income statement follows traditional lines (see Figure 6.7). This is simplified for ease of understanding, but more lines could be added to subdivide the categories to display an increased level of detail.

Figure 6.6

Model structure



The input cells in Excel are marked blue and the totals are in bold green on the screen. The latter cells only add up the cells above, which all adhere to the cash flow rule. Cash received is positive, while cash outflows are entered as negative numbers. Numbers are formatted so that zeros display as a '-' to make the schedule easier to understand.

Excel does not allow you to 'drill down' to the answers from one schedule to another. It can be a problem understanding the source of the cell results. The model uses a numbering system, for example 'P' for profit and loss or 'B' for balance sheet, when referring to this data in the calculation schedules. The format for the numbering is:

```
= "P" & TEXT (ROW (A10) , "00")
```

Income statement

Figure 6.7

	A	B	C	D	E	F	G	H	I	J	K	L	M	
		Item	USD'000,000							Dec-05	Dec-06	Dec-07	Dec-08	Dec-09
8														
9														
10	P10	Sales								7,789.0	17,617.0	35,908.0	39,080.0	35,179.0
11	P11	Cost of Goods Sold								(8,807.0)	(18,559.0)	(28,020.0)	(30,937.0)	(31,665.0)
12	P12	Gross Margin								982.0	(942.0)	7,888.0	8,153.0	3,514.0
13	P13	Depreciation		Manufacturer						-	-	-	-	-
14	P14			Amortisation/Other						-	-	-	-	-
15	P15	Sales, General & Administration Overheads								-	-	-	-	-
16	P16	Net Operating Profit (NOP)								982.0	(942.0)	7,888.0	8,153.0	3,514.0
17	P17	Interest Expense								(450.0)	(692.0)	(966.0)	(970.0)	(1,533.0)
18	P18	Interest Income								-	-	-	-	-
19	P19	Other Financial Income								46.0	44.0	242.0	385.0	412.0
20	P20	Profit after Financial Items								578.0	(1,590.0)	7,164.0	7,568.0	2,393.0
21	P21	Exceptional Expense								-	-	-	-	-
22	P22	Profit before Tax								578.0	(1,590.0)	7,164.0	7,568.0	2,393.0
23	P23	Tax								(393.0)	(677.0)	(2,965.0)	(3,025.0)	(827.0)
24	P24	Net Profit after Tax (NPAT)								185.0	(2,467.0)	4,199.0	4,543.0	1,466.0
25	P25	Minority Interest								(42.0)	(268.0)	(156.0)	(390.0)	35.0
26	P26	Dividends								-	(42.0)	(72.0)	(65.0)	(117.0)
27	P27	Retained Profit for the Year								143.0	(2,767.0)	3,941.0	4,088.0	1,384.0

Label	Alternative
Gross Profit	Gross Margin
Net Operating Profit	Earnings or Profit before Interest and Tax (EBIT, PBIT)
Profit after Financial Items	
Profit before Tax	Earnings before Tax
Net Profit after Tax	Earnings or Profit after Tax (EAT, PAT)
Retained Earnings	Retained Profit

Table 6.1

The levels of profit are clearly marked and Table 6.1 shows the alternative descriptions.

For completeness, the common size analysis is calculated on the right-hand side (see Figure 6.8). This acts as a first step to ratios and shows each of the cost and profit lines as a percentage of sales. Figure 6.8 shows the declining gross margin and profits coupled with an increasing dividend payout ratio.

BALANCE SHEET

The balance sheet shows the book value of assets and liabilities of the company at each year end. The format corresponds to international notation and is split into current and fixed assets followed by current liabilities, long-term debt and shareholders' funds, which is split into shares and retained profit and loss. The number of categories is again limited but could be expanded, for example to include other share categories.

Figure 6.8

Income statement – percentages

Client: ClientCo		Percentages Comparison					
No	Item	USD'000,000	Dec-05	Dec-06	Dec-07	Dec-08	Dec-09
P10	Sales		100.0	100.0	100.0	100.0	100.0
P11	Cost of Goods Sold		87.4	105.3	78.0	79.1	90.0
P12	Gross Margin		12.6	5.3	22.0	20.9	10.0
P13	Depreciation	Manufacturer	-	-	-	-	-
P14		Amortisation/Other	-	-	-	-	-
P15	Sales, General & Administration Overheads		-	-	-	-	-
P16	Net Operating Profit (NOP)		12.6	5.3	22.0	20.9	10.0
P17	Interest Expense		5.8	3.9	2.7	2.5	4.4
P18	Interest Income		-	-	-	-	-
P19	Other Financial Income		0.6	0.2	0.7	1.0	1.2
P20	Profit after Financial Items		7.4	9.0	20.0	19.4	6.8
P21	Exceptional Expense		-	-	-	-	-
P22	Profit before Tax		7.4	9.0	20.0	19.4	6.8
P23	Tax		5.0	5.0	8.3	7.7	2.6
P24	Net Profit after Tax (NPAT)		2.4	14.0	11.7	11.6	4.2
P25	Minority Interest		0.5	1.5	0.5	1.0	0.1
P26	Dividends		-	0.2	0.2	0.2	0.3
P27	Retained Profit for the Year		1.8	15.7	11.0	10.5	3.9

Figure 6.9

Assets

Client: ClientCo		Units USD'000,000					
No	Assets	USD'000,000	Dec-05	Dec-06	Dec-07	Dec-08	Dec-09
B10	Cash and Deposits		155.0	1,727.0	876.0	761.0	1,416.0
B11	Marketable Securities/Investments		54.0	-	-	-	-
B12	Trade Debtors (Receivables)		1,241.0	5,309.0	5,746.0	8,915.0	5,308.0
B13	Inventory		-	-	-	-	-
B14	Sundry Current Assets		424.0	3,753.0	3,702.0	2,179.0	2,481.0
B15	Current Assets		1,874.0	10,769.0	10,324.0	9,755.0	9,205.0
B16	Land and Buildings		-	-	-	-	-
B17	Plant and Machinery		7,569.0	26,642.0	33,728.0	44,627.0	48,661.0
B18	Depreciation		(855.0)	(2,275.0)	(5,110.0)	(7,204.0)	(9,852.0)
B19	Net Property, Plant and Equipment		6,714.0	24,367.0	28,618.0	37,423.0	38,809.0
B20	Other Investments		1,129.0	4,470.0	4,822.0	5,131.0	5,363.0
B21	Intangibles/Goodwill		13,882.0	47,285.0	47,308.0	46,594.0	50,637.0
B22	Non Current and Fixed Assets		21,722.0	76,323.0	80,748.0	89,148.0	94,709.0
B23							
B24	Total Assets		23,596.0	87,092.0	91,072.0	98,903.0	103,914.0

The total assets are given for each year and there is again a percentage split (see Figure 6.9). This is an input sheet and therefore no ‘work’ is done here. Rather, the data is standardized for further analysis in the cash flow and ratios sheets. The schedule includes a ‘Checksum’ to check that assets equal liabilities (see Figure 6.10). If they do not, then cell E43 displays a warning message:

=IF(SUM(I43:M43)<>0,"Errors","No Errors")

Liabilities

Figure 6.10

No	Liabilities	USD'000,000	Dec-05	Dec-06	Dec-07	Dec-08	Dec-09
B28	Short Term Bank Loans		11.0	4,757.0	5,015.0	7,648.0	790.0
B29	Trade Creditors (Payables)		470.0	1,771.0	6,809.0	6,022.0	4,844.0
B30	Other Creditors		119.0	-	-	-	-
B31	Other Current Liabilities		1,474.0	9,852.0	5,825.0	4,005.0	3,576.0
B32	Current Liabilities		2,074.0	16,180.0	17,749.0	17,673.0	9,210.0
B33	Long Term Bank Loans		7,413.0	16,448.0	13,123.0	17,898.0	30,038.0
B34	Long Term Liabilities		7,413.0	16,448.0	13,128.0	17,696.0	30,038.0
B35	Tax/Deferred Taxation		208.0	5,523.0	6,988.0	5,533.0	6,635.0
B36	Long Term Liabilities and Provisions		7,721.0	21,971.0	20,026.0	23,229.0	36,673.0
B37	Ordinary Shares (Common Stock)		15,540.0	50,201.0	52,136.0	52,906.0	54,328.0
B38	Profit and Loss Reserve (Retained Earnings)		(1,739.0)	(4,960.0)	(1,438.0)	2,503.0	3,602.0
B39	Shareholders' Funds		13,801.0	45,241.0	50,698.0	55,409.0	57,930.0
B40	Minorities/Deferred Accounts		-	3,700.0	2,599.0	2,592.0	101.0
B41	Total Liabilities and Equity		23,596.0	87,092.0	91,072.0	98,903.0	103,914.0
	CheckSum: No Errors		-	-	-	-	-
	Market Data						
	Number of Shares Issued & Outstanding		981,616	2,776,759	2,849,744	2,887,960	2,933,000
	Current Share Price		20.00	45.00	50.00	19.00	13.00

Together the income statement and balance sheet constitute the basic inputs to the model. In this form, you can look along the rows and try to pick out trends. The common size views assist with a cursory view of trends, but eventually you need to look more closely by calculating ratios and discerning trends.

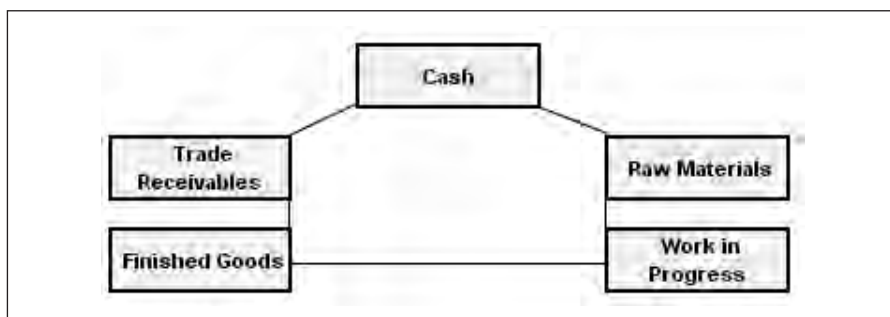
OPERATING EFFICIENCY

The three areas of risk determine the quality and quantity generated by the organization. The decisions of what and how much to produce are underpinned by the management. In turn, the efficiency in the business cycle (see Figure 6.11) underlines the control exerted by the management in the use of resources.

Cash is used to purchase raw materials, which move through the production process into finished goods. The company delivers the goods, invoices its clients and has to wait for the customer to pay. It is a measure of management ability as to how fast it can 'turn' this cycle. If it cannot sell its finished goods, then they will remain in a warehouse and have to be funded from cash in the operating cycle, bank finance or new equity. More borrowings will increase the company's costs and reduce profits through an increased interest burden. This is termed 'business risk'.

Figure 6.11

Operating cycle



Liquidity is the ability of management to turn operating assets into cash. Here it is necessary to question the valuation of the current assets. Questions could relate to the saleability of the stock or the composition of the debtors where cash can safely be expected. For example, a leasing company could fail to terminate slow payers and thereby delay booking a loss because of a client's insolvency. The effect would overstate debtors and profits by including non-viable debts.

Solvency requires that the organization can meet cash demands as they fall due. Bankers require cash payment both of capital and interest. Here the accounts should demonstrate the margin of safety should sales decline. Stocks are of particular interest, especially in industries such as retailing where the number of days stock could hide other more fundamental problems.

The balance sheet structure is shown in Figure 6.12. The model calculates ratios such as:

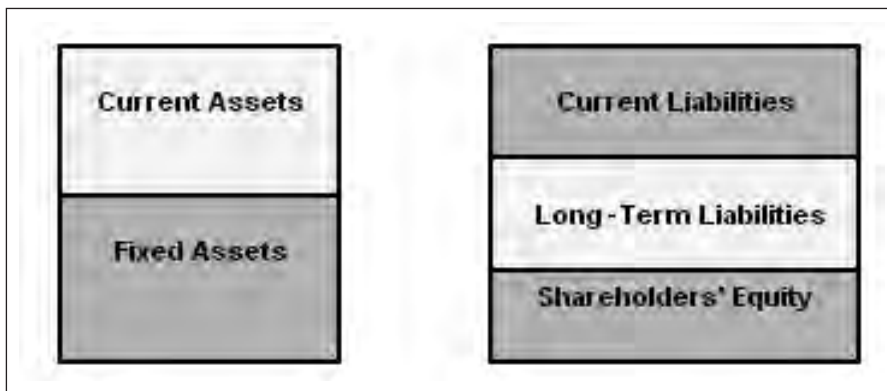
- Stock days – this is the number of stock days on hand. A rising number of stock days could demonstrate the company's inability to shift old or out-of-date stock. This could be further sub-divided into raw materials, work in progress and finished goods.
- Creditor days – this is the number of days taken to pay creditors. A high or rising ratio could indicate that the company was overtrading and using supplier cash.
- Debtor days indicate the accounts receivable days or collection period. The attitude towards credit policy and collection can illustrate the management's abilities or problems with sub-standard or returned products.
- Funding gap or cash conversion cycle. This is the debtor days plus stock days minus creditor days. A longer cycle means more risk since the company has to wait longer to turn debtors and stock back into cash.
- Working capital turnover. This is $\text{sales}/(\text{stocks} + \text{debtors} - \text{creditors})$ and represents the number of times in a year that the company turns the working capital. Again, different companies and industries require differing

levels for efficient operation. The ratio may also indicate overtrading where the ratio is high and growing quickly. The level of growth may be too high for the financial resources of the company. In the short term, overtrading may be a source of low-cost financing, but in the longer term the risk of insolvency increases. Other symptoms are:

- decreasing liquidity;
- high stock turnover;
- increasing interest costs;
- high working capital turnover;
- capital expenditure or increased investment in intangibles.

Balance sheet structure

Figure 6.12



The model uses functions to determine if last year is better than the two previous years ('Better'), ahead of one year ('OK') or worse than both years ('Worse'). This directs the user at the lines that need investigation or further attention. The cell formula in cell M11 on the ratios sheet is:

```
=IF(K11=0,"N/A",IF(J11=0,"N/A",IF(AND(L11>K11,L11>J11),"Better",IF(OR(L11>K11,L11>J11),"OK","Worse"))))
```

Gearing and inventory together with the funding gap use opposite logic. If the number of days or the gap increases, this means that the company has to find more resources to fund the cycle. The funding gap increases in the two previous periods and so the cell formula returns 'Worse'.

In each formula, the possibility of an error caused by a zero number is handled by an IF statement. This is Ratios cell L11:

```
=IF(Income!M10<>0,(Income!M24/Income!M10)*100,0)
```

An alternative would be to use ISERROR or ERROR.TYPE to force zero if Excel cannot calculate a valid answer. The answer is multiplied by 100 since the application standardizes on numbers rather than a mixture of numbers and percentages.

$$=IF(ISERROR(Income!M24/Income!M10),0,(Income!M24/Income!M10)*100)$$

Figure 6.13 shows an improved position in receivables, where the number of days is declining, and a worsening position for creditors. Working capital turnover is increasing because of the reduced sales, debtors and creditors. Overall the operating efficiency is increasing against a background of falling sales.

Figure 6.13

Ratios

Line	Item	USD'000,000	Reference	Dec-08	Dec-09
Core Ratios					
R11	Return on Sales (NPAT/Sales %)		P24/P10	11.82	4.17
R12	Asset Turnover (Sales / Total Assets)		P10/B24	0.40	0.34
R13	Asset Leverage (Total Assets/Equity)		B24/B39	1.78	1.79
R14	Return on Equity (NPAT/Equity %)		P24/B39	8.20	2.53
Profitability					
R18	Gross Profit / Sales (%)		P12/P10	20.88	9.99
R19	Net Operating Profit / Sales (%)		P16/P10	20.88	9.99
R20	Profit before Tax / Sales (%)		P22/P10	19.38	6.80
R21	Return on Capital Employed (ROCE)		P16/B39+B33	11.15	3.99
R22	Return on Invested Capital (ROIC)		P16*(1-T)/B28+33+39	14.13	5.48
R23	Return on Assets (ROA)		P16/B24	3.24	3.38
Operating Efficiency					
R27	Inventory Days		B13/P11	-	-
R28	Trade Receivables (Debtor) Days		B12/P10	83.63	55.07
R29	Creditors Days		B29/P11	71.05	55.64
R30	Funding Gap Debtors-Inventory-Creditors		R25+R28-R27	(7.41)	(0.76)
R31	Working Capital Turnover		P10/B12-13-B29	49.29	75.82
Financial Structure					
R35	Current Ratio		B15/B32	0.55	1.00
R36	Quick Ratio (Acid Test)		B15-B13/B32	0.55	1.00
R37	Working Capital (Thousands)		B15-B32	(7,918)	(5)
R38	Gross Gearing (%)		B28-B33/B39	45.74	53.22
R39	Net Gearing (%)		B28+B33-B10-11/B39	44.38	50.77
R40	Solvency (Times Interest Earned)		P16/P17	8.41	2.29
R41	Total Equity/Total Assets		B39/B24	58.02	55.75

PROFITABILITY

Profitability is supposed to be the goal of companies to reward the shareholders for risking their investment in the company. Financial reporting standards set out the general rules, but there are always different interpretations of the rules by operating officers. Furthermore, there are several profit

and return measures which may provide differing results. If a company is profitable, then one would expect to see the returns revealed in cash flow, but this is not always the case. Therefore, profitability should not be reviewed to the exclusion of operating efficiency, financial structure and cash flow.

Where you have profits, but no cash flow, then you may need to examine the accounting methods and standards. For example, the company in the model has increased sharply the amounts in intangible assets to the point where this is almost as great as the shareholders' funds. This could hide costs that are being 'parked' in the balance sheet in order to bolster profits.

The ratios in this section are:

- gross profit/sales as the percentage gross margin;
- net operating profit/sales as a percentage return on trading;
- profit before tax/sales as the profit margin after interest costs;
- return on capital employed (ROCE) as net operating profit divided by long-term debt plus shareholders' funds;
- return on invested capital (ROIC) as net operating profit multiplied by $(1 - \text{tax})$ divided by long- and short-term debt plus shareholders' funds;
- return on assets as the net operating profit divided by total assets.

Figure 6.14 show a volatile position with returns worse in the last period for all ratios. The income statement profit ratios have all halved, and balance sheet measures such as the return on assets have sunk to levels lower than the cost of capital.

FINANCIAL STRUCTURE

Financial risk is concerned with the structure of the balance sheet together with the sources of finance to the company. Bankers are concerned with the liabilities taken on by companies and their ability to service debt. Prospects are often more volatile than originally anticipated and therefore the model needs to provide information about the financial strength. The company needs to manage debt and equity efficiently in order to reduce the cost of capital but also not take on obligations which cannot be paid back. In general terms, the cost of capital falls with an increasing debt percentage on the balance sheet, but the financial risk increases because of the interest burden. The ratios calculated by the model are:

Figure 6.14

Profitability

Line	Item	USD'000,000	Dec-05	Dec-06	Dec-07	Dec-08	Dec-09	Action
Profitability								
R18	Gross Profit / Sales (%)		12.61	(5.35)	21.97	20.86	9.99	Worse
R19	Net Operating Profit / Sales (%)		12.61	(5.35)	21.97	20.86	9.99	Worse
R20	Profit before Tax / Sales (%)		7.42	(8.03)	19.95	19.36	6.80	Worse
R21	Return on Capital Employed (ROCE)		4.63	(1.53)	12.36	11.15	3.99	Worse
R22	Return on Invested Capital (ROIC)		7.77	(0.64)	16.20	14.13	5.48	Worse
R23	Return on Assets (ROA)		4.16	(1.06)	8.66	8.24	3.36	Worse

- Current ratio – basic measure of liquidity as the ratio of current assets to liabilities. The working capital requirement varies across industries so the absolute value is less important than the trend.
- Quick ratio – this excludes stock from the current ratio. The rationale is that stock is often difficult to sell at book prices and may not be as realizable in the short term.
- Working capital as current assets minus current liabilities.
- Gross gearing (leverage) as short- plus long-term debt divided by shareholders' funds.
- Net gearing (leverage) as gross gearing debt less cash and marketable securities.
- Solvency or time interest earned measures the number of times profit before interest and tax covers the interest payment.
- Total equity/total assets is a measure of financial strength or who owns the company. Companies with a high ratio are financially more resilient.

Figure 6.15 shows increasing gearing and reduced solvency as returns only cover the interest payment twice over. The findings are in line with operating efficiency and profitability, both of which have declined in the last year.

Figure 6.15

Financial structure

Line	Item	USD'000,000	Dec-05	Dec-06	Dec-07	Dec-08	Dec-09	Action
Financial Structure								
R35	Current Ratio		0.90	0.67	0.58	0.55	1.00	Better
R36	Quick Ratio (Acid Test)		0.90	0.67	0.58	0.55	1.00	Better
R37	Working Capital (Thousands)	(200)	(5,411)	(7,425)	(7,918)	(5)		Better
R38	Gross Gearing (%)		53.79	46.87	35.79	45.74	53.22	Worse
R39	Net Gearing (%)		52.28	43.05	34.08	44.35	50.77	Worse
R40	Solvency (Times Interest Earned)		2.18	(1.33)	8.17	8.41	2.23	Worse
R41	Total Equity/Total Assets		58.49	51.95	55.67	56.02	55.75	OK

CORE RATIOS

One method of calculating ratios from key areas is to use Du Pont or core ratios and calculate the components of the return on equity. Return on

equity defines the return the shareholders receive from the enterprise. As a shortcut, the method also provides a ratio from each of the risk areas discussed above.

The return on equity is net profit after tax/shareholders' equity and this can be subdivided into:

Return on Sales	(NPAT/Sales)	Profitability	P24/P10
Asset Turnover	(Sales/Total Assets)	Operating Efficiency	P10/B24
Asset Leverage	(Total Assets/Equity)	Financial Structure	B23/B39

These three ratios, when multiplied together, equal the return on equity.

$$\text{NPAT/Equity} = \text{Sales/Total assets} * \text{Total assets/Equity} * \text{NPAT/Sales}$$

Core ratios

Figure 6.16

Line	Item	USD'000,000	Dec-05	Dec-06	Dec-07	Dec-08	Dec-09	Action
Core Ratios								
R11	Return on Sales (NPAT/Sales %)		2.36	(14.00)	11.69	11.62	-4.17	Worse
R12	Asset Turnover (Sales / Total Assets)		0.33	0.20	0.39	0.40	0.34	Worse
R13	Asset Leverage (Total Assets/Equity)		1.71	1.93	1.80	1.78	1.79	OK
R14	Return on Equity (NPAT/Equity %)		1.34	(5.45)	8.28	8.20	2.53	Worse

The ratios in this section (see Figure 6.16) are multiplied out to show the composition of the return on equity (see Figure 6.17). This has declined over the period and underlines the worsening performance. Faced with the weaker areas, the analysis can then proceed to review these areas in more detail.

The ratios demonstrate the levers that management can use to extract performance from the business:

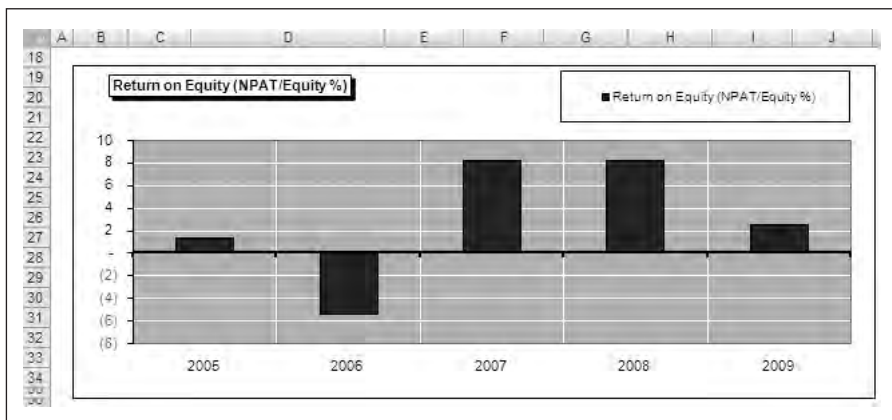
- earnings from each \$1 of sales – profit margin (income statement)
- sales for each \$1 of assets – asset turnover (asset side of balance sheet)
- equity used to finance each \$1 of assets – financial or asset leverage (liabilities side of balance sheet).

Return on equity is often considered to be the most important return measure, but it has limitations:

- The return on equity (ROE) is historic and may not be a good indicator for the future.
- The calculation does not include a measure of the risk profile of the industry and company. More risk should demand a greater return to shareholders.

Figure 6.17

Return on equity



- The ROE is an accounting measure and is based on book values. The value of equity may be better presented by the market value of debt and the market value of equity (enterprise value).

Asset turnover depends on the sector and the assets needed in the business. Knowledge-based companies invest in people and information as major assets in developing competitive advantage as opposed to high levels of plant and equipment. These values are not recorded on the balance sheet.

Asset leverage depends on the uncertainty of cash flows. In a risky or volatile business, such as pharmaceuticals, shareholders are normally expected to fund research and development. There may be pressure to advance revenues and capitalize costs which can distort the asset leverage.

MARKET RATIOS

The model includes a number of market ratios (see Figure 6.18). The market capitalization is reducing because of a reduced share price. The earnings per share has declined and the P/E ratio increases because of the reduction in share price. The dividend per share has increased, reflecting management’s desire to maintain the dividends despite falling profits. The market to book ratio is below one and therefore the stock market does not rate the prospects for the company or have faith in the management.

TREND ANALYSIS

The Historic_Mgt_Analysis sheet provides a dynamic chart for reviewing all the rows in the income statement, balance sheet and ratios. See Chapter

2 for an explanation of the method. It can often ‘see’ the trends when faced with the schedules of numbers produced by Excel. On the basis that different audiences needs varying levels of detail, the chart allows you to look at individual lines.

Market ratios

Figure 6.18

Line	Item	USD'000,000	Dec-05	Dec-06	Dec-07	Dec-08	Dec-09	Action
Market Related Data								
R51	Number of Shares Issued & Outstanding		982	2,777	2,850	2,888	2,933	
R52	Current Share Price		20.00	45.00	50.00	18.00	13.00	
R53	Market Capitalisation		19,632	124,954	142,467	54,871	38,129	Worse
R54	Earnings per Share		0.19	(0.89)	1.47	1.57	0.50	Worse
R55	P / E Ratio		106.12	(50.65)	33.93	12.08	26.01	OK
R56	Dividends per Share		-	0.02	0.03	0.02	0.04	Better
R57	Dividend Cover		-	(64.88)	55.74	63.89	12.83	Worse
R58	Market Price / Book		1.42	2.76	2.81	0.99	0.66	Worse
R59	Enterprise Value (EV)		27,058	146,159	160,630	80,213	68,957	Worse
R60	EV / EBITDA		-	(155.16)	20.36	9.64	18.62	OK

Office 2007 – Developer, Controls, Insert, Form Controls (Excel 2003 – View, Toolbars, Forms)

Figure 6.19 shows the return on assets where the components are:

- combo box with the labels as inputs and cell J13 as the link;
- OFFSET function looking at the block of data below and using the cell link as the row number;
- chart of the single series.

Dynamic chart

Figure 6.19

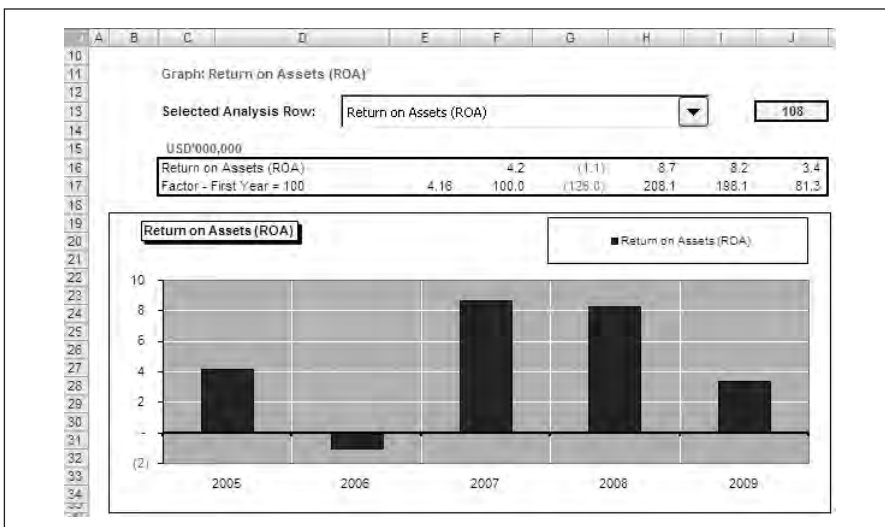
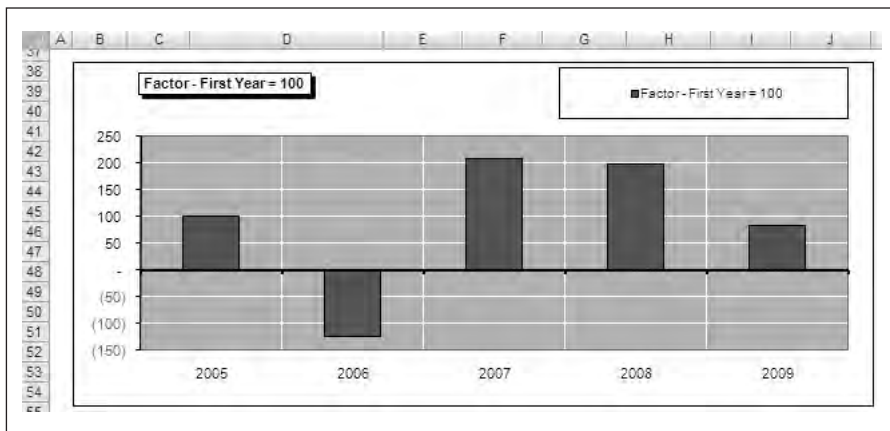


Figure 6.20 provides a relative result where the first year is a factor of 100 and the next years the percentage movement. Thus factor 80 would be a 20 per cent reduction.

Figure 6.20

Factor chart



CASH FLOW

The ratio analysis shows a worsening financial position so the next stage is to examine the cash flow produced by operations and consumed by the company. Since cash flow should not be affected by accounting standards and conventions, this analysis may reveal more about the financial prospects. Similarly, as bankers seek a steady and non-volatile cash flow to repay debts, cash flow analysis should provide further information on financial health.

The model includes a sheet called Cashflow which reconciles the income statement and balance sheet back to change in cash.

- Starting cash balance
- + Cash generated from operations and other sources
- Cash used to fund operations, investment, research, etc.
- = Ending cash balance.

The model uses a layout which calculates the trading cash or net operating cash flow (NOCF) and then the uses of the cash together with the new capital introduced into the business to reconcile back to bank. The key objective is to split the cash generated through trading operations, one-off sources of cash, uses of cash and new capital introduced into the business. Provided the model is correct, the remaining balance should reconcile back to the change in cash on the balance sheet.

The important lines are:

- EBITDA – net operating profit adding back non-cash items such as depreciation of fixed assets and amortization of goodwill as a simplistic proxy for cash flow;
- net operating cash flow – trading cash produced from the trading of the company;
- cash flow before financing – cash before new capital.

Figure 6.21 illustrates the derivation of the lines in the cash flow. This is particularly useful where the information is derived from the change in balance from the beginning to the end of the year in the balance sheet and the amounts passed through the income statement.

Cash flow method

Figure 6.21

Item	Comment
Net Operating Profit (NOP)	Income Statement
Depreciation / Amortisation	Non cash items
Earnings before Interest, Tax, Depreciation and Amortisation (EBITDA)	
Operating Items	
(-)/+ Current Assets	Inc = negative, Dec = positive
+(-) Current Liabilities	Inc = Positive, Dec = negative
Net Operating Cash Flow (NOCF)	EBITDA + change in working capital
Returns on Investment and Servicing of Finance	
Interest Received	Income statement
Interest Paid	Income statement
Dividends	Income statement
Net Cash Outflow from Returns on Investments and Servicing of Finance	
Taxation	
Taxes Paid	Income statement
Deferred Tax	Change in balance sheet
Net Cash Outflow for Taxation	
Investing Activities	
Expenditure on Property, Plant and Equipment	Change in balance sheet + depreciation in P&L
Expenditure on Investments & Intangibles	Change in balance sheet
Marketable Securities	Change in balance sheet
Net Cash Outflow for Capital Expenditure and Financial Investment	
Exceptional and Minority Items	
Exceptional Income and Expense	Income statement and balance sheet (if applicable)
Net Cash Outflow from Exceptional and Minority Items	
Reconciliation	
Reconciliation Figure	Difference between PE on P&L and balance sheet
Total Cash (Outflow)/Inflow before Financing	Addition
Financing	
Share Capital and Reserves	Change in balance sheet
Short Term Debt and Provisions	Change in balance sheet
Long Term Debt and Provisions	Change in balance sheet
Net Cash Inflow/(Outflow) from Financing	
Increase / (Decrease) in Cash	Addition

The method is summarized in Figure 6.21 where the statement starts with the net operating profit and adds back non-cash items resulting in

earnings before interest, tax, depreciation and amortization (EBITDA). The changes in working capital are subtracted to form the net operating cash flow. An increase in current assets results in a reduction of cash, while an increase in current liabilities results in an increase of cash.

The net operating cash flow is usually the first line of a reported cash flow statement and the lines above are shown as a note. Below the net operating cash flow, there are categories for returns on investment and servicing of finance, taxation, investing activities, exceptional and minority items.

Figure 6.22

Cash flow

Line	Item	USD'000,000	Reference	Dec-06	Dec-07
C10	Net Operating Profit (NOP)			(942.0)	7,888.0
C11	Depreciation / Amortisation		P13.14		
C12	Earnings before Interest, Tax, Depreciation and Amortisation (EBITDA)			(942.0)	7,888.0
C14	Operating Items				
C15	(+/-) Current Assets		B12.14	(7,377.0)	(406.0)
C16	+/(-) Current Liabilities		B29.31	9,360.0	1,311.0
C17	Net Operating Cash Flow (NOCF)			1,041.0	8,793.0
C19	Returns on Investment and Servicing of Finance				
C20	Interest Received		P18		
C21	Interest Paid		P17	(692.0)	(966.0)
C22	Dividends		P26	(42.0)	(72.0)
C23	Net Cash Outflow from Returns on Investments and Servicing of Financ			(734.0)	(1,038.0)
C25	Taxation				
C26	Taxes Paid		P23	(877.0)	(2,965.0)
C27	Deferred Tax		B36	5,215.0	1,375.0
C28	Net Cash Outflow for Taxation			4,338.0	(1,590.0)
C30	Investing Activities				
C31	Expenditure on Property, Plant and Equipme		B19-P13-P14	(17,854.0)	(4,050.0)
C32	Expenditure on Investments, LT Assets & Int		B20.21-P19	(36,703.0)	(133.0)
C33	Marketable Securities		B11	54.0	
C34	Net Cash Outflow for Capital Expenditure and Financial Investment			(54,503.0)	(4,183.0)
C36	Exceptional and Minority Items				
C37	Exceptional Income and Expense		P21-P25-B40	3,442.0	(1,287.0)
C38	Net Cash Outflow from Exceptional and Minority Items			3,442.0	(1,287.0)
C40	Reconciliation				
C41	Reconciliation Figure			(454.0)	(419.0)
C42	Total Cash (Outflow)/Inflow before Financing			(46,870.0)	276.0
C44	Financing				
C45	Share Capital and Reserves		B37	34,661.0	1,935.0
C46	Short Term Debt and Provisions		B28	4,746.0	258.0
C47	Long Term Debt and Provisions		B33	9,035.0	(3,320.0)
C48	Net Cash Inflow/(Outflow) from Financing			48,442.0	(1,127.0)
C50	Increase / (Decrease) in Cash			1,572.0	(851.0)

The reconciliation items catch any differences between the retained earnings in the income statement and the amount actually added to the reserves in the balance sheet. These could consist of:

- prior year P&L adjustment;
- shares issued or repurchased;
- preference shares issued;
- goodwill written off or written back;

- foreign exchange translation;
- revaluation for the year;
- transfer to/from reserves.

The balance at the bottom should agree with the change in cash on the balance sheet and there is a CheckSum to ensure that any errors are reported visually on the schedule (see Figure 6.22).

Cell E55: =IF(ROUND(SUM(J55:M55),0)=0,"No Errors","Errors")

Net operating cash flow (NOCF)

Figure 6.23 illustrates the variability in the underlying cash flow over the four periods. The operating cash flow has declined in the last three periods.

NOCF

Figure 6.23

Line	Item	USD'000,000	Reference	Dec-06	Dec-07	Dec-08	Dec-09
C10	Net Operating Profit (NOP)			(942.0)	7,888.0	8,153.0	3,514.0
C11	Depreciation / Amortisation		F1314				
C12	Earnings before Interest, Tax, Depreciation and Amortisation (EBITDA)			(942.0)	7,888.0	8,153.0	3,514.0
C14	Operating Items						
C15	(+/-) Current Assets		B1214	(7,377.0)	(908.0)	454.0	1,205.0
C16	+/- Current Liabilities		B2331	3,380.0	1,310.0	(2,707.0)	(1,607.0)
C17	Net Operating Cash Flow (NOCF)			1,041.0	8,793.0	5,396.0	3,112.0

Cash ratios

Figure 6.24

Line	Item	USD'000,000	Dec-05	Dec-06	Dec-07	Dec-08	Dec-09	Action
Cashflow Ratios								
R45	EBITDA / Sales (%)		-	(5.35)	21.97	20.86	9.99	Worse
R46	Net Operating Cash Flow/Sales			5.91	24.49	15.09	8.85	Worse
R47	Cash Flow before Financing/Sales			(286.05)	0.77	(20.66)	(17.77)	Worse

The ratios schedule contains cash flow ratios at the bottom calculated by dividing different cash measures back into sales (see Figure 6.24). These again show a reduction in cash flow. Sales are used since this number should not be varied by international accounting conventions, but there are still variances on when revenues are recognized.

- EBITDA/sales (%)
- net operating cash flow/sales
- cash flow before financing/sales.

Free cash flow

Free cash flow has a number of definitions and Figure 6.25 shows the difficulty of defining the elements that should be included or excluded. In simple terms, free cash flow is the cash flow available to pay debt providers and equity holders. It is defined here as:

- net operating profit (NOP)
- + depreciation/amortization/non-cash items
- earnings before interest, tax, depreciation and amortization (EBITDA)
- +/- changes in net working assets
- net operating cash flow (NOCF)
- expenditure on property, plant and equipment, investment and proceeds of sale
- net cash outflow for taxation
- operating free cash flow.

There is a schedule in the model called Free_Cash_Flows, which uses information from the cash flow schedule to derive free cash flow. This schedule includes expenditure on investments and shows a cash outflow when capital expenditure and investments are taken into account (see Figure 6.25).

Figure 6.25

Free cash flow

Line	Reference	USD'000,00	Dec-06	Dec-07	Dec-08	Dec-09
FC10	Free Cash Flow					
FC11	Operating Profit (NOP)	C10	(942.0)	7,888.0	8,153.0	3,514.0
FC12	Depreciation / Amortisation / Non-cash Items	C11	-	-	-	-
FC13	Earnings before Interest, Tax, Depreciation and Amortisation (E	FCF11.12	(942.0)	7,888.0	8,153.0	3,514.0
FC14	Changes in Net Working Assets	C15.16	1,983.0	906.0	(2,253.0)	(402.0)
FC15	Net Operating Cash Flow (NOCF)	FCF13.14	1,041.0	8,793.0	5,900.0	3,112.0
FC16	Expenditure on Property, Plant and Equipment / Proceeds of Sale	C21.32	(54,567.0)	(4,183.0)	(8,015.0)	(5,149.0)
FC17	Net Cash Outflow for Taxation	C28	4,338.0	(1,590.0)	(4,390.0)	175.0
FC18	Operating Free Cashflow	FCF15.17	(49,178.0)	3,020.0	(6,505.0)	(1,862.0)

FORECASTS

The financial analysis model has concentrated on the historic results whereas this section sets out the forecast method used in the file. Bankers need to forecast cash flows in order to ascertain the ability to repay future debts. Whilst statistical methods such as exponential smoothing or harmonic means could be applied, this method focuses on the key determinants of value creation.

The objective is to provide values for key drivers such as sales growth or capital expenditure and then to redraw the financial statements to provide both a historic and forecast perspective. This provides an income statement, balance sheet together with a cash flow, and ratios. The exact layouts are used for the forecast and historic schedules in order to minimize the errors. Similarly, management analysis can be enhanced with charts to show the anticipated changes.

The completed model should assist in answering management questions, for example:

- Does the company possess sufficient internal resources to fund the anticipated growth?
- Will the company's financial position strengthen or weaken?
- Is the risk of insolvency likely to increase?

Key drivers

This approach is sometimes called percent of sales forecasting. It involves:

- calculating profit and loss items as a percentage of sales;
- calculating balance sheet items as a percentage of sales;
- drawing the profit and loss;
- drawing the balance sheet;
- using cash or short-term overdraft as the 'plug' to make the balance sheet add up.

Figure 6.26 is an extract from the forecast sheet showing drivers and the historic percentages.

Key drivers

Figure 6.26

	A	B	C	D	E	F	G	H	I	J	
8	Line		Item	USD'0	Reference	Dec-05	Dec-06	Dec-07	Dec-08	Dec-08	
9						Actual	Actual	Actual	Actual	Actual	
10	Forecast:										
11	F11	Initial sales		P10		7,789.0	17,617.0	35,908.0	39,090.0	35,179.0	
12	F12	Sales growth		Change P10		126.2%	103.8%	103.8%	8.9%	(10.0%)	
13	F13	Costs of goods sold/Sales		P11/P10		87.4%	105.3%	78.0%	79.1%	90.0%	
14	F14	Depreciation rate		P13/P14/B19		-	-	-	-	-	
15	F15	SG&A/Sales		P15/P10		-	-	-	-	-	
16	F16	Interest paid on debt		P17/B28+B33		8.1%	3.3%	5.3%	3.8%	5.0%	
17	F17	Interest earned on cash		P18.19/B10.11		22.0%	2.5%	27.6%	50.6%	29.1%	
18	F18	Exceptionals/Sales		P21/F11		-	-	-	-	-	
19	F19	Marginal tax rate		P23/P22		58.0%	(55.2%)	41.4%	40.0%	38.7%	
20	F20	Dividend payout ratio		P26/P24		-	(1.7%)	1.7%	1.4%	6.0%	
21	F21	Fixed assets increase		B19			17,854	4,050	8,805	1,386	
22	F22	Intangibles increase		B21			33,403	23	(714)	3,943	
23	F23	Current assets/Sales		B11.14/F11		22.1%	51.3%	28.3%	23.0%	22.1%	
24	F24	Current liabilities/Sales		B32-B28/F11		26.5%	64.8%	35.5%	25.7%	23.9%	
25	F25	Debt/Sales		B33-B28/F11		95.3%	120.4%	50.5%	64.8%	87.6%	
26	F26	Deferred tax/Sales		B35/F11		4.0%	31.4%	19.2%	14.2%	18.9%	
27	F27	New Equity		B37			34,661	1,935	770	1,422	
28	F28	Current Share Price				20.00	45.00	50.00	19.00	13.00	

Since most variables on the income statement are assumed to have a linear relationship to sales, the only items with links to the balance sheet are interest payments and receipts together with depreciation. These require information from the income statement and balance sheet as detailed in Figure 6.27. New equity, capital expenditure and investments are actual amounts rather than percentages. This matrix could be made more complex with more drivers and amounts rather than sales percentages.

Figure 2.27

Variables

Item	Reference	
Forecast		
Initial sales	P10	Use last year as the base
Sales growth	Change P10	Sales growth
Costs of goods sold/Sales	P11/P10	Percentage of sales
Depreciation rate	P13.P14/B19	Depreciation on previous year's fixed asset in balance sheet
SG&A/Sales	P15/P10	Percentage of sales
Interest paid on debt	P17/B28+B33	Interest paid on debt in balance sheet
Interest earned on cash	P18.19/B10.11	Interest received on marketable securities in balance sheet
Exceptionals/Sales	P21/F11	Percentage of sales
Marginal tax rate	P23/P22	Tax paid / Profit before tax
Dividend payout ratio	P26/P24	Dividends / Profit after tax
Net fixed assets/Sales	B19/F11	
Intangibles/Sales	B20.21/F11	
Current assets/Sales	B12.14/F11	
Current liabilities/Sales	B32-B28/F11	
Debt/Sales	B33+B28/F11	
Deferred tax/Sales	B35/F11	
New Equity	B37	Actual amount

Sales growth is usually the most important variable since it drives the company forward. The growth rate in cell G12 is based on this formula. In all cases, the model will display zero if there are no sales in the previous period, and it will suppress mathematical errors.

$$=IF(F11=0,0,(G11-F11)/F11)$$

Columns K to O are inputs for the five years of the forecast, and the user simply reviews the previous five-year period and after investigation can select a percentage for each of the variables. It is a good idea to establish a 'Base Case' and save it as a scenario using Data, Data Tools, What-if Analysis (Excel 2003 – Tools, Scenarios, Add). It is likely that you would want to test various views of the future and scenarios are a good way of recording the 'audit trail'. For example, the case in the model

is optimistic as it anticipates growth and a reduced cost of sales. Using figures for the previous year will not produce such a positive outcome.

The percentages are all shown as input cells in Figure 6.28. You can then develop the answers by changing individual years. There is no rule that sales growth or depreciation has to be the same each year although for simplicity the inputs have been restricted to the first two years.

The model provides the user with immediate feedback as each variable is changed. You do not want to have to select the forecast statement to see the answer every time you change an input cell. Below the main table, there is a table of results showing the net operating profit, shareholders' funds, net operating cash flow and the return on equity (see Figure 6.29).

Figures 6.30 to 6.32 show a construction of the financial statements by line.

Deriving financial statements

The model produces the income statement (see Figure 6.33) and balance sheet by applying the ratio percentages to the enhanced sales. These are called FIncome and FBalance and follow exactly the framework of the historic sheets. The past results are repeated together with the future values.

Forecast variables

Figure 6.28

Line	Item	USD'0	Dec-10	Dec-11	Dec-12	Dec-13	Dec-14
			Forecast	Forecast	Forecast	Forecast	Forecast
F11	Initial sales	37,641.5	40,276.4	43,095.8	46,112.5	49,340.4	
F12	Sales growth	7.0%	7.0%	7.0%	7.0%	7.0%	
F13	Costs of goods sold/Sales	85.0%	85.0%	85.0%	85.0%	85.0%	
F14	Depreciation rate	5.0%	5.0%	5.0%	5.0%	5.0%	
F15	SG&A/Sales	0.0%	0.0%	0.0%	0.0%	0.0%	
F16	Interest paid on debt	5.0%	5.0%	5.0%	5.0%	5.0%	
F17	Interest earned on cash	5.0%	5.0%	5.0%	5.0%	5.0%	
F18	Exceptionals/Sales	0.0%	0.0%	0.0%	0.0%	0.0%	
F19	Marginal tax rate	35.0%	35.0%	35.0%	35.0%	35.0%	
F20	Dividend payout ratio	8.0%	8.0%	8.0%	8.0%	8.0%	
F21	Fixed assets increase	2,000	2,000	2,000	2,000	2,000	
F22	Intangibles increase	4,000	4,000	4,000	4,000	4,000	
F23	Current assets/Sales	25.0%	25.0%	25.0%	25.0%	25.0%	
F24	Current liabilities/Sales	24.0%	24.0%	24.0%	24.0%	24.0%	
F25	Debt/Sales	85.0%	85.0%	85.0%	85.0%	85.0%	
F26	Deferred tax/Sales	19.0%	19.0%	19.0%	19.0%	19.0%	
F27	New Equity	-	-	-	-	-	
F28	Current Share Price	13.00	13.00	13.00	13.00	13.00	

Figure 6.29

Results

	A	B	C	D	K	L	M	N	O
	Line	Item	USD'0	Dec-10	Dec-11	Dec-12	Dec-13	Dec-14	
22	F22	Intangibles increase		4,000	4,000	4,000	4,000	4,000	
23	F23	Current assets/Sales		25.0%	25.0%	25.0%	25.0%	25.0%	
24	F24	Current liabilities/Sales		24.0%	24.0%	24.0%	24.0%	24.0%	
25	F25	Debt/Sales		85.0%	85.0%	85.0%	85.0%	85.0%	
26	F26	Deferred tax/Sales		19.0%	19.0%	19.0%	19.0%	19.0%	
27	F27	New Equity		-	-	-	-	-	
28	F28	Current Share Price		13.00	13.00	13.00	13.00	13.00	
31		Results							
32	F32	Net Operating Profit (NOP)		3,706	4,098	4,518	4,968	5,450	
33	F33	Shareholders' Funds		59,572	61,347	63,310	65,494	67,927	
34	F34	Net Operating Cash Flow (NOCF)		4,639	6,015	6,436	6,887	7,389	
35	F35	Return on Equity (NPAT/Equity %)		2.9	3.1	3.3	3.6	3.8	

Figure 6.30

Income statement

No	Item	USD '000,000	Description
P10	Sales		Calculate using sales growth
P11	Cost of Goods Sold		Calculate using gross profit margin
P12	Gross Margin		
P13	Depreciation	Manufacturer	Use Deprn. / (average) FA ratio
P14		Amortisation/Other	
P15	Sales, General & Administration Overheads	SGA / Sales	
P16	Net Operating Profit (NOP)		
P17	Interest Expense		Use interest % on (average) debt
P18	Interest Income		
P19	Other Financial Income		
P20	Profit after Financial Items		
P21	Exceptional Expense		
P22	Profit before Tax		
P23	Tax		Use tax payout ratio
P24	Net Profit after Tax (NPAT)		
P25	Minority Interest		Retain at same rate
P26	Dividends		Use dividend payout ratio
P27	Retained Profit for the Year		

Figure 6.31

Assets

No	Assets	USD '000,000	Description
B10	Cash and Deposits		
B11	Marketable Securities		Balance
B12	Trade Debtors (Receivables)		Current assets / Sales
B13	Inventory		Current assets / Sales
B14	Sundry Current Assets		Current assets / Sales
B15	Current Assets		
B16	Land and Buildings		Actual increase / (decrease)
B17	Plant and Machinery		Actual increase / (decrease)
B18	Depreciation		Balance + P&L Deprn
B19	Net Property, Plant and Equipment		
B20	Other Investments		Actual increase / (decrease)
B21	Intangibles/Goodwill		Actual increase / (decrease)
B22	Non Current and Fixed Assets		
B23			
B24	Total Assets		

Liabilities

Figure 6.32

No	Liabilities	USD '000,000	Description
B28	Short Term Bank Loans		
B29	Trade Creditors (Payables)		Current liabilities / Sales
B30	Other Creditors		Current liabilities / Sales
B31	Other Current Liabilities		Current liabilities / Sales
B32	Current Liabilities		
B33	Long Term Bank Loans		Debt / Sales
B34	Long Term Liabilities		
B35	Tax/Deferred Taxation		Deferred tax / Sales
B36	Long Term Liabilities and Provisions		
B37	Ordinary Shares (Common Stock)		Balance + New equity
B38	Profit and Loss Reserve (Retained Earnings)		Balance + retained earnings
B39	Shareholders' Funds		
B40	Minority Interests		Balance
B41	Total Liabilities and Equity		

Income statement

Figure 6.33

No	Item	USD'000,000	Dec-09	Dec-10	Dec-11
			Actual	Forecast	Forecast
P10	Sales		35,178.0	37,641.5	40,276.4
P11	Cost of Goods Sold		(31,885.0)	(31,895.3)	(34,235.0)
P12	Gross Margin		3,514.0	5,646.2	6,041.5
P13	Depreciation	Manufacturer	-	(1,940.6)	(1,342.4)
P14		Amortisation/Other	-	-	-
P15	Sales, General & Administration Overheads		-	-	-
P16	Net Operating Profit (NOP)		3,514.0	3,705.8	4,098.0
P17	Interest Expense		(1,533.0)	(1,501.9)	(1,599.8)
P18	Interest Income		-	70.8	-
P19	Other Financial Income		412.0	412.0	412.0
P20	Profit after Financial Items		2,393.0	2,686.7	2,910.3
P21	Exceptional Expense		-	-	-
P22	Profit before Tax		2,393.0	2,686.7	2,910.3
P23	Tax		(927.0)	(949.3)	(1,016.6)
P24	Net Profit after Tax (NPAT)		1,466.0	1,746.3	1,891.7
P25	Minority Interest		35.0	35.0	35.0
P26	Dividends		(117.0)	(139.7)	(151.3)
P27	Retained Profit for the Year		1,384.0	1,641.6	1,775.3

Colour coding in the form of shaded cells is also used to highlight the forecast. The method used to create the sheets was as follows:

- copy the historic sheet by right clicking the tab or using Home, Cells, Format, Move or Copy Sheet (Excel 2003 – Edit, Move, Create a Copy);
- change the name to 'F' (e.g. FIncome);
- code the labels in columns B to G to look up the historic sheet (this means that if you change anything on the Income sheet, it will update on the forecast);

- insert the formulas in the historic cells to look up the values in the historic sheet;
- insert the formulas by multiplying out from the Forecast sheet;
- check the results including the signs (negative or positive).

The formulas use the forecast sheet to derive the new values as with the detail for column N below. In rows 17 and 18, the logic checks if cash is positive or negative and only applies funding interest on negative balances. The cash rules are followed and costs are all negative. (See Figure 6.34.)

Figure 6.34

Assets

	A	B	C	D	E	F	G	M	N	O
9		No	Assets			USD'000,000		Dec-09	Dec-10	Dec-11
9								Actual	Forecast	Forecast
10		B10	Cash and Deposits					1,416.0	-	107.6
11		B11	Marketable Securities/Investments					-	-	-
12		B12	Trade Debtors (Receivables)					5,308.0	6,412.9	6,861.8
13		B13	Inventory					-	-	-
14		B14	Sundry Current Assets					2,481.0	2,997.5	3,207.3
15		B15	Current Assets					9,205.0	9,410.4	10,176.7
16		B16	Land and Buildings					-	-	-
17		B17	Plant and Machinery					48,661.0	50,661.0	52,661.0
18		B18	Depreciation					(9,852.0)	(11,792.5)	(13,735.9)
19		B19	Net Property, Plant and Equipment					38,809.0	38,868.6	38,925.1
20		B20	Other Investments					5,363.0	5,363.0	5,363.0
21		B21	Intangibles/Goodwill					50,537.0	54,537.0	58,537.0
22		B22	Non Current and Fixed Assets					94,709.0	98,768.6	102,825.1
23		B23								
24		B24	Total Assets					103,914.0	103,178.9	113,001.8

The balance sheet follows the same pattern using the drivers from the Forecasting sheet. Where necessary, the model apportions the forecast percentage between different rows. The current assets percentage is 40 per cent and this is split between debtors, inventory and sundry current assets in rows 12 to 14.

$$=(Forecast!K\$11*Forecast!K\$23) * (M12/SUM(M\$12:M\$14))$$

Cash and short-term debt are used to balance the assets and liabilities as the model's 'plug' (see Figures 6.34 and 6.35). The model includes workings at row 47 on the forecast balance sheet, which compare the assets without cash to the liabilities without short-term debt. If the assets are greater than liabilities, the model assumes there is a requirement for loans. In the event that liabilities are greater than assets, the model adds the balance to cash.

Liabilities

Figure 6.35

No	Liabilities	USD'000,000	Dec-09	Dec-10	Dec-11
B28	Short Term Bank Loans		790.0	325.1	-
B29	Trade Creditors (Payables)		4,844.0	5,197.2	5,561.0
B30	Other Creditors		-	-	-
B31	Other Current Liabilities		3,576.0	3,836.8	4,105.3
B32	Current Liabilities		9,210.0	9,359.1	9,666.3
B33	Long Term Bank Loans		30,038.0	31,995.3	34,235.0
B34	Long Term Liabilities		30,038.0	31,995.3	34,235.0
B35	Tax/Deferred Taxation		6,635.0	7,151.9	7,652.5
B36	Long Term Liabilities and Provisions		36,673.0	39,147.2	41,887.5
B37	Ordinary Shares (Common Stock)		54,328.0	54,328.0	54,328.0
B38	Profit and Loss Reserve (Retained Earnings)		3,602.0	5,243.6	7,019.0
B39	Shareholders' Funds		57,930.0	59,571.6	61,347.0
B40	Minorities/Deferred Accounts		101.0	101.0	101.0
B41	Total Liabilities and Equity		103,914.0	108,178.9	113,004.8
	Checksum: No Errors		-	-	-

The balance sheet self-checks and there are no errors at the bottom in row 43 (see Figure 6.35). If there are errors of addition, an error message is displayed.

With the completed financial statements, you can review the figures for obvious logic and formula errors and then examine the trends in the figures. The sales growth has to be financed and therefore you would expect to see changes in the structure of the balance sheet:

- fixed assets – new and replacement assets;
- requirement for new debt and consequent changes in gearing;
- debtors + inventory – creditors = funding gap;
- discretionary funding = new loans and equity.

New funding requirement, expressed simply in this model as cash, is either positive or negative and makes the balance sheet assets equal liabilities. This is shown in cash or short-term debt.

The second stage of the forecast is to copy forward to cash flow and ratios information to new worksheets. You can then update the cell formulas to point at FIncome and FBalance. Since the logic on the cash flow worked with the historic sheet, it must also work when using data from the forecast (see Figure 6.36).

The formula in cell N15, change in current assets, calculates the difference between the two balance sheet dates:

```
=SUM(FBalance!M12:FBalance!M14) - SUM (FBalance!N12 : FBalance!N14)
```


Figure 6.36

Forecast cash flow

Line	Item	USD'000,000	Dec-09	Dec-10	Dec-11
			Actual	Forecast	Forecast
C10	Net Operating Profit (NOP)		3,514.0	3,705.0	4,098.0
C11	Depreciation / Amortisation		-	1,940.5	1,943.4
C12	Earnings before Interest, Tax, Depreciation and		3,514.0	5,645.2	6,041.5
C14	Operating Items				
C15	(-)/+ Current Assets		1,205.0	(1,621.4)	(968.7)
C16	+(-) Current Liabilities		(1,607.0)	614.0	632.4
C17	Net Operating Cash Flow (NOCF)		3,112.0	4,638.3	5,015.1
C18	Returns on Investment and Servicing of Finance				
C20	Interest Received		-	70.8	-
C21	Interest Paid		(1,533.0)	(1,601.8)	(1,619.8)
C22	Dividends		(117.0)	(1,347.3)	(161.3)
C23	Net Cash Outflow from Returns on Investment:		(1,650.0)	(1,578.3)	(1,751.1)
C24	Taxation				
C25	Taxes Paid		(927.0)	(940.3)	(1,001.8)
C26	Deferred Tax		1,020.0	516.9	500.6
C27	Net Cash Outflow for Taxation		175.0	(423.4)	(518.0)
C29	Investing Activities				
C30	Expenditure on Property, Plant and Equipment		(1,388.0)	(2,000.0)	(2,000.0)
C31	Expenditure on Investments, LT Assets & Intan		(3,763.0)	(3,688.0)	(3,688.0)
C32	Marketable Securities		-	-	-
C33	Net Cash Outflow for Capital Expenditure and f		(5,149.0)	(5,688.0)	(5,588.0)
C35	Exceptional and Minoritg Items				
C36	Exceptional Income and Expense		(3,456.0)	35.0	35.0
C37	Net Cash Outflow from Exceptional and Minori		(2,456.0)	35.0	35.0
C39	Reconciliation				
C40	Reconciliation Figure		(285.0)	-	-
C41	Total Cash (Outflow)/Inflow before Financing		(6,253.0)	(2,908.4)	(1,806.9)
C43	Financing				
C44	Share Capital and Reserves		1,422.0	-	-
C45	Short Term Debt and Provisions		(5,356.0)	(464.9)	(325.1)
C46	Long Term Debt and Provisions		12,342.0	1,957.3	2,239.7
C47	Net Cash Inflow/(Outflow) from Financing		6,908.0	1,492.4	1,914.5
C49	Increase / (Decrease) in Cash		655.0	(1,416.0)	107.6

The other cells all follow exactly the logic in the Cashflow sheet. The advantage is now a longer period to view:

- EBITDA;
- net operating cash flow (NOCF);
- cash flow before financing;
- cash movement.

The ratios are forecast using the same method in FRatios, by copying forward and then using Home, Editing, Find & Replace (Excel 2003 – Edit, Replace) to update the cells and then copy to the right (see Figure 6.37).

The text on the right refers to the last two years actual and the first year of the forecast to provide some information on the direction of the ratios. If

the forecast is better than the last two years', the cell displays 'Better' and if there is an improvement over one of two years, displays 'OK'. If the ratio has deteriorated, the cell reads 'Worse'. The formula in cell R11 reads:

Forecast ratios

Figure 6.37

Line	Item	USD'000,000	Reference	Dec-09	Dec-10	Dec-11
				Actual	Forecast	Forecast
Core Ratios						
R11	Return on Sales (NPAT/Sales %)		P24/P10	4.17	4.84	4.70
R12	Asset Turnover (Sales / Total Assets)		P10/B24	0.34	0.35	0.36
R13	Asset Leverage (Total Assets/Equity)		B24/B39	1.79	1.82	1.84
R14	Return on Equity (NPAT/Equity %)		P24/B38	2.53	2.93	3.08
Profitability						
R18	Gross Profit / Sales (%)		P12/P10	9.99	15.00	15.00
R19	Net Operating Profit / Sales (%)		P16/P10	9.98	9.84	10.17
R20	Profit before Tax / Sales (%)		P22/P10	8.80	7.14	7.23
R21	Return on Capital Employed (ROCE)		P16/B39-B33	3.99	4.05	4.29
R22	Return on Invested Capital (ROIC)		P16*(1-T)/B28+33+39	5.49	5.44	5.79
R23	Return on Assets (ROA)		P16/B24	3.38	3.43	3.63
Operating Efficiency						
R27	Inventory Days		B13/P11	-	-	-
R28	Trade Receivables (Debtor) Days		B12/P10	55.07	62.18	62.18
R29	Creditors Days		B29/P11	55.84	59.28	59.29
R30	Funding Gap Debtors+Inventory-Creditors		R25-R26-R27	(0.76)	2.90	2.90
R31	Working Capital Turnover		P10/B12.13-B29	75.82	30.96	30.96
Financial Structure						
R35	Current Ratio		B15/B32	1.00	1.01	1.05
R36	Quick Ratio (Acid Test)		B15-B13/B32	1.00	1.01	1.05
R37	Working Capital (Thousands)		B15-B32	15	51	510
R38	Gross Gearing (%)		B28-B33/B39	53.22	54.25	55.81
R39	Net Gearing (%)		B28-B33-B10-11/B39	50.77	54.25	55.63
R40	Solvency (Times Interest Earned)		P18/P17	2.29	2.47	2.58
R41	Total Equity/Total Assets		B39/B24	55.75	55.07	54.29

```
=IF(P11=0,"N/A",IF(O11=0,"N/A",IF(AND(Q11>P11, Q11>O11)
,"Better",IF(OR(Q11>P11,Q11>O11),"OK", "Worse"))))
```

FINANCIAL ANALYSIS

The qualitative analysis shows an improving financial position with solid cash flow over the forecast period. Such a scenario may or may not be achievable by the management team, but were it to achieve these figures then cash flow and return ratios certainly improve as per the summary shown in Figure 6.38.

Two more schedules in the application assist with analysis: they are called Management_Summary and Management_Analysis. The first looks up important lines in the other schedules and puts together the summary of

the income statement, balance sheet, cash flow and ratios. The tests on the right try to assist with pinpointing the rows for management attention in the first year of the forecast.

The Management_Analysis looks up each line from the four forecast schedules in rows 79 to 224 and uses a control and an OFFSET function to form a dynamic graph. This enables you to analyse a line on three graphs:

- line graph with three series, historic, forecast and historic trend line, extrapolated by five years;
- block graph of the historic and forecast figures;
- block graph of the factors where the first period is equal to 100.

Figure 6.38

Management summary

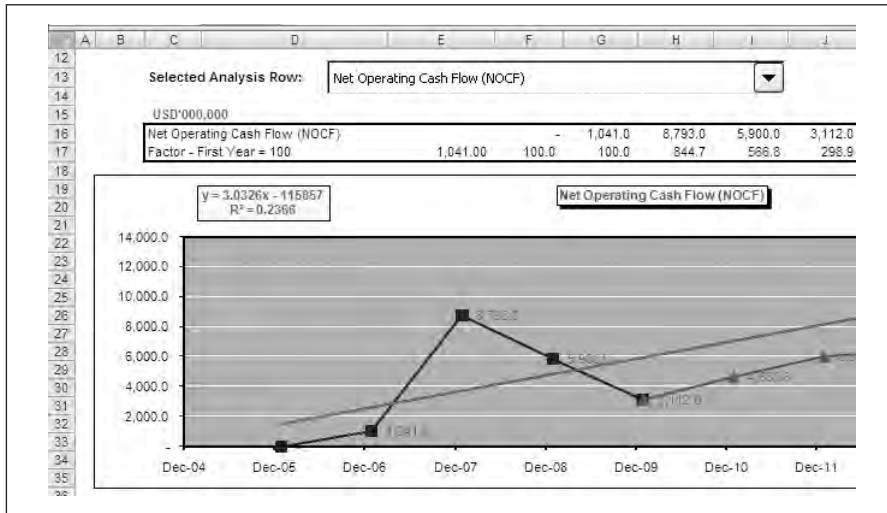
8	A	B	C	D	E	J	K	L
9	Line	Item	Reference	Dec-09	Dec-10	Dec-11		
10	MS10	Sales	P10	35,179.0	37,641.5	40,276.4	Actual	Forecast
11	MS11	Sales growth	F12	(10.0%)	7.0%	7.0%		
12	MS12	Gross Margin	P12	3,514.0	5,646.2	6,041.5		
13	MS13	Net Operating Profit (NOP)	P16	3,514.0	3,705.8	4,098.0		
14	MS14	Net Profit after Tax (NPAT)	P24	1,466.0	1,746.3	1,891.7		
15								
16	MS16	Current Assets	B15	9,205.0	9,410.4	10,176.7		
17	MS17	Non Current and Fixed Assets	B22	94,709.0	98,769.6	102,825.1		
18	MS18	Current Liabilities	B32	9,210.0	9,359.1	9,666.3		
19	MS19	Long Term Liabilities and Provisions	B36	36,673.0	39,147.2	41,887.5		
20	MS20	Shareholders' Funds	B39	57,930.0	59,571.6	61,347.0		
21								
22	MS22	Net Operating Cash Flow (NOCF)	C17	3,112.0	4,638.8	6,015.1		
23	MS23	Total Cash (Outflow)/Inflow before Financ	C42	(5,253.0)	(2,306.4)	(1,806.9)		
24	MS24	Increase / (Decrease) in Cash	C50	655.0	(1,416.0)	107.8		
25								
26	MS26	Return on Sales (NPAT/Sales %)	P24/P10	4.17	4.64	4.70		
27	MS27	Asset Turnover (Sales / Total Assets)	P10/B24	0.34	0.35	0.36		
28	MS28	Asset Leverage (Total Assets/Equity)	B24/B39	1.79	1.82	1.84		
29	MS29	Return on Equity (NPAT/Equity %)	P24/B39	2.63	2.93	3.08		

An example of the historic and forecast net operating cash flow is shown in Figure 6.39. This method illustrates clearly the reduction in cash flow in the most recent period. The forecast is rising according to expectations, and this merits further investigation.

The advantage of this method is that you can view each line, because none of the lines is hard coded and you can see immediately the link between the past and the future. You can change the inputs on the Forecast sheet to see the result on the ratios or cash flow. In this example, net operating cash flow is variable and therefore the next stage would be to review the operating cycle ratios, such as debtor or creditor days, and then the requirement for new funding and the borrowing ratios.

Dynamic chart

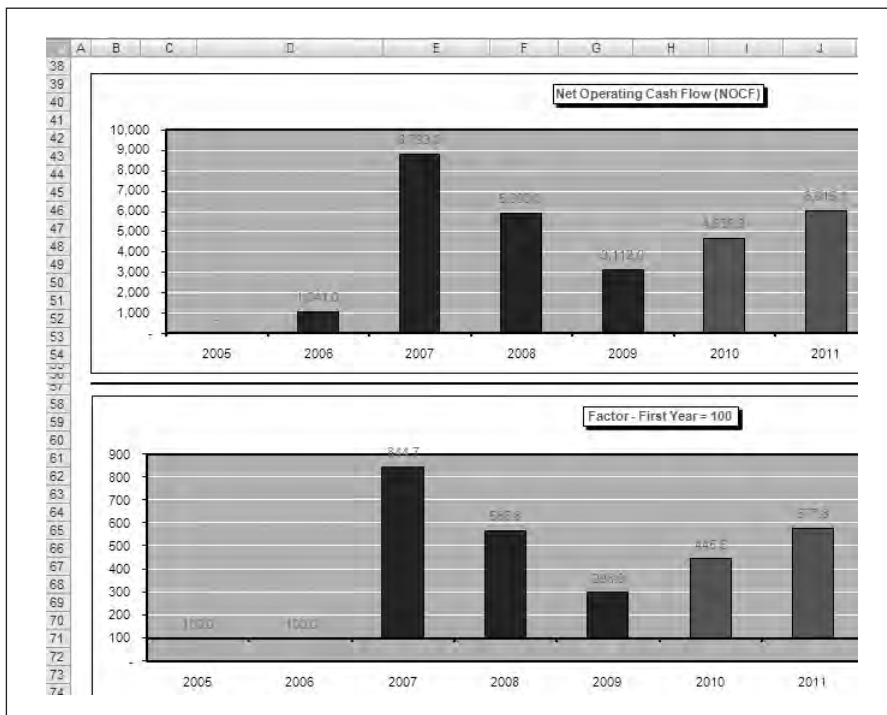
Figure 6.39



The second set of block graphs (see Figure 6.40) contains one series, but the individual points are formatted differently. The pattern on the forecast was produced by selecting the individual data point, right clicking it, and then formatting patterns.

Block graphs

Figure 6.40



The forecast has shown a favourable position, but the company would exhibit worse prospects if the same pattern as for the previous year were to be repeated. The sales decline, and the cost of goods sold remains high. This squeezes profits and cash flow, and cash is still expended on capital expenditure and investments. Debt increases to fund the outgoings (see Figure 6.41).

Figure 6.41

Revised forecast

	A	B	C	J	K	L	M
8	Line	Item	Dec-09	Dec-10	Dec-11	Dec-12	
9			Actual	Forecast	Forecast	Forecast	
10		Forecast					
11	F11	Initial sales	35,179.0	31,661.1	28,495.0	25,645.5	
12	F12	Sales growth	(10.0%)	-10.0%	-10.0%	-10.0%	
13	F13	Costs of goods sold/Sales	90.0%	90.0%	90.0%	90.0%	
14	F14	Depreciation rate	-	0.0%	0.0%	0.0%	
15	F15	SG&A/Sales	-	0.0%	0.0%	0.0%	
16	F16	Interest paid on debt	5.0%	5.0%	5.0%	5.0%	
17	F17	Interest earned on cash	29.1%	29.1%	29.1%	29.1%	
18	F18	Exceptionals/Sales	-	0.0%	0.0%	0.0%	
19	F19	Marginal tax rate	38.7%	38.7%	38.7%	38.7%	
20	F20	Dividend payout ratio	8.0%	8.0%	8.0%	8.0%	
21	F21	Fixed assets increase	1,386	1,386	1,386	1,386	
22	F22	Intangibles increase	3,943	3,943	3,943	3,943	
23	F23	Current assets/Sales	22.1%	22.1%	22.1%	22.1%	
24	F24	Current liabilities/Sales	23.9%	23.9%	23.9%	23.9%	
25	F25	Debt/Sales	87.6%	87.6%	87.6%	87.6%	
26	F26	Deferred tax/Sales	18.9%	18.9%	18.9%	18.9%	
27	F27	New Equity	1,422	-	-	-	
28	F28	Current Share Price	13.00	13.00	13.00	13.00	

The accounts become weaker in the key areas of operating efficiency, profitability and financial structure as borrowings rise and solvency ratios fall (see Figures 6.42 and 6.43). Profitability remains static at the previous period's levels, but the return on capital and asset falls. This would be an unacceptable position for bankers and shareholders.

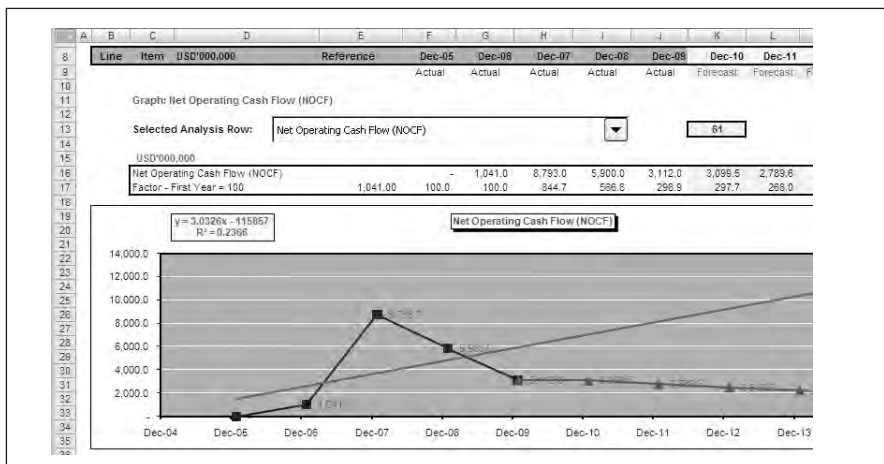
Revised ratios

Figure 6.42

Line	Item	USD'000,000	Reference	Dec-09	Dec-10	Dec-11
				Actual	Forecast	Forecast
Core Ratios						
R11	Return on Sales (NPAT/Sales %)		P24/P10	4.17	4.82	4.04
R12	Asset Turnover (Sales / Total Assets)		P10/B24	0.34	0.30	0.26
R13	Asset Leverage (Total Assets/Equity)		B24/B39	1.79	1.80	1.85
R14	Return on Equity (NPAT/Equity %)		P24/B39	2.53	2.57	1.90
Profitability						
R18	Gross Profit / Sales (%)		P12/P10	9.99	9.99	9.99
R19	Net Operating Profit / Sales (%)		P16/P10	9.99	9.99	9.99
R20	Profit before Tax / Sales (%)		P22/P10	6.80	7.67	8.59
R21	Return on Capital Employed (ROCE)		P16/B39+B33	3.99	3.63	3.33
R22	Return on Invested Capital (ROIC)		P16*(1-T)/B28+33+39	5.49	4.70	3.67
R23	Return on Assets (ROA)		P16/B24	3.38	2.95	2.55
Operating Efficiency						
R27	Inventory Days		B13/P11	3	-	-
R28	Trade Receivables (Debtor) Days		B12/P10	55.07	55.07	55.07
R29	Creditors Days		B29/P11	55.84	55.84	55.84
R30	Funding Gap Debtors-Inventories-Creditors		R25-R26-R27	(0.76)	(0.76)	(0.76)
R31	Working Capital Turnover		P10/B12.13-B29	75.82	75.82	75.82
Financial Structure						
R35	Current Ratio		B15/B32	1.00	0.51	0.30
R36	Quick Ratio (Acid Test)		B15-B13/B32	1.00	0.51	0.30
R37	Working Capital (Thousands)		B15-B32	(5)	(6,850)	(14,437)
R38	Gross Gearing (%)		B28-B33/B39	53.22	57.31	64.36
R39	Net Gearing (%)		B28-B33-B10-11/B39	50.77	57.31	64.36
R40	Solvency (Times Interest Earned)		P16/P17	2.29	2.12	2.06
R41	Total Equity/Total Assets		B39/B24	55.75	55.46	54.14
Cashflow Ratios						
R45	EBITDA / Sales (%)		C12/P10	9.99	9.99	9.99
R46	Net Operating Cash Flow/Sales		C17/P10	8.85	9.79	9.79
R47	Cash Flow before Financing/Sales		C42/P10	(17.77)	(14.55)	(17.15)

Revised net operating cash flow

Figure 6.43



SUMMARY

The financial analysis model can be built up from the templates for the income statement and balance sheet. Ratios and cash flows are derived to examine the key areas of risk which affect the operating cash flow. The model supports other non-financial data about a company and should show the risk inherent as evidenced in the accounts.

Forecasts are useful for understanding the performance or key drivers producing value. In particular, forecasts can reveal the requirement for capital expenditure or new debt. Alternatively, they can be used to check client forecasts. The model has shown that the example cash flows are volatile and that the trading position is worsening. Using a different forecast illustrates the uncertainty of future trading, and the next stage is to introduce methods for examining loan cover and models for bankruptcy analysis.

Credit risk

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Springgate analysis

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Logit analysis

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H-Factor model

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Ratings agency

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Summary

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INTRODUCTION

The previous chapter reviewed a financial analysis model in terms of the sources of risk inherent in the financial statements and forecasts. This chapter extends the model to include credit risk models to show the ability of a company to repay debt or to remain solvent during a forecast period. The existing forecast model provides forecast cash flow and ratios schedules. However, the analysis needs to reveal any inherent weaknesses with the company. If a bank grants credit and the client becomes insolvent and is unable to repay, the potential losses usually outweigh the potential margin many times. Not only are there capital losses but also increased costs in terms of administration, legal and other costs. Therefore it would improve the analysis if the credit model could look for signs of financial weakness.

There are many reasons for financial weakness, but here are some of the main ones:

- cyclical decline in demand and failure to react to a changing environment;
- weak management with a lack of a coherent strategy or conflict at board level;
- lack of centralized financial control and direction;
- poor acquisitions or lack of integration strategy;
- inappropriate product, market strategy or an inward-looking product mentality;
- wrong financial policy, poor working capital management or a failure to control overheads;
- problems with new projects or products.

Risk increases with each of the above and a marked deterioration in ratios is often evident. The signs could be:

- liquidity – reduced working capital, reduced creditor days and increased stock and debtor days;
- profitability – reduced profits and return on assets and capital: reduced profits will mean a falling interest cover;
- financial structure – increased loans and gearing, which will lead to increased interest charges and lower profits in the future;
- cash flow – reduced cash flow perhaps augmented by one-off sales of assets or subsidiaries to reduce debts;
- market – falling share price, earnings per share and market to book ratio.

Cash flow

Figure 7.1

Line	Reference	USD'000.00	Dec-06	Dec-07	Dec-08	Dec-09
FC10	Free Cash Flow					
FC11	Operating Profit (NOP)	C10	(942.0)	7,888.0	8,153.0	3,514.0
FC12	Depreciation / Amortisation / Non-cash Items	C11				
FC13	Earnings before Interest, Tax, Depreciation and Amortisation (E	FCF11.12	(942.0)	7,888.0	8,153.0	3,514.0
FC14	Changes in Net Working Assets	C15.16	1,383.0	905.0	(2,253.0)	(402.0)
FC15	Net Operating Cash Flow (NOCF)	FCF13.14	1,041.0	8,793.0	5,900.0	3,112.0
FC16	Expenditure on Property, Plant and Equipment /Proceeds of Sale	C31.32	(54,557.0)	(4,183.0)	(8,015.0)	(5,149.0)
FC17	Net Cash Outflow for Taxation	C28	4,338.0	(1,590.0)	(4,390.0)	175.0
FC18	Operating Free Cashflow	FCF15.17	(49,178.0)	3,020.0	(6,505.0)	(1,862.0)

CASH FLOW

For any lender the levels of cash flow confirm the cash available to meet further commitments (see Figure 7.1). The Loan Cover sheet sets out the categories:

- earnings before interest, taxation, depreciation and amortization (EBITDA) as the net operating profit plus the non-cash items such as depreciation and amortization;
- net operating cash flow (NOCF) as the EBITDA less changes in working capital such as debtors, creditors, stock, prepayments and accruals – this is the primary cash from trading operations;
- operating free cash flow as the net operating cash flow less expenditure on fixed assets and investments and taxation.

There are several definitions of free cash flow to define the cash available to specific stakeholder groups. This is the cash available to pay dividends to shareholders and interest and principal to debt providers. Adjustments may be required for off balance sheet debt and contingencies. An alternative definition would deduct dividends to form the cash flow available to debt providers. Nevertheless, the method provides a meaningful measure of cash flow.

COVER RATIOS

The Loan Cover sheet includes a calculator for estimating the amount of cash required on a new loan. An annual rental is calculated based on a period, nominal interest rate, capital value and terminal or future value. The model computes the annual rental and then the level of cover created by the different cash flow lines. This is simply the cash that has to be found rather than loan amortization plus interest. For example, solvency ratios concentrate on the times interest is earned rather than cash whereas this is an estimate of cash covers.

Here a loan of 10 million is derived over a five-year period at a rate of 10 per cent nominal (see Figure 7.2). This is a time value of money problem and can be solved using the PMT function. Cell E18 calculates the annual payment using the function. There is an IF condition to ensure that all entries are present before a rental is calculated.

Loan cover

Figure 7.2

The screenshot shows an Excel spreadsheet with the following data:

Cell	Label	Value
F29	Formula Bar	=IF(SUM(F23:F26)<>0,PMT(F24,F23,-ABS(F25),F26,D55),0)
F23	Period (Years)	5.00 yrs
F24	Interest Rate	10.00%
F25	Capital Value USD'000,000 PV	2,500.00
F26	Future or Terminal Value FV	0.00
F27	Advance or Arrears Payments	Advance
F29	Annual Rental USD'000,000	

=IF (SUM (E12 : E15) <> 0, PMT (E13 , E12 , -ABS (E14) , E15 , D71) , 0)

The annual rental can then be used to derive covers against the cash flow lines. The cash flow is volatile and whilst the covers increase against operating profit and EBITDA, the cover at the NOCF level is declining. The level is also lower in the forecast period based on the forecast in the previous chapter. When capital expenditure, investments and taxation are taken into account, the covers are negative since the trading cash is being absorbed by investment (see Figure 7.3). If the cash flow is negative, the proposed loan can only be covered by new loans or share capital. In the example, net loans have increased by 6 billion dollars in the last year and share capital by 1.4 billion.

Times cover

Figure 7.2

The screenshot shows the following data:

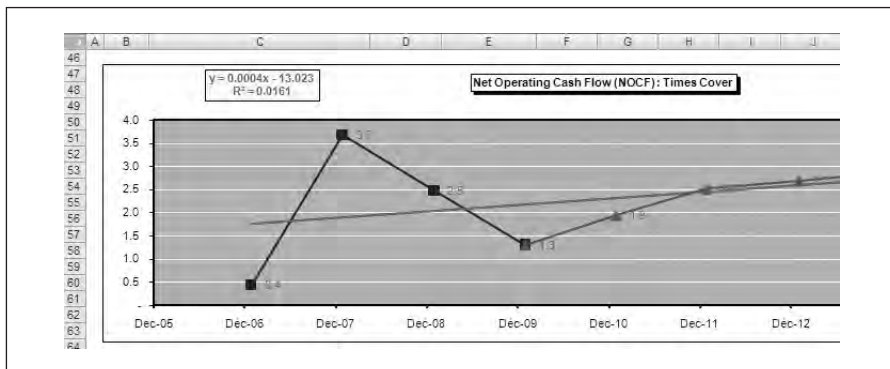
Line	Reference	USD'000,00	Dec-06	Dec-07	Dec-08	Dec-09
Free Cash Flow						
FC34	Operating Profit (NOP) : Times Cover		(1.57)	13.16	13.60	5.86
FC35	Earnings before Interest, Tax, Depreciation and Amortisation (EBITDA) : Times Cover		(1.57)	13.16	13.60	5.86
FC36	Net Operating Cash Flow (NOCF) : Times Cover		1.74	14.67	9.84	5.19
FC37	Operating Free Cashflow : Times Cover		(82.03)	5.04	(10.85)	(3.11)

The dynamic chart (see Figure 7.4) shows clearly the variance in the net operating cash flow and the risk to any lender in advancing more funds to

the company. The forecast appears to rise and therefore an analyst can question the reality of the projection and the management’s ability to deliver the cash flow.

Figure 7.4

Net operating cash flow times cover



Sensitivity

With the initial model in place, one key area of risk is the sales growth. The forecast shows a 7 per cent growth, but one could question what happens to the covers if the sales growth is lower or higher. Sales growth is important since it drives costs and investment.

There is a sheet called Loan Cover Sensitivity, which looks up information from a data table at the bottom of the Forecast sheet (see Figure 7.5). You cannot look up information on a data table on another sheet and therefore the solution is to locate the table in workings on the forecast sheet and then look up the information on a reporting sheet.

Figure 7.5

Loan Cover Sensitivity sheet

		4.0%	5.0%	
F41	Operating Profit (NOP)	3,705.8	3,547.5	3,600.2
F42	Depreciation / Amortisation / Non-cash Items	1,940.5	1,940.5	1,940.5
F43	Earnings before Interest, Tax, Depreciation and Amortisation (EBITDA)	5,646.2	5,487.9	5,540.7
F44	Changes in Net Working Assets	(1,007.4)	(998.9)	(1,000.4)
F45	Net Operating Cash Flow (NOCF)	4,638.8	4,491.1	4,540.3
F46	Expenditure on Property, Plant and Equipment / Proceeds of Sale	(5,588.0)	(5,588.0)	(5,588.0)
F47	Net Cash Outflow for Taxation	(790.1)	(733.3)	(776.1)
F48	Operating Free Cashflow	(1,372.6)	(1,689.5)	(1,597.9)
F49	Cash Flow - Minimum Values		-	-
F50	Operating Profit (NOP) : Times Cover	1.55	1.48	1.50
F51	Earnings before Interest, Tax, Depreciation and Amortisation (EBITDA) : Time	2.35	2.29	2.31
F52	Net Operating Cash Flow (NOCF) : Times Cover	1.93	1.87	1.89
F53	Operating Free Cashflow : Times Cover	(0.57)	(0.89)	(0.65)

Figure 7.6

Data table

Line	Item	USD'000,000	4.00%	5.00%	6.00%
Sensitivity Table based on Constant Sales Growth - Minimum Values					
S11	Operating Profit (NOP)		3,547.5	3,600.2	3,653.0
S12	Depreciation / Amortisation / Non-cash Items		1,940.5	1,940.5	1,940.5
S13	Earnings before Interest, Tax, Depreciation and Amortisation (EBITDA)		5,487.9	5,540.7	5,593.5
S14	Changes in Net Working Assets		(999.9)	(1,000.4)	(1,003.9)
S15	Net Operating Cash Flow (NOCF)		4,488.0	4,540.3	4,589.6
S16	Expenditure on Property, Plant and Equipment / Proceeds of Sale		(5,588.0)	(5,588.0)	(5,588.0)
S17	Net Cash Outflow for Taxation		(783.3)	(776.1)	(767.2)
S18	Operating Free Cashflow		(1,685.5)	(1,567.9)	(1,470.3)
S20	Cash Flow - Minimum Values				
S21	Operating Profit (NOP) : Times Cover		1.48	1.50	1.52
S22	Earnings before Interest, Tax, Depreciation and Amortisation (EBITDA) : Times C		2.29	2.31	2.33
S23	Net Operating Cash Flow (NOCF) : Times Cover		1.87	1.89	1.91
S24	Operating Free Cashflow : Times Cover		(0.65)	(0.65)	(0.61)

The left column uses the function, MIN, to find the minimum along the forecast columns. Cell H41 obtains the minimum on the loan cover sheet since you want to know the low point in the forecast period. The function below returns 18,762.4 (see Figure 7.6).

=MIN(Loan_Cover!J22:N22)

Office 2007 – Data, Data Tools, What-if Analysis (Excel 2003 – Data, Table)

The data table is set up to use the sales growth on the forecast grid at cell Forecast!K12 as the input. The sales growth is along the top of the table and the elements down the left-hand side. This means that you can obtain the results for each of the cash flow lines and covers for differing levels of sales growth. With only one variable, you only need an input for the row input cell (see Figure 7.7).

Data table entry

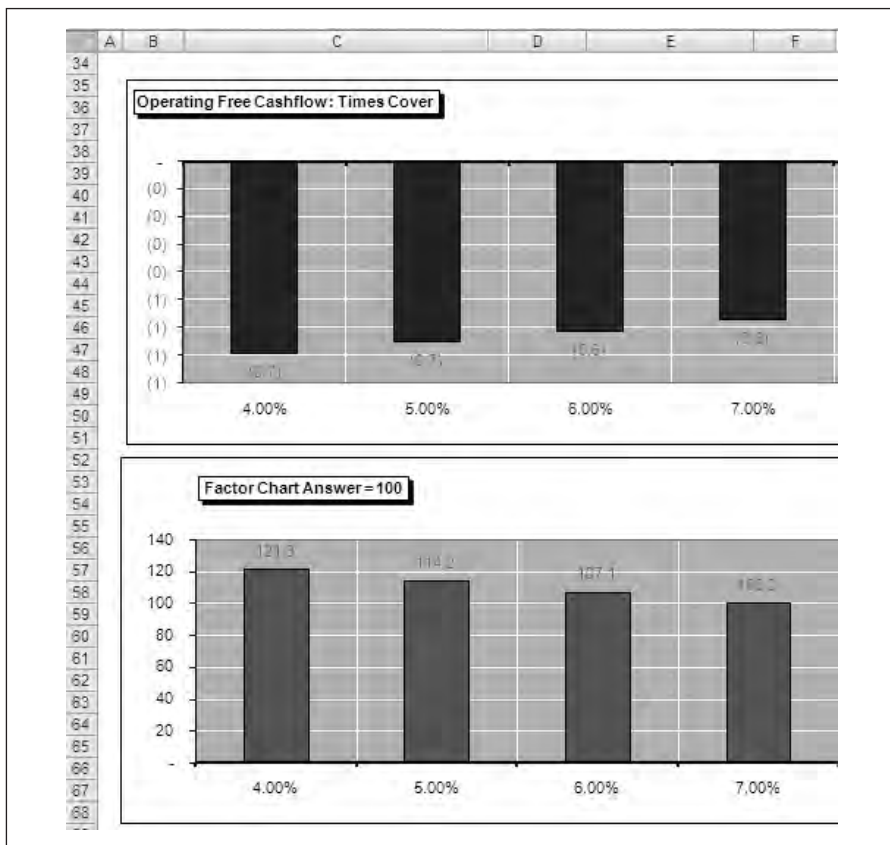
Figure 7.7

	G	H	I	J	K	L	M	N	O
38	Minimum Values								
39									
40			4.0%	5.0%	6.0%	7.00%	8.0%	9.0%	10.0%
41		3,705.8	3,547.5	3,600.2	3,653.0	3,705.8	3,758.5	3,811.3	3,864.1
42		1,940.5	1,940.5	1,940.5	1,940.5	1,940.5	1,940.5	1,940.5	1,940.5
43	(TDA)	5,646.2	5,646.2	5,646.2	5,646.2	5,646.2	5,699.0	5,751.8	5,804.5
44		(1,007.4)	(1,007.4)	(1,007.4)	(1,007.4)	(1,007.4)	(1,010.9)	(1,014.5)	(1,018.0)
45		4,638.8	4,638.8	4,638.8	4,638.8	4,638.8	4,688.1	4,737.3	4,786.6
46		(5,588.0)	(5,588.0)	(5,588.0)	(5,588.0)	(5,588.0)	(5,588.0)	(5,588.0)	(5,588.0)
47		(790.1)	(790.1)	(790.1)	(790.1)	(790.1)	(811.4)	(830.3)	(846.5)
48		(1,372.6)	(1,372.6)	(1,372.6)	(1,372.6)	(1,372.6)	(1,275.0)	(1,177.4)	(1,079.8)
49									
50		1.56	1.56	1.56	1.56	1.56	1.57	1.59	1.61
51	(TDA) : Time	2.38	2.29	2.31	2.33	2.35	2.38	2.40	2.42
52		1.93	1.87	1.89	1.91	1.93	1.95	1.98	2.00
53		(0.67)	(0.68)	(0.65)	(0.61)	(0.57)	(0.53)	(0.49)	(0.45)

On the Loan Cover Sensitivity sheet, you can see the results with a chart for each of the key lines (see Figure 7.8). This fits with the modularity of the model with a separate report for management purposes.

Figure 7.8

Sensitivity charts

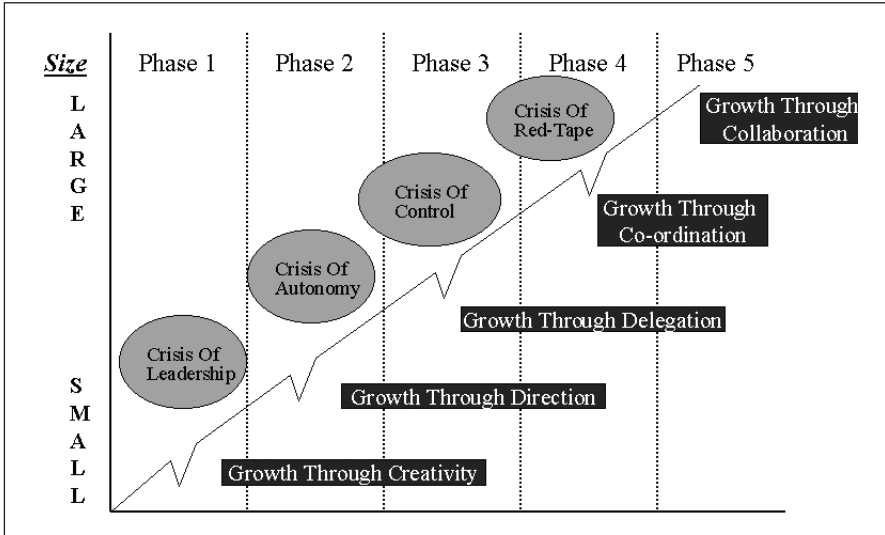


SUSTAINABILITY

Two areas of financial analysis can be difficult to ascertain from the figures: growth and decline. Figure 7.9 is the classic 1972 Greiner model showing the crises of growth for a young company. Organizations typically grow and pass through a number of stages with periods of rapid and slower growth. Particularly small companies are undercapitalized and show signs of overtrading. Mature companies become inefficient and start to decline. For these reasons, models of management competence often focus on these stages in company evolution as exhibiting a greater risk of insolvency.

Greiner growth model

Figure 7.9



The models in this section on the Growth sheet demonstrate methods for highlighting overtrading where a company's retained profits and existing resources are not sufficient to fund the actual growth percentages. There are a number which seek to show ratios of available resources and the degree of overtrading.

Growth model (1)

Figure 7.10

Line	Item	USD'000,000	Dec-09	Dec-10	Dec-11	Dec-12
G10	Sales		35,179.0	37,641.5	40,276.4	43,095.8
G11	G = Sales Growth %		(10.01)	7.00	7.00	7.00
G12	Profit after Tax		2,393.0	2,686.7	2,910.3	3,223.7
G13	Profit after Tax before Depreciation		2,393.0	4,627.1	4,863.7	5,170.0
G14	Dividend		(117.0)	(139.7)	(151.3)	(167.6)
G15	Dividend Percentage		0.08	0.08	0.08	0.08
G16	Net Working Assets		(631.0)	376.4	402.8	431.0
G17	Fixed Assets		38,809.0	38,868.8	38,925.1	38,976.9
G18	Liabilities/Equity		0.53	0.54	0.56	0.58
G19	Profit or (Loss) for the Financial Year		1,384.0	1,841.8	1,775.3	1,962.8
G20	Current Assets		9,205.0	9,410.4	10,176.7	11,694.5
G22	Sustainable Growth		(0.78)	(1.09)	(1.09)	(1.09)
G24	Sustainable Growth % (1)		8.34	12.91	13.58	14.54
G25	Variance Actual-Equilibrium		(16.34)	(5.91)	(6.53)	(7.64)
G27	Sales Growth with same Liabilities/Equi		(0.84)	(0.69)	(0.63)	(0.56)

The model above seeks to show the ability to grow without restraining resources (see Figure 7.10). If there is capacity in fixed assets, then a 1 per

cent growth in sales will need a 1 per cent increase in net working assets. This is given by the first formula on line 22:

$$g = (PATBD - D)/NWA - (PATBD - D)$$

where:

g	sustainable growth
$PATBD$	profit after tax before depreciation
D	dividend
NWA	net working assets.

The assumptions may be slightly unrealistic since a company also needs to invest in fixed assets as it grows. The formula can therefore be extended to include both net working and fixed assets.

$$g = (PATBD - D)/\{(NWA + FA) - (PATBD - D)\}$$

If growth is in excess of the formula, then the company would have the choice of raising extra debt, issuing more shares or reducing the dividend payout. This model shows a sustainable growth below the equilibrium in the last two years after rapid growth in the first two periods. This is also reflected by the relatively unchanged turnover in the last periods.

The last model in this section attempts to ascertain the rate of sales growth that can be achieved while maintaining the same ratio of external liabilities to equity (see Figure 7.11). The formula is:

$$g = \{[(PAT/S) * (1 - (Dividend/PAT)) * (1 + (Liabilities/Equity))]/ \\ \{((FA + CA)/S) - (PAT/S) * (1 - (Dividend/PAT)) \\ * (1 + (Liabilities/Equity))\}\}$$

where:

PAT	profit after tax
S	sales
FA	fixed assets
CA	current assets.

The sustainable rate keeping the liabilities/equity percentage constant is - 0.84 per cent in the last year. The liabilities/equity ratio is 0.53 and this will remain the same with this growth rate.

The second model is based on two formulas:

$$R = \text{Retained earnings/Sales}$$

$$T = \text{Total assets/Sales}$$

$$g = R/T$$

Growth model (2)

Figure 7.11

	A	B	C	D	J	K	L	M
8	Line	Item	USD'000,000	Dec-09	Dec-10	Dec-11	Dec-12	
28								
29	G29	R = Retained Earnings / Sales		3.93	4.38	4.41	4.85	
30	G30	T=TotalAssets/Sales		1.36	1.28	1.22	1.18	
31	G31	Growth from Retained Earnings (R/T)		2.88	3.40	3.62	3.87	
32								
33	G33	Sustainable Growth RE/Opening OF (2)		2.65	3.01	3.18	3.42	
34	G34	Variance Actual-Equilibrium		(12.65)	3.99	3.82	3.58	

This formula is then simplified as:

Retained earnings/Opening owners' funds

Growth in excess of this rate will require extra equity or will cause a weakening of the balance sheet.

The next model (PRAT) derives the sustainable growth by multiplying out the drivers detailed below:

- profit margin (P) as net operating profit/sales
- retained earnings (R) as retained earnings/sales
- asset turnover (A) as sales/total assets
- asset equity (T) as total assets/shareholders' equity.

The sustainable growth is lower in the final periods as the balance sheet has weakened (see Figure 7.12). The reduction is from 7 per cent to 2 per cent, reflecting the same findings as the earlier models.

The last model of equilibrium growth uses the formula:

$$g = \{R * T\} * \text{return on assets}$$

R = retained earnings

T = asset equity

Again, this formula shows a declining equilibrium growth. Figure 7.13 summarizes the findings from the four methods where the high growth in the early periods was higher than could be sustained through retained earnings. The growth in the last two periods has been more restrained and below the maximums indicated by the model.

BEAVER'S MODEL

There are several ratio models for predicting bankruptcy and Beaver's early work reviewed single ratios as important indicators of failure. He identified trends in three key ratios for predicting default (see Figure 7.14):

Figure 7.12

PRAT formula

	A	B	C	D	J	K	L	M
8		Line	Item	USD'000,000	Dec-09	Dec-10	Dec-11	Dec-12
35								
36	G36		Profit Margin (P)		0.04	0.05	0.05	0.05
37	G37		Retained Earnings (R)		0.04	0.04	0.04	0.05
38	G38		Asset Turnover (A)		0.34	0.35	0.36	0.36
39	G39		Asset Equity (T)		1.79	1.82	1.84	1.87
40	G40		Sustainable Growth (PRAT) (3)		1.00	1.28	1.36	1.51
41	G41		Variance Actual-Equilibrium		(11.00)	5.72	5.64	5.49
42								
43	G43		Return on Assets		3.38	3.43	3.63	3.81
44	G44		Retention * Leverage R*T		0.07	0.08	0.08	0.09
45	G45		Equilibrium Growth = (RT * ROA) (4)		2.38	2.71	2.94	3.25
46	G46		Variance Actual-Equilibrium		(12.39)	4.29	4.06	3.75

Figure 7.13

Growth model summary

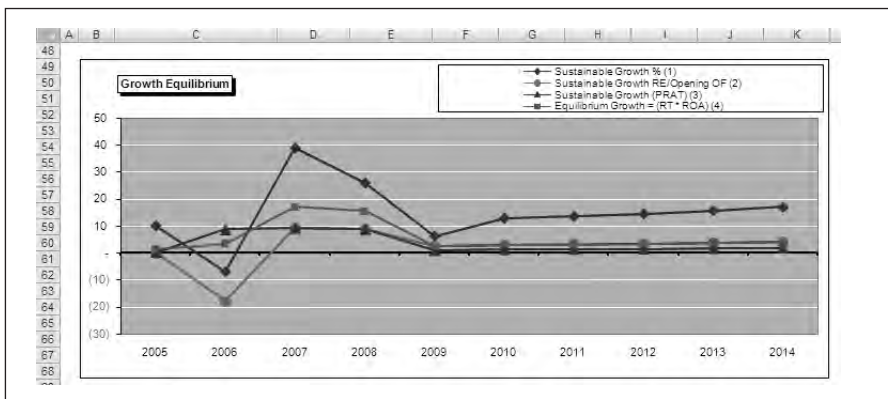


Figure 7.14

Beaver's model

	A	B	C	D	E	L	M	N	O	
8		Ref	Item			Dec-09	Dec-10	Dec-11	Dec-12	
9						Actual	Forecast	Forecast	Forecast	
10			Beaver Model							
11	Z011		Cash flow / total debt			(0.06)	(0.04)	(0.00)	0.01	
12	Z012		Net income / total debt			0.05	0.05	0.06	0.06	
13	Z013		Total debt / total assets			0.30	0.30	0.30	0.31	
14										

- operating free cash flow/total debt
- net profit after tax/total debt
- total debt/total assets.

BATHORY MODEL

Whilst single ratios provide part of the answer, it may be unsafe to depend on them. Researchers have studied combinations of ratios which provide some guidance on the tendency towards insolvency. These tend to be ratios of cash flow, debt structure and debt cover. The Bathory model does not try to weight a series of ratios, but instead picks ratios historically associated with company failure and multiplies them out equally (see Figure 7.15). The factors are:

- X1 – Gross cash flow/Current debt;
- X2 – Pre-tax profit/Capital employed;
- X3 – Equity/Current liabilities;
- X4 – Tangible net worth/Total liabilities;
- X5 – Working capital/Total assets.

Gross cash flow is the profit after tax plus depreciation and amortization. Debt includes all sources of debt including leasing and hire purchase. Capital employed is composed of shareholders' funds and loans over one year. Equity means the shareholders' funds, while tangible net worth is the shareholders' funds less intangible assets.

The result here is unconvincing as the score appears to rise whereas all the indicators so far have pointed to a weaker financial situation. On closer examination, the main contender is X3 which rises owing to a reduction in current liabilities. It appears that credit is being squeezed and this leads to an increase in the ratio and the overall score. Given that there are equal weights, this would seem an unscientific method of determining potential financial weakness.

Bathory model

Figure 7.15

	A	B	C	D	E	L	M	N	O	
8	Ref	Item				Dec-09	Dec-10	Dec-11	Dec-12	
14		Bathory's Model								
15										
16	Z016	X1 - Gross cash flow / current debt				0.048	0.114	0.112	0.110	
17	Z017	X2 - Pretax profit / capital employed				0.040	0.040	0.043	0.045	
18	Z018	X3 - Equity / current liabilities				6.290	6.365	6.346	6.121	
19	Z019	X4 - Tangible net worth / total liabilities				0.071	0.047	0.025	0.007	
20	Z020	X5 - Working capital / total assets				(0.000)	0.000	0.005	0.011	
21										
22		Formula = 0,2 * X1 + 0,2 * X2 + 0,2 * X					1.290	1.313	1.306	1.259
23										

Z SCORES

Altman and others have attempted to find statistical answers to why some companies go bust and others survive. The technique is known as multi-discriminant analysis which uses a sample of companies and then splits them into failed and survivor companies. Studies take a number of ratios and then determine combinations of ratios and weightings which result in a score that predicts failure.

Altman started with 22 ratios and classified them into five ratio groups:

- 1 liquidity
- 2 profitability
- 3 leverage
- 4 solvency
- 5 activity.

The original data sample consisted of 66 firms, half of which had filed for bankruptcy under Chapter 11 of the US bankruptcy code. All businesses in the database were manufacturers, and small firms with assets of less than \$1 million turnover were eliminated. The Z score calculates five ratios:

- $X1 = \text{Working capital}/\text{Total assets}$.
- $X2 = \text{Retained earnings}/\text{Total assets}$. This is a measure of cumulative profitability that should increase with the firm's age as well as earning power. Studies have shown failure rates to be closely related to the age of the business especially for mature companies.
- $X3 = \text{Earnings before income taxes}/\text{Total assets}$. This is a measure of operating efficiency separated from any leverage effects. It recognizes operating earnings as a key to long-term viability.
- $X4 = \text{Market value of equity}/\text{Book value of debt}$. This ratio adds a market dimension, and academic studies of stock markets suggest that security price changes may foreshadow upcoming problems.
- $X5 = \text{Sales}/\text{Total assets}$. This is a standard turnover measure of activity.

The formula calculates a weighted score:

$$1.2 * X1 + 1.4 * X2 + 3.3 * X3 + 0.6 * X4 + 0.999 * X5$$

These ratios are then multiplied by the predetermined weight factors above, and the results are added together. The final number (Z score) normally yields a number between -4 and $+8$. Financially sound companies show Z scores above 2.99, while those scoring below 1.81 are in fiscal danger, maybe even heading toward bankruptcy. Scores that fall between these ends indicate potential trouble. In Altman's initial study of 66 bankrupt

companies, Z scores for 95 per cent of these companies pointed to trouble or imminent bankruptcy.

Although the numbers that go into calculating the Z score (and a company's financial soundness) are influenced by external macro factors, it provides a useful quick analysis of where an organization stands, and a tool for analysing the variances in a company's financial stability over time. In the example below, the deteriorating financial position is clearly visible in the Z score which ends the period at 1.24 within the range for high probability of failure (see Figure 7.16).

Public Z scores

Figure 7.16

Ref	Item	USD'000,000	Reference	Dec-09	Dec-10
Z-Score					
Z025	Working capital / total assets			(0.000)	0.000
Z026	Retained earnings / total assets			0.035	0.048
Z027	EBIT / total assets			0.034	0.034
Z028	Market value equity / total liabilities			1.237	1.180
Z029	Sales / total assets			0.339	0.348
Z Score: If Publicly Held					
Z032	1.2 * Working capital / total assets	2.9	1.200	(0.000)	0.001
Z033	1.4 * Retained earnings / total assets	1.81	1.400	0.049	0.068
Z034	3.3 * EBIT / total assets		3.300	0.112	0.113
Z035	0.6 * Market value equity / total liabilities		0.600	0.742	0.708
Z036	0.999 * Sales / total assets		0.999	0.338	0.348
Z037	Public Z Score Sum		Slope	(104.503)	1.240
				1.237	

The model uses the SUMPRODUCT function from the Functions Library to multiply the factors by the ratios and then adds them to form the score. The probability of failure uses IF statements between the limits of 2.9 and 1.81. The results are 1 for unlikely, 01 for not sure and zero for high, and the colours are set using square brackets as per the custom number format below.

[Black] "Unlikely"; [Red] "Not Sure"; [Black] "High"?_-;_-@_-

Using the sample, Altman gained the results shown in Table 7.1 over five years. The model appeared to provide success of up to 72 per cent over two years.

Altman's results

Table 7.1

Years prior to bankruptcy	N	Hits	Misses	Percentage correct
1	33	31	2	95
2	32	23	9	72
3	29	14	15	48
4	28	8	20	29
5	25	9	16	36

Privately held firms

If a firm's stocks and shares are not publicly traded, the X4 term (Market value of equity/Book value of debt) cannot be calculated. To correct for this problem, the Z score can be re-estimated using book values of equity. This provides the following score:

$$Z \text{ score} = 0.717 * X1 + 0.847 * X2 + 3.107 * X3 + 0.420 * X4 + 0.998 * X5$$

The upper limit is set at 2.9 and the lower limit at 1.23 with the uncertain zone in the middle.

Merchandising and service firms

The X5 (Sales/Total assets) ratio is believed to vary significantly by industry. It is likely to be higher for merchandising and service firms than for manufacturers, since the former are typically less capital intensive. Consequently, non-manufacturers would have significantly higher asset turnovers and Z scores. The model is thus likely to underpredict certain sorts of bankruptcy. To correct for this potential defect, Altman used a correction that eliminates the X5 ratio:

$$Z \text{ score} = 6.56 * X1 + 3.26 * X2 + 6.72 * X3 + 1.05 * X4$$

The upper limit is set at 2.6 and the lower limit at 1.11 with the uncertain zone in the middle. Figure 7.17 displays the results for this example with bankruptcy predicted in all periods. The example is, however, a public company so the results are for illustration only.

Figure 7.17

Private and service scores

	A	B	C	D	E	F	G	L	M	N	
	Ref	Item	USD'000,000	Reference				Dec-05	Dec-10	Dec-11	
41											
42		Z Score: If Privately Held:									
43	Z043	0.717 * Working capital / total assets	2.9		0.717	(0.000)		0.000		0.003	
44	Z044	0.847 * Retained earnings / total assets	1.23		0.847	0.029		0.041		0.053	
45	Z045	3.107 * EBIT / total assets			3.107	0.105		0.106		0.113	
46	Z046	0.042 * Market value equity / total liabilities			0.042	0.052		0.050		0.047	
47	Z047	0.998 * Sales / total assets			0.998	0.338		0.347		0.356	
48	Z048	Private Z Score Sum		Slope	755.042	0.524		0.545		0.571	
49											
50	Z050	% Difference in Z Score:							(25.70)	3.90	4.84
51	Z051	Probability of failure: >2.9=Unlikely, 1.23-2.9=Not Sure, <1.23=High							High	High	High
52											
53		Z Score: If Small Firms & Service & Retail & Wholesale									
54	Z054	6.56 * Working capital / total assets	2.6		6.560	(0.000)		0.003		0.030	
55	Z055	3.26 * Retained earnings / total assets	1.11		3.260	0.113		0.158		0.202	
56	Z056	6.72 * EBIT / total assets			6.720	0.227		0.230		0.244	
57	Z057	1.05 * Sales / total assets			1.050	0.355		0.365		0.374	
58	Z058	Small Firm Z Score Sum		Slope	792.480	0.695		0.757		0.850	
59											
60	Z060	% Difference in Z Score:							32.14	8.81	12.34
61	Z061	Probability of failure: >2.6=Unlikely, 1.11-2.6=Not Sure, <1.11=High							High	High	High

SPRINGGATE ANALYSIS

This model was developed in 1978 by Gordon Springgate, following procedures developed by Altman. Springgate used step-wise multiple discriminate analysis to select 4 out of 19 popular financial ratios that best distinguished between sound businesses and those that actually failed. The Springgate model uses this formula:

$$Z = 1.03A + 3.07B + 0.66C + 0.4D$$

where:

- A = Working capital/total assets
- B = Net profit before interest and taxes/total assets
- C = Net profit before taxes/current liabilities
- D = Sales/total assets.

If $Z < 0.862$ then the firm is classified as 'failed' (see Figure 7.18).

Springgate model

Figure 7.18

	Ref	Item	USD'000,000	Reference	Dec-09	Dec-10	Dec-11	
63		Springgate						
64								
65	Z065	Working capital / total assets			(0.000)	0.000	0.005	
66	Z066	Net profit before interest and taxes / total assets			0.038	0.039	0.040	
67	Z067	Net profit before taxes / current liabilities			0.426	0.448	0.467	
68	Z068	Sales / total assets			0.339	0.348	0.356	
69	Z069							
70	Z070	1.03 * Working capital / total assets		1.030	(0.000)	0.000	0.005	
71	Z071	3.07 * Net profit before interest and taxes / total assets		3.070	0.116	0.119	0.123	
72	Z072	0.66 * Net profit before taxes / current liabilities		0.660	0.281	0.295	0.308	
73	Z073	0.4 * Sales / total assets		0.400	0.135	0.139	0.143	
74	Z074	Sum		Slope	622.142	0.533	0.554	0.578
75								
76	Z076	% Difference in Score:			(19.22)	3.98	4.29	
77	Z077	Probability of failure: <0.862=High		0.862	High	High	High	

This model achieved an accuracy rate of 92.5 per cent using the 40 companies tested by Springgate and can be used in conjunction with other models. Companies achieving low scores may not go bust within the time period and the analysis merely suggests those companies exhibiting risk characteristics.

LOGIT ANALYSIS

The Altman model has been widely used but despite the positive results of his study, Altman's model has some weaknesses for commercial use:

- the model assumes variables in the sample data to be normally distributed;
- beyond two years prior to failure, it has a poorer predictive ability than a random chance model of 50 per cent;
- it is based on small samples so may not be representative;
- it does not eliminate all the problems relating to accounting ratios and book values;
- it is based on US industrial companies.

The Logit model attempts to correct the problem of abnormal distribution. The output from the model is a probability (in terms of a percentage) of bankruptcy (see Figure 7.19). This could be considered a measure of the effectiveness of management since effective management would not allow a company to drift towards bankruptcy.

Application of the Logit model requires four steps:

- 1 Calculation of a series of seven financial ratios.
- 2 Each ratio is multiplied by a coefficient unique to that ratio (coefficient either positive or negative).
- 3 Resulting values are summed together (y).
- 4 The probability of bankruptcy for a firm is calculated as the inverse of $(1 + e^y)$.

Figure 7.19

Logit model

	Ref	Item	USD'000,000	Reference	Dec-09	Dec-10	Dec-11
78							
79							
80		Logit Analysis					
81	Z081	Average inventories / sales			0.172	0.156	0.165
82	Z082	Average receivables / average inventories			-	-	-
83	Z083	Cash + marketable securities / total assets			0.014	-	0.001
84	Z084	Quick assets / current liabilities			0.999	1.005	1.053
85	Z085	Income from continuing operations / (total assets - current liab)			0.041	0.042	0.044
86	Z086	Long-term debt / (total assets - current liab)			0.317	0.324	0.331
87	Z087	Sales / (net working capital + fixed assets)			0.907	0.967	1.021
88							
89	Z089	Constant		0.238	0.239	0.239	0.239
90	Z090	-0.108 * Average inventories / sales		(0.108)	(0.019)	(0.017)	(0.018)
91	Z091	-1.583 * Average receivables / average inventories		(1.583)	-	-	-
92	Z092	-10.78 * Cash + marketable securities / total assets		(10.780)	(0.147)	-	(0.610)
93	Z093	3.074 * Quick assets / current liabilities		3.074	3.072	3.081	3.236
94	Z094	0.486 * Income from continuing operations / (total assets		0.486	0.020	0.021	0.021
95	Z095	-4.35 * Long-term debt / (total assets - current liab)		(4.350)	(1.380)	(1.408)	(1.441)
96	Z096	0.11 * Sales / (net working capital + fixed assets)		0.110	0.100	0.106	0.112
97	Z097	Y = Sum of Ratios and Constant	Slope	507.263	1.886	2.031	2.139
98	Z098	Probability of Bankruptcy	$1/(1+EXP(Y))$		13.2%	11.6%	10.5%

Table 7.2

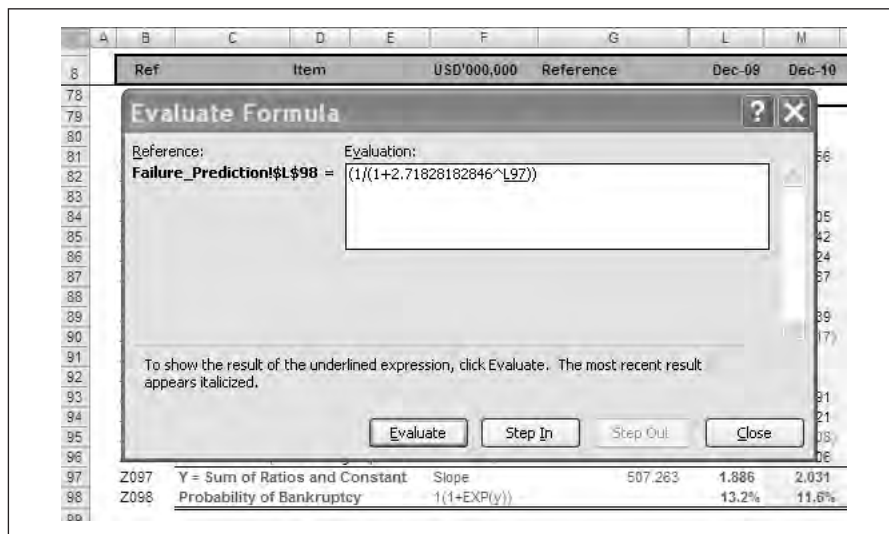
Financial ratio	Coefficient
Constant	+0.23883
Average inventories/sales	-0.108
Average receivables/average inventories	-1.583
(Cash + marketable securities)/total assets	-10.78
Quick assets – current liabilities	+3.074
Income from continuing operations/ (total assets – current liabilities)	+0.486
Long-term debt/(total assets - current liabilities)	-4.35
Sales/(net working capital + fixed assets)	+0.11
y=	Sum of (coefficient*ratio)
Probability of bankruptcy=	$1/(1 + e^y)$

The model uses the ratios above and multiplies them out by the factors shown in Table 7.2.

The formula in cell H98 = $1/(1 + e^y)$. The evaluation using the formula auditing tool at Formulas, Formula Auditing, Evaluate Formula (Excel 2003 – Tools, Formula Auditing, Evaluate Formula) is as in Figure 7.20 repeating the formula $(1 + e^y)$.

Evaluate H98

Figure 7.20



Explanatory variables with a negative coefficient increase the probability of bankruptcy because they reduce e^y toward zero, with the result that the bankruptcy probability function approaches 1/1, or 100 per cent. Likewise, independent variables with a positive coefficient decrease the probability of bankruptcy. The example above shows an increasing probability of bankruptcy (see Figure 7.19).

H-FACTOR MODEL

Fulmer used step-wise multiple discriminate analysis to evaluate 40 financial ratios applied to a sample of 60 companies: 30 failed and 30 were successful. The average asset size of these firms was \$455,000. Fulmer reported a 98 per cent accuracy rate in classifying the test companies one year prior to failure and an 81 per cent accuracy rate more than one year prior to bankruptcy.

The H-factor model takes the following form:

$$H = 5.528(V1) + 0.212(V2) + 0.073(V3) + 1.270(V4) - 0.120(V5) + 2.335(V6) + 0.575(V7) + 1.083(V8) + 0.984(V9) - 6.075$$

where:

V1 = Retained earnings/total assets

V2 = Sales/total assets

V3 = EBIT/equity

V4 = Cash flow/total debt

V5 = Total debt/total assets

V6 = Current liabilities/total assets

V7 = Log tangible total assets

V8 = Working capital/total debt

V9 = Log EBIT/Interest

Constant = 6.075.

Figure 7.21

Fulmer H-Factor

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
8	Ref	Item	USD'000,000	Reference	Dec-09	Dec-10	Dec-11							
100		Fulmer H-Factor												
101														
102	Z102	Retained earnings / total assets			0.035	0.048	0.062							
103	Z103	Sales / total assets			0.339	0.348	0.358							
104	Z104	EBIT / equity			0.065	0.068	0.075							
105	Z105	Cash flow / total debt			0.104	0.145	0.176							
106	Z106	Total debt / total assets			0.289	0.296	0.303							
107	Z107	Current liabilities / total assets			0.089	0.087	0.088							
108	Z108	Log tangible total assets			4.589	4.590	4.590							
109	Z109	Working capital / total debt			(0.000)	0.002	0.015							
110	Z110	Log EBIT / Interest			0.360	0.392	0.409							
111														
112	Z112	5.528 * Retained earnings / total assets		5.528	0.192	0.268	0.343							
113	Z113	0.212 * Sales / total assets		0.212	0.072	0.074	0.078							
114	Z114	0.073 * EBIT / equity		0.073	0.005	0.005	0.008							
115	Z115	1.27 * Cash flow / total debt		1.270	0.132	0.184	0.223							
116	Z116	-0.12 * Total debt / total assets		(0.120)	(0.035)	(0.035)	(0.036)							
117	Z117	2.335 * Current liabilities / total assets		2.335	0.207	0.202	0.200							
118	Z118	0.575 * Log tangible total assets		0.575	2.639	2.639	2.639							
119	Z119	1.083 * Working capital / total debt		1.083	(0.000)	0.002	0.016							
120	Z120	0.984 * Log EBIT / interest		0.984	0.322	0.351	0.365							
121	Z121	Constant		(6.075)	(6.075)	(6.075)	(6.075)							
122														
123	Z123	Sum		Slope	502.559	(2.643)	(2.386)	(2.243)						
124	Z124	Classification			-	Failed	Failed	Failed						

The model multiplies out the factors and adds up the score (see Figure 7.21). If the score is less than zero, the company is classed as failed. Again, this company is classed as failed using this analysis since it has a negative score.

RATINGS AGENCY

One widely used measure of a firm's default risk is its bond rating, which is assigned by an independent ratings agency. The ratings process begins when a company requests a rating from a bond ratings agency. Information is collated from public and company sources and the agency analyses the information to ascertain the company's ability to service and repay the debt. The rating will provide a score of financial strength. Firms that are profitable and have low debt ratios with strong cash flow are more likely to be rated higher than indebted companies with marginal profitability.

This model is introduced on the FRatios_Debt sheet. It produces a score for each year but the scores should be treated as a guide in conjunction with other methods:

- the medians are not intended to be hurdles or scores that have to be achieved to attain a specific rating score;
- caution should be exercised when using the ratio medians for comparisons with specific company or industry data because of major differences in method of ratio computation, importance of industry or business risk, and the impact of mergers and acquisitions;
- since company ratings are designed to be valid over the entire business cycle, ratios of a particular firm at any point in the cycle may not appear to be in line with its assigned debt ratings;
- particular caution should be used when making cross-border comparisons, owing to major differences in accounting principles, financial practices and business environments.

Table 7.3 sets out the characteristics for each category. The financial ratios used to measure default risk are:

- 1 EBIT interest coverage = $\frac{\text{[earnings from continuing operations before interest and taxes]}}{\text{[gross interest incurred before subtracting (1) capitalized interest and (2) interest income]}}$
- 2 EBITDA interest coverage = $\frac{\text{[earnings from continuing operations before interest, taxes, depreciation and amortization]}}{\text{[gross interest incurred before subtracting (1) capitalized interest and (2) interest income]}}$
- 3 Funds from operations/total debt = $\frac{\text{[net income from continuing operations + depreciation, amortization, deferred income taxes and other]}}{\text{[total debt]}}$

- non-cash items)/[long-term debt + current maturities, commercial paper and other short-term borrowings]
- 4 Free operating cash flow/total debt = [funds from operation – capital expenditures, – (+) increase (decrease) in working capital (excluding changes in cash, marketable securities and short-term debt)]/[long-term debt + current maturities, commercial paper and other short-term borrowings]
- 5 Return on capital = EBIT/[average of beginning of year and end of year capital, including short-term debt, current maturities, long-term debt, non-current deferred taxes and equity]
- 6 Operating income/sales = [sales – cost of goods manufactured (before depreciation and amortization), selling, general and administrative, and research and development costs]/sales
- 7 Long-term debt/capital = long-term debt/[long-term debt + shareholders' equity (including preferred stock) + minority interest]
- 8 Total debt/capital = [long-term debt + current maturities, commercial paper and other short-term borrowings]/[(long-term debt + current maturities, commercial paper and other short-term borrowings) + shareholders' equity (including preferred stock) + minority interest].

Table 7.3

Ratings

Rating	Comment
AAA	Issues rated AAA are judged to be of the best quality and offer the highest safety for timely payment of interest and principal.
AA	High safety for timely payment of interest and principal.
A	Adequate safety for timely payment of interest and principal. More susceptible to changes in circumstances and economic conditions than debts in higher-rated categories.
BBB	Moderate safety for timely payment of interest and principal. Lacking in certain protective elements. Changes in circumstances are more likely to lead to weakened capacity to pay interest and principal than debts in higher-rated categories.
BB	Inadequate safety for timely payment of interest and principal. Future cannot be considered as well-assured.
B	High risk associated with timely payment of interest and principal. Adverse business or economic conditions would lead to lack of ability on the part of the issuer to pay interest or principal.
CCC	Very high risk of default. Factors present make them vulnerable to default. Timely payment of interest and principal possible only if favourable circumstances continue.
D	Payment of interest and/or repayment of principal are in arrears. Already in default.

Median scores

Table 7.4

	AAA	AA	A	BBB	BB	B	CCC
1 EBIT int. cov. (x)	23.8	13.6	6.9	4.2	2.3	0.9	0.4
2 EBITDA int. cov. (x)	25.3	17.1	9.4	5.9	3.1	1.6	0.9
3 Free oper. cash flow/Total debt (%)	167.8	77.5	43.2	34.6	20.0	10.1	2.9
4 FFO/Total debt (%)	104.1	41.1	25.4	16.9	7.9	2.6	(0.9)
5 Return on capital (%)	35.1	26.9	16.8	13.4	10.3	6.7	2.3
6 Operating income/Sales (%)	24.6	23.4	18.2	14.7	15.8	13.9	11.4
7 Long-term debt/Capital (%)	13.3	28.2	33.9	42.5	57.2	69.7	68.8
8 Total debt/Capital (incl. STD) (%)	6.2	34.8	39.8	45.6	57.2	74.2	101.2
Companies	6	18	124	207	274	250	43

The example medians scores used for each of the rating classes are shown in Table 7.4.

Figure 7.22 shows the calculation of the rating for EBIT coverage. The ratio is calculated as 2.29 in the final historic year. The next line then compares each ratio against the listing and converts it back into a rating.

EBIT interest coverage

Figure 7.22

	A	B	C	D	E	F	G	H	I	J	K
14		D14		EBIT Interest Coverage X							
15		D15	1	EBIT		P16	982.0	(942.0)		7,888.0	
16		D16		Interest		P17	(450.0)	(892.0)		(988.0)	
17		D17		1 EBIT/Interest			2.18	(1.38)		8.17	
18		D18		Ratio EBIT/Interest			B	Default		A	
19											
20											

This is the code in cell M123 which uses the MATCH function along the listing of EBIT coverage for each rating. The value of 2.29 is closest to the fifth value 2.1 and therefore the function returns 5.

```
=IF (M17>$I137,0, IF (M17<=O137,7,MATCH (M17,$I137:$O137,-1)))+1
```

In cell M18 this can be used as an OFFSET value along the list of ratings letters, which in this case is BB. This process is repeated for each ratio and the values are averaged as a score (see Figure 7.23). For December 2002, this is 5.50, which is rounded up using the ROUNDUP function with zero decimal places:

```
=ROUNDUP (M131,0)
```

Again, this score can be read using the list of ratings with an OFFSET function where cell M132 has the value 6. The result is a B rating:

```
=OFFSET ($H$136,0,M132)
```

Figure 7.23

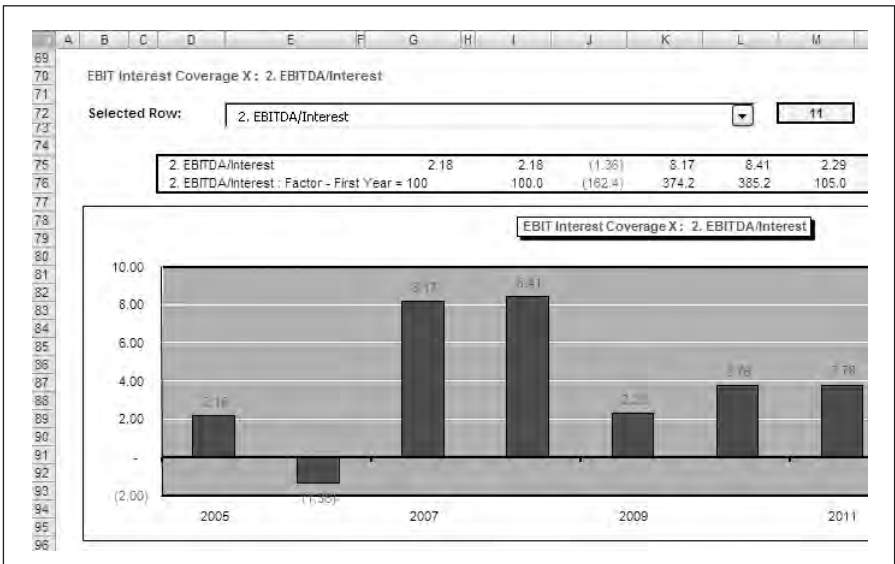
Ratings calculation

		Ratings Workings	
		Dec-09	Dec-10
121			
122	D122		
123	D123	1 EBIT Interest Coverage X	6 5
124	D124	2 EBITDA Interest Coverage X	8 9
125	D125	3 Funds Flow Operations/Total Debt %	7 6
126	D126	4 Free Operating Cash Flow/Total Debt %	8 8
127	D127	5 Return on Capital %	7 7
128	D128	6 Operating Income/Sales %	8 4
129	D129	7 Long Term Debt/Capital %	3 4
130	D130	8 Total Debt/Capital %	2 3
131	D131	Average	5.88 5.25
132	D132	Offset Roundup	6 8
133	D133	Rating	B B

Again, Figure 7.23 provides a trend over time and the score above is declining from a BBB in December 1999 to a B in December 2002. This confirms the same results trend as the default models earlier in this chapter. At the bottom, there is a dynamic chart allowing review of any line. Figure 7.24 is the EBITDA/Interest coverage. The chart shows clearly the volatility and the declining financial strength.

Figure 7.24

EBITDA/Interest chart



SUMMARY

This chapter has reviewed credit risks and introduced methods for extending financial analysis to understand more fully an organization's solvency risk and ability to repay debts. The methods have included cash flow sensitivity, sustainability and growth measures, insolvency models such as Z scores or Logit analysis and finally bond ratings. The modular approach demonstrates again how a basic model can be extended with further blocks to improve the quality of management information. The model now yields extra information since the example company shows declining financial strength, and this is reinforced by the findings of sustainability and bankruptcy models.

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Valuation

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Valuation and returns

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Sensitivity analysis

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Management summary

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Summary
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INTRODUCTION

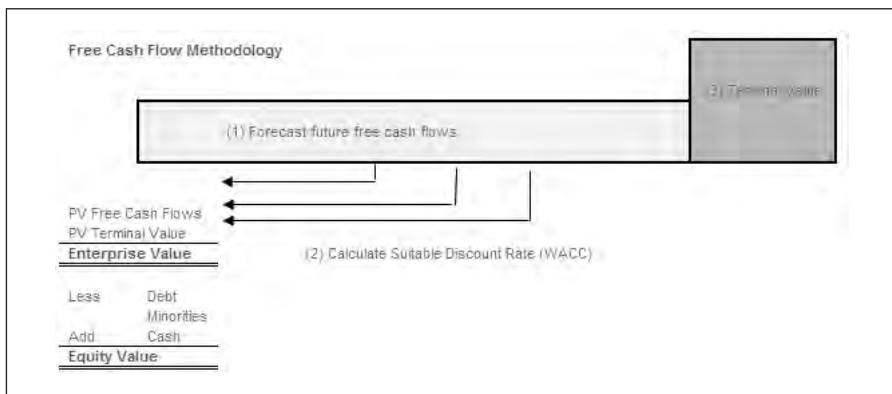
Financial analysis models can be extended to include valuation using cash flow methods. This chapter introduces a free cash flow company valuation model as a buyout model with options. The transaction value is funded by a mixture of cash and debt, and the company is forecast to grow over a 10-year period to a planned exit point. The objective is to understand and develop the net present value (NPV) or valuation for the equity investors and the whole firm. Value is derived from the free cash flows over the forecast period and the compounded or exit value of the firm on expiry. The internal rate of return (IRR) to the firm and investors is also important in determining the acceptability of the proposal. The lower the cost of capital, the higher the eventual valuation derived. In addition, the mix of debt and equity drives the value as the model needs to find an acceptable mix between value and interest cover as measured by debt service ratios.

Figure 8.1 shows the necessary tasks. The model must calculate the future cash flows to equity and to the organization, which will vary based on sales growth costs, interest rates and capital expenditure requirements. A suitable discount rate is required, which reflects the weighted cost of the sources of capital and a terminal value as a value of the organization in ten years. A completed model is structured with these key components:

- inputs or control section for the initial transaction, funding rates, future growth rates, costs, capital expenditure, cost of capital and exit route;
- cash flow to equity and to the organization over ten years to build up the profit and loss and cash statements with terminal values;
- capital structure sheet for calculation of the debt/equity ratio, cost of equity, after-tax cost of debt and weighted average cost of capital;
- results such as the NPV and IRR to equity and to the firm, and a decision on their acceptability;
- sensitivity of the answer to equity injection against the firm's beta or the exit multiple built up with Sensitivity tables, conditional formatting and dynamic charts;
- management summary of key inputs and results.

Figure 8.1

Free cash flow model



INPUTS

The first inputs are for the cost of the transaction and the breakdown of funding (see Figure 8.2). Here 20 per cent is equity and the remaining 80 per cent debt. There is space for up to three funding facilities together with preference shares. Debt will increase the interest burden and depress cash flow, but a smaller more efficient equity injection will increase returns for the investors. The model should therefore show how returns to the organization and equity investors flex as the percentage of equity investment increases.

Figure 8.3 sets out the interest cost for each facility and the repayment percentages per annum. The percentages are added on the right-hand side and error checked with the formula below to ensure that they add up to 100 per cent or less:

```
=IF(OR($Q$16>1,$Q$17>1,Q18>1),"ERROR: Check the loan repayment schedule","No errors")
```

Figure 8.2

Cost

	A	B	C	D	E	F	G	H
4								
5			(1) Transaction Cost					
6		C006	Current Share Price	20.0			Equity Injection	1000.0
7		C007	Number of Shares Outstanding	200.0			Preferred Shares	-
8		C008	Current Debt Outstanding	1,000.0			Facility 1	2,000.0
9		C009	Other Costs (Banker, Legal etc.)	-			Facility 2	2,000.0
10		C010					Facility 3	-
11		C011	Total Cost	5,000.0			Total	5,000.0
12								

The model has an option of using an exit multiple or a growth model calculation to derive the terminal value. The interest rate on debt remaining in the terminal year is used in the calculation of interest in the final year. If the debt outstanding is zero, as in the inputs above, then the value is not used.

Financing

Figure 8.3

	A	B	C	D	E	F	G
12							
13							
14			(2) Deal Financing				
15		C015	Preferred Shares		0.00%		
16		C016	Debt: Facility 1		10.00%	20.00%	20.00%
17		C017	Debt: Facility 2		8.00%	10.00%	10.00%
18		C018	Debt: Facility 3		0.00%	0.00%	0.00%
19		C019	Interest Rate on Debt Remaining in Terminal Year		10.00%		

Figure 8.4 shows the income statement variables together with the growth rates over the 10-year period. The revenue starts at 10,000 and grows at 10 per cent per annum. Similarly, capital spending commences at 500 and grows by 5 per cent per annum. Cost of goods sold is a calculated cell using the formula:

$$1 - (EBIT + Depreciation)/Revenues$$

Income statement

Figure 8.4

	A	B	C	D	E	F	G	H	I	J
20										
21			(3) Income Statement							
22		C022	Revenues		10,000.0		COGS as % of Revenue		85.00%	
23		C023	Current Earnings before Interest and Tax (EBIT)		1,000.0		Current Capital Spending		500.0	
24		C024	Current Interest Cost		200.0		Interest Rate on Debt Currently		10.00%	
25		C025	Current Depreciation		500.0					
26										
27			(4) Future Growth							
28		C028	Revenues		10.00%	5.00%	5.00%	5.00%	5.00%	5.00%
29		C029	Depreciation Growth		5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
30		C030	Capital Spending Growth		5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
31		C031	Working Capital as % of Revenue		15.00%	15.00%	15.00%	15.00%	15.00%	15.00%
32		C032	Cost of Goods Sold as % of Revenues		85.00%	85.00%	85.00%	85.00%	85.00%	85.00%
33										

The current risk-free rate, tax rate and risk premium are needed in the cost of capital calculations.

The section is mainly control driven by scroll bars and combo boxes (see Figure 8.5). Sliding the scroll bars changes the organization’s beta and exit multiple using cell links in the workings area below the printed schedule (see Figure 8.6). Using a control means that cells E38 and E41 can be formulas, and the same formulas can be used in the Sensitivity tables. Since these are indirect references, this ensures that the tables remain synchronized without resorting to macros.

Office 2007 – Developer, Insert, Form Controls (Excel 2003 – View, Toolbars, Forms)

Figure 8.5

Background and exit information

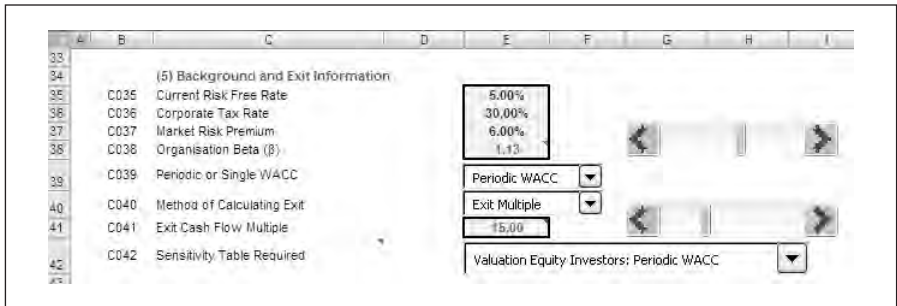
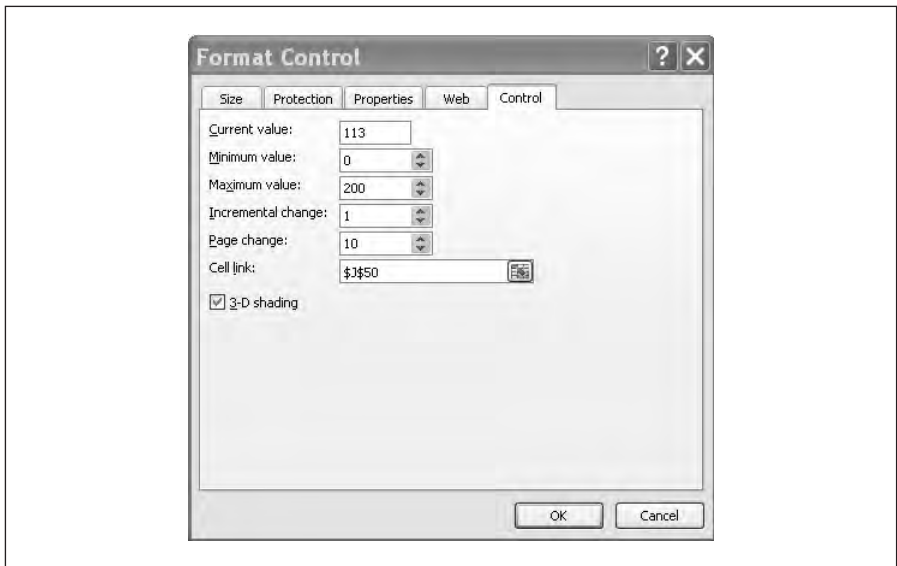


Figure 8.6

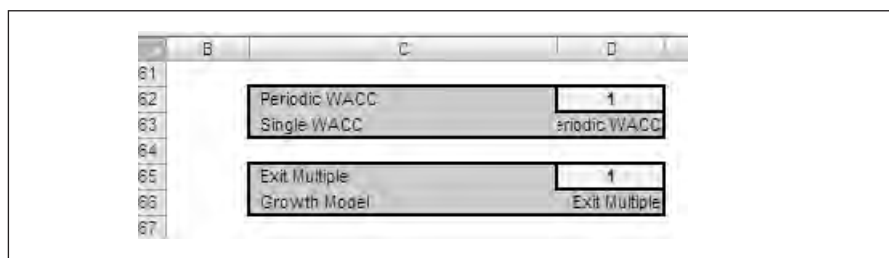
Format scroll bar control



The model includes both single discount rate and periodic discount rate calculations. An NPV is simpler to derive with a single rate and both answers are given (see Figure 8.7). The exit formula is either an exit multiple of cash flow or a derivation of the perpetuity (Gordon's) model.

Control workings

Figure 8.7



The Sensitivity tables are set up to return multiple values. Rather than creating a matrix table just to look at a single value, the combo box returns an index number which can be used to make the tables more flexible. This means that the tables can include any one of the following options:

- present value of cash flow to equity investors;
- present value of cash flow to all investors;
- valuation for equity investors;
- valuation for all investors;
- IRR for equity investors;
- IRR for all investors;
- decision for equity investors;
- decision for all investors.

The text in the combo box is an updating text string, for example:

```
=Capital_Structure!$F$35&" "&Capital_Structure!$C$36 (Valuation Equity Investors: Periodic WACC)
```

The control area contains all the entries for the cash flow and other sheets. The cash flow and capital structure sheets build up the cash flows using these inputs to a valuation and return result.

CASH FLOW

The cash flow schedule includes line numbers and references to show the source of the figures. This is achieved by formulas, for example row eight:

```
Cell B8="P"&TEXT(ROW(A8),"000")
Cell D8=$B$8&"*(1+"&Inputs!$B$28&)"
```


Office 2007 – Formulas, Function Library, Text (Excel 2003 – Insert, Function, Text)

Each line uses dynamic references and this means that references will remain synchronized even if lines are inserted or deleted. The statement builds up the earnings before interest and tax, and charges interest on each of the facilities against earnings. The income is taxed and depreciation added back to form cash from operations. To achieve cash due to equity, capital expenditure, the change in working capital and capital repayments are subtracted. The final cash flow due to the organization reduces the cash flow to equity by preference dividend, after-tax interest and principal repayments.

Lines 26 and 30 of Figure 8.8 show the cash flow to equity and the firm. The terminal value is also required as the end cash flow. This is the forecast valuation at the end of the forecast period. The choices are an exit multiple or a perpetuity model calculation. Option one is an exit multiple, which takes the final equity cash flow and multiplies it by the exit multiple input in the control area.

```
=IF (Inputs!D67=1, Cash_Flow!P26*Inputs!E41, $P$26/ (Capital_Structure!$P$20 - Inputs!$O$28))
```

Figure 8.8

Cash flow layout

	A	B	C	D
5				
6				Reference
7				
8	P008	Revenues		P008 * (1+C028)
9	P009	Cost of Goods Sold (COGS)		P008 * C032
10	P010	Depreciation		P018 * (1+C029)
11	P011	Earnings before Interest and Tax (EBIT)		
12	P012	Interest: Facility 1		S008 * C016
13	P013	Interest: Facility 2		S008 * C017
14	P014	Interest: Facility 3		S010 * C018
15	P015	Taxable Income		
16	P016	- Taxes		P015 * C036
17	P017	Net Income		Sum
18	P018	+ Depreciation		P018 * (1+C029)
19	P019	Cash Flow from Operations		
20	P020	- Capital Expenditure		P020 * (1+C030)
21	P021	- Working Capital Charge		Δ P008 * C031
22	P022	- Preference Dividend		C015 * C007
23	P023	- Principal Repayment: Facility 1		C016 * C008
24	P024	- Principal Repayment: Facility 2		C017 * C009
25	P025	- Principal Repayment: Facility 3		C018 * C010
26	P026	Cash Flow to Equity		
27	P027	+ Preference Dividend		P022
28	P028	+ Interest (1-Tax)		P012.P014 * (1-C038)
29	P029	+ Principal Repayment		P023.P025
30	P030	Cash Flow to Firm		
31	P031	Terminal Value of Equity		P026/(S020-C028)
32	P032	Terminal Value of Firm		P031+S008.S010

The second option uses the perpetuity model with the formula below. This formula present values cash flows growing at a constant rate in perpetuity.

Final cash flow (Cost of equity – Revenue growth rate)

For example: $1154.77 / (10.77\% - 5\%) = 1154.77 / 5.77\% = 20,013.34$.

Figure 8.9 shows all the cash flows necessary for the valuation with the flexibility to choose the method of calculating the terminal value. There are no inputs on this sheet and all the variables are contained on the Inputs sheet.

CAPITAL STRUCTURE

The schedule needs to calculate a discount rate that reflects the cost of each source of capital and weights the final cost by the market weighting of each source of capital. The first lines of the schedule calculate the percentages of debt, equity and preferred shares (see Figure 8.10). In year one after the acquisition, debt is four times equity or, alternatively, debt is 80 per cent of the combined capital.

Completed cash flow

Figure 8.9

	A	B	C	E	F	G
5						
6				Current	1	2
7						
8	P008	Revenues		10,000.00	11,000.00	11,550.00
9	P009	Cost of Goods Sold (COGS)		(8,500.00)	(9,350.00)	(9,817.50)
10	P010	Depreciation		(500.00)	(525.00)	(551.25)
11	P011	Earnings before Interest and Tax (EBIT)		1,000.00	1,125.00	1,181.25
12	P012	Interest: Facility 1		(200.00)	(200.00)	(180.00)
13	P013	Interest: Facility 2			(150.00)	(144.00)
14	P014	Interest: Facility 3			-	-
15	P015	Taxable Income:		800.00	765.00	877.25
16	P016	- Taxes		(240.00)	(229.50)	(263.18)
17	P017	Net Income		560.00	535.50	614.08
18	P018	+ Depreciation		500.00	525.00	551.25
19	P019	Cash Flow from Operations		1,060.00	1,060.50	1,165.33
20	P020	- Capital Expenditure		(500.00)	(525.00)	(551.25)
21	P021	- Working Capital Charge		(135.35)	(150.00)	(82.50)
22	P022	- Preference Dividend			-	-
23	P023	- Principal Repayment: Facility 1			(400.00)	(400.00)
24	P024	- Principal Repayment: Facility 2			(200.00)	(200.00)
25	P025	- Principal Repayment: Facility 3			-	-
26	P026	Cash Flow to Equity		423.64	(214.50)	(68.43)
27	P027	+ Preference Dividend			-	-
28	P028	+ Interest (1-Tax)		140.00	252.00	212.80
29	P029	+ Principal Repayment			600.00	600.00
30	P030	Cash Flow to Firm		563.64	637.50	744.38
31	P031	Terminal Value of Equity				
32	P032	Terminal Value of Firm				

The cost of equity is based on the Capital Asset Pricing Model (CAPM) using the formula:

$$\text{Cost of equity} = \text{Risk free rate} + \beta * \text{risk premium}$$

Beta is a measure of risk plotted as the volatility of the share against the market, which here was input as 1.13. The market is one and therefore this share appears more risky than the market. Betas can be derived from plotting the returns on a share against, and index or betas are available from on-line feeds such as Bloomberg. The other variables are also on the Input sheet. The beta needs to be un-levered to strip out the effect of the historic debt burden and then re-levered using the forecast debt to equity ratio. The formulas are:

$$\text{Un-levered or Asset } \beta = \beta / (1 + (1 - \text{Tax}) * \text{Debt/Equity})$$

$$\text{Re-levered or Equity } \beta = \beta * (1 + (1 - \text{Tax}) * \text{Debt/Equity})$$

Figure 8.10

Capital structure

	B	C	D	E	F
	Current				
S008	Debt: Facility 1	S008 - P023	*	1,000.00	2,000.00
S009	Debt: Facility 2	S009 - P024		-	2,000.00
S010	Debt: Facility 3	S010 - P025		-	-
S011	Preferred Shares	C007		-	-
S012	Equity Injection	S012 - P017		4,000.00	1,000.00
S013	Debt / Equity (D/E)	S008.S010/S012		25.00%	400.00%
S014	D / (D+E+Preferred)	S008.S010/S008.S012		20.00%	80.00%
S015	Preferred / (D+E+Preferred)	S011/S008.S012		0.00%	0.00%
S017	Asset Beta (β)	(S013/(1+(1-C038)*S013))			0.98*
S018	Organisation Beta (β)	S017*(1+(1-C038)*S013)		1.13	3.65
S020	Cost of Equity	C035+S018*C037		11.78%	26.93%
S021	Interest rate	(S008*C016+S009*C017-S010*C018)/S008.S010		10.00%	9.00%
S022	WACC	S020*(1-S014-S015)+S021*(1-C036)*S014-S015*C05		10.82%	10.43%
S024	Cumulative Cost of Equity	S024*(1+S020)			1,2693
S025	Cumulative WACC	S025*(1+S022)			1,1043
S027	Cash Flow to Equity	P026		(1,000.00)	(214.50)
S028	Cash Flow to Firm	P030		(5,000.00)	-637.50
S030	Cumulative Valuation - Equity	S027/S024			(169.00)
S031	Cumulative Valuation - Firm	S028/S025			577.31

In the example above, the initial beta is 1.13 which reduces to 0.96 as an asset beta. With the effect of the high forecast debt/equity ratio, the beta rises to 3.65. The cost of equity is therefore:

$$\begin{aligned} \text{Cost of equity} &= \text{Risk free rate} + \beta * \text{Risk premium} \\ &= 5\% + 3.65 * 6\% \\ &= 26.9\% \end{aligned}$$

The cost of debt depends on the balances outstanding, and the formula below weights the interest rate against the balance in each of the three facilities. Since the company is paying tax, the cost of debt used in the final cost of capital calculation will be multiplied by $(1 - Tax)$ as an after-tax rate.

$$\text{Cell F21} = (\text{F8} * \text{Inputs!}\$E16 + \text{F9} * \text{Inputs!}\$E17 + \text{F10} * \text{Inputs!}\$E18) / \text{SUM}(\text{F8:F10})$$

The weighted average cost of capital uses the market weights of each source and multiplies them out by the individual costs. The cost of capital changes in each period as the capital structure changes with the repayment of loans.

$$\text{Cell F22} = \text{F20} * (1 - \text{F14} - \text{F15}) + \text{F21} * (1 - \text{Inputs!}\$E36) * \text{F14} + \text{F15} * \text{Inputs!}\$E15$$

In order to compute a present value based on the periodic, it is necessary to compound the discount rate in rows 24 and 25 (see Figure 8.11). The number increases progressively as a compound figure to year 10. Rows 27 and 28 bring forward the cash flows from the previous schedule. The present value for the period is therefore the cash flow divided by the compounded discount rate. The periodic values can simply be added to form the total in the last column. The final results are in Figure 8.12.

Present value calculations

Figure 8.11

	F	G	H	I
23				
24	=F20	=F24*(1+G20)	=G24*(1+H20)	=H24*(1+I20)
25	=F22	=F25*(1+G22)	=G25*(1+H22)	=H25*(1+I22)
26				
27	=Cash_Flow/F26	=Cash_Flow/G26	=Cash_Flow/H26	=Cash_Flow/I26
28	=Cash_Flow/F30	=Cash_Flow/G30	=Cash_Flow/H30	=Cash_Flow/I30
29				
30	=F27/F24	=G27/G24	=H27/H24	=I27/I24
31	=F28/F25	=G28/G25	=H28/H25	=I28/I25
32				

Figure 8.12

Final present values

	A	B	C	D	N	O	P
5							Units \$'000,000
9					9	10	Term Year
23							
24		S024	Cumulative Cost of Equity	S024*(1+S020)	3,4673	3,8440	
25		S025	Cumulative WACC	S025*(1+S022)	2,4661	2,7311	
26							
27		S027	Cash Flow to Equity	P026	825.01	18,210.13	20,130.95
28		S028	Cash Flow to Firm	P030	1,047.41	18,421.33	
29							
30		S030	Cumulative Valuation - Equity	S027/S024	237.94	4,737.33	5,634.90
31		S031	Cumulative Valuation - Firm	S028/S025	424.72	6,745.09	11,429.71

VALUATION AND RETURNS

The objective of the model is to compute the valuation and returns to investors and the firm. There is an alternative using a single cost of capital, but this would tend to give an incorrect answer since the capital structure changes markedly during the period. The IRR formula uses the full cash flows on the schedule and the decision is a simple IF statement, where the valuation needs to be greater than the initial investment:

$$= \text{IF}(F36 > \text{ABS}(G36), \text{"Accept"}, \text{"Decline"})$$

Results are shown in Figure 8.13.

Figure 8.13

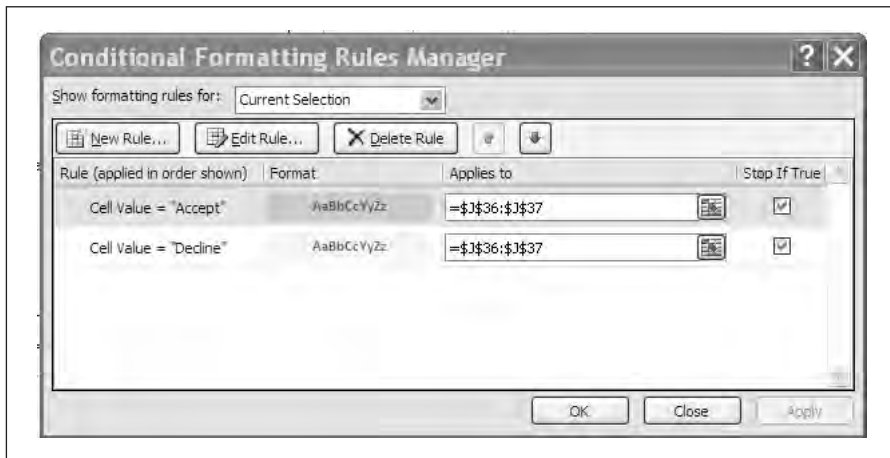
Results

	A	B	C	D	E	F	G	H	I	J
5										
9					Current	1	2	3	4	5
33										
34										
35										
36		S035	Equity Investors: Periodic WACC		PV of CF	Investment	Valuation	IRR	Decision	
37		S036	All Investors: Periodic WACC		5,634.90	11,429.71	4,634.90	26.16%	Accept	
38		S037			11,429.71	11,429.71	6,429.71	23.83%	Accept	
39										
40										
41		S040	Average FCF		834.8					
42		S041	Maximum FCF in period 10		1,059.6					
43		S042	Minimum FCF in period 1		637.6					
44		S043	Standard Deviation of FCF		143.8					
45										
46										
47		S046	Debt/Equity Ratio before Transaction		25.00%			Beta before LBO	1.13	
48		S047	Debt/Equity Ratio after Transaction		400.00%			Beta after LBO	3.65	
49		S048	Debt/Equity Ratio in Year 5		22.39%			Beta in Year 5	1.25	
50		S049	Debt/Equity Ratio in Year 10		0.00%			Beta in Year 10	0.95	

The cell formatting uses conditional formatting to emphasize the answer (see Figure 8.14).

Conditional formatting

Figure 8.14



Office 2007 – Home, Styles, Conditional Formatting (Excel 2003 – Format, Conditional Formatting)

Other answers include background information on the cash flows, leverage and beta. The cash flow formulas use simple formulas:

```
=AVERAGE(Cash_Flow!F30:O30)
=MAX(Cash_Flow!F30:O30)
=MIN(Cash_Flow!F30:O30)
=STDEV(Cash_Flow!F30:O30)
```

Single rate workings

Figure 8.15

Workings					
	Rate	Equity	Rate	Company	
Periodic WACC		4,634.50		6,429.71	
Single WACC	11.78	6,161.62	10.82	6,211.31	
Single WACC Valuation/NPV Sensitivity					
Interval	0.10				
	11.48	11.58	11.68	11.78	11.88
Equity	6,351.39	6,287.53	6,224.28	6,161.62	6,099.56
	10.52	10.62	10.72	10.82	10.92
Company	6,451.60	6,370.83	6,290.71	6,211.31	6,132.63

The single discount rate workings use the discount rates from cells E20 and E22, 11.78 per cent and 10.82 per cent respectively (see Figure 8.15). This provides a simple Sensitivity table against the rates and the chart is plotted on the Sensitivity_Beta sheet.

SENSITIVITY ANALYSIS

Since the inputs for data tables have to be on the same sheet, all the workings for the two sets of data tables are at the bottom of the Inputs sheet in the workings area. The two tables are:

- 1 equity injection across and organization beta (b) down;
- 2 equity injection across and exit cash flow multiple down.

Office 2007 – Data, Data Tools, What-if Analysis (Excel 2003 – Data, Data Table)

This is to provide information on how the answers change as you vary the beta or the exit multiple. Remember that the tables are flexible in that you can choose using the combo box in the Inputs area:

- present value of cash flow to equity investors;
- present value of cash flow to all investors;
- valuation for equity investors;
- valuation for all investors;
- IRR for equity investors;
- IRR for all investors;
- decision for equity investors;
- decision for all investors.

The inputs for the tables are the equity injection in cell 16, the beta in cell E38 and the exit multiple in cell E41 (see Figure 8.16). Note that these cells are updated by spinners and are not input cells. The data table axes are also linked to the spinners in order to keep the tables synchronized.

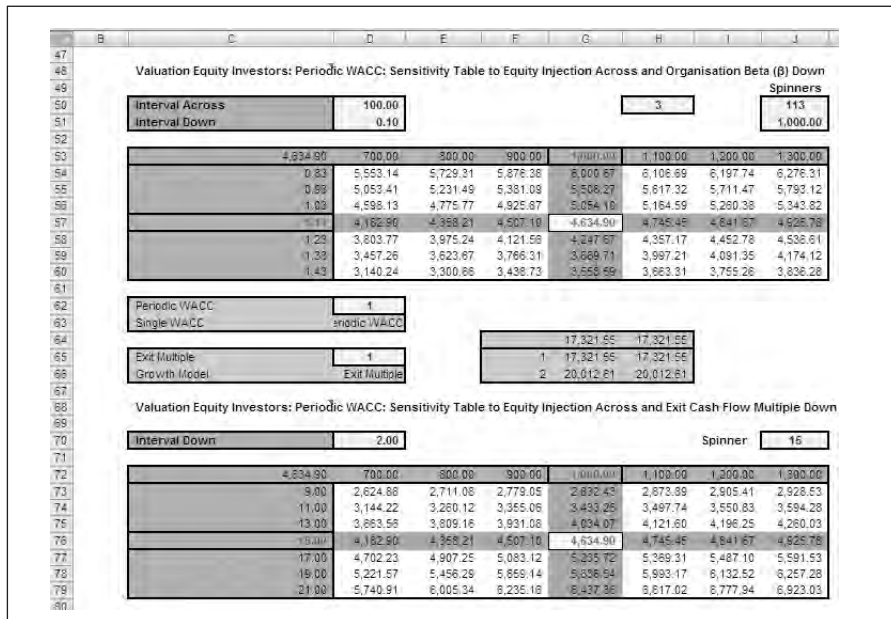
The tables have conditional formatting to generate the exact formatting for the answer and the distinctive stripes for the x - and y -axis of the answer. The answer should always stay in the middle of the table. Figure 8.17 shows the conditional formatting for the first table which uses both cell value and formula parameters.

There are two sensitivity schedules to bring forward the data from the tables and display charts. You need the charts to be able to assess easily the rate of change in the underlying result. The two schedules are Sensitivity_Beta (see Figure 8.18) and Sensitivity_Exit (see Figure 8.19). Each provides a dynamic chart to plot a single row from the table and insert the answer as a point. The beta represents the risk on the share, so as you increase risk the valuation declines because of the increased cost of capital.

Figure 8.18 illustrates how the equity value rises with increased investment at a constant beta. The downside is that the rate of return falls as the effect of leverage decreases.

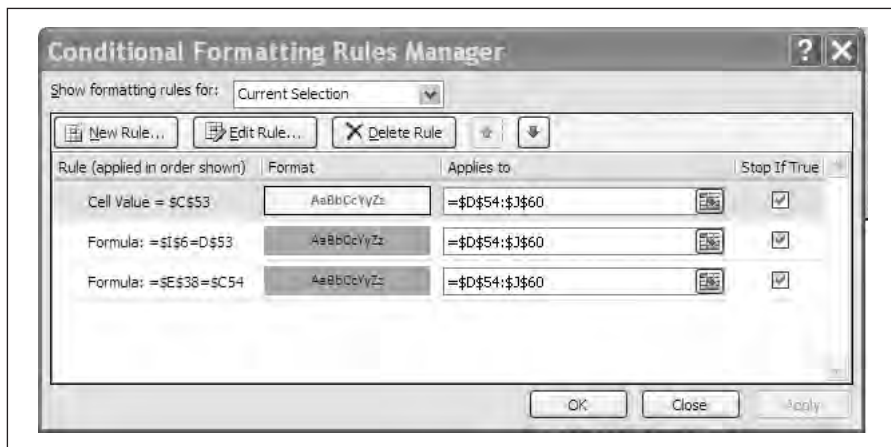
Sensitivity tables

Figure 8.16



Conditional formatting

Figure 8.17



The exit multiple could be the projected sale price at the end of the period and therefore Figure 8.19 shows an increased valuation with a higher multiple. The values range from 2,624 to 6,923. As an alternative, the second table in Figure 8.19 highlights the cells where the answers are within the input 15 per cent plus or minus of the single point value.

Figure 8.18

Sensitivity to beta

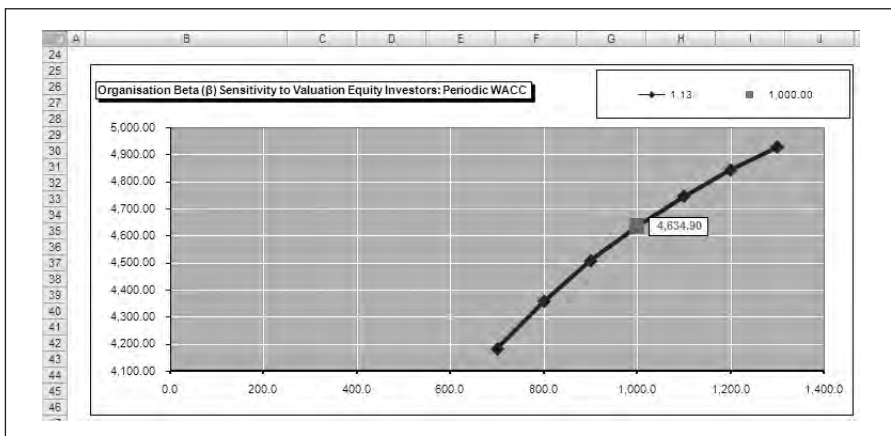


Figure 8.19

Sensitivity to exit multiples

Valuation Equity Investors: Periodic WACC: Sensitivity Table to Equity Injection Across and Exit Cash Flow Multiple Down										
Equity Injection Valuation	1,000.00									
Exit Cash Flow Multiple	15.00									
Valuation Equity Investors: Periodic WACC	4,634.90									
	4,634.90	700.00	800.00	900.00	1,000.00	1,100.00	1,200.00	1,300.00		
8.00	2,624.88	2,711.08	2,779.05	2,832.43	2,873.89	2,905.41	2,928.53			
11.00	3,144.22	3,260.12	3,355.06	3,433.25	3,497.74	3,550.83	3,594.28			
15.00	3,663.56	3,809.16	3,931.08	4,034.07	4,121.60	4,196.25	4,260.03			
16.00	4,182.90	4,358.21	4,507.10	4,634.90	4,745.45	4,841.67	4,925.76			
17.00	4,702.23	4,907.25	5,083.12	5,236.72	5,369.31	5,487.10	5,591.53			
19.00	5,221.57	5,456.29	5,659.14	5,836.54	5,993.17	6,132.52	6,257.28			
21.00	5,740.91	6,005.34	6,235.16	6,437.36	6,617.02	6,777.94	6,923.03			
Shaded Tolerance to 4,635		15.00%								Answers within 15.00% of 4,635 are shaded
	4,634.90	700.00	800.00	900.00	1,000.00	1,100.00	1,200.00	1,300.00		
8.00	2,624.88	2,711.08	2,779.05	2,832.43	2,873.89	2,905.41	2,928.53			
11.00	3,144.22	3,260.12	3,355.06	3,433.25	3,497.74	3,550.83	3,594.28			
15.00	3,663.56	3,809.16	3,931.08	4,034.07	4,121.60	4,196.25	4,260.03			
16.00	4,182.90	4,358.21	4,507.10	4,634.90	4,745.45	4,841.67	4,925.76			
17.00	4,702.23	4,907.25	5,083.12	5,236.72	5,369.31	5,487.10	5,591.53			
19.00	5,221.57	5,456.29	5,659.14	5,836.54	5,993.17	6,132.52	6,257.28			
21.00	5,740.91	6,005.34	6,235.16	6,437.36	6,617.02	6,777.94	6,923.03			

The conditional formatting uses the formulas: = \$B\$11*(1 - \$C\$20) and = \$B\$11*(1 + \$C\$20) to capture the values (see Figure 8.20). This allows a range of values to be used since the variables are not hard coded.

Figure 8.21 explains how valuation increases with increased equity injection and uses the same format as the beta chart.

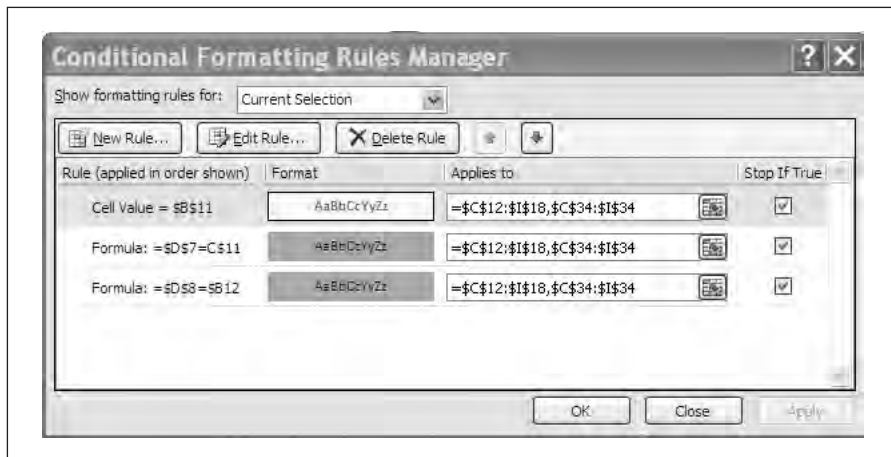
MANAGEMENT SUMMARY

The management summary brings together all the findings on a single-page report (see Figure 8.22). This includes an executive summary of the initial

transaction, the valuations and return calculations, and the Sensitivity tables. This provides all the key findings, without the detail, on a simple report.

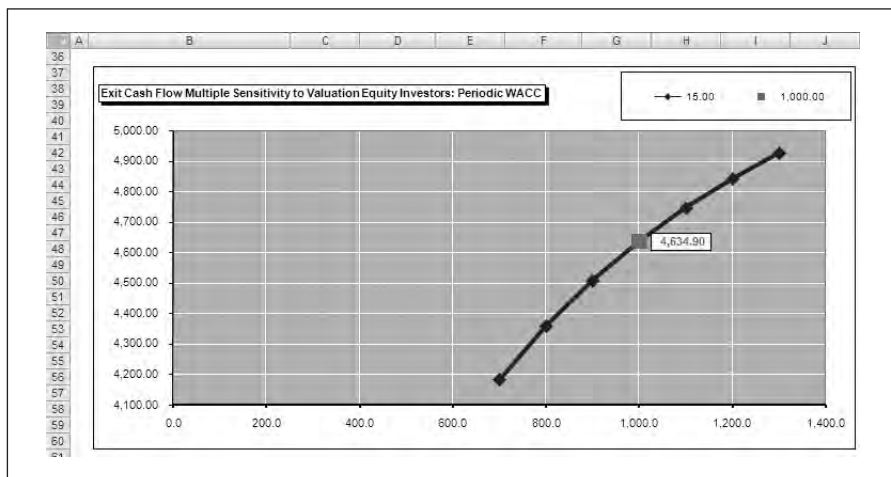
Conditional formatting

Figure 8.20



Cash flow exit multiple

Figure 8.21



The data tables are shown in Figure 8.23.

SUMMARY

This chapter uses a leveraged buyout valuation model to show the key elements in free cash flow models and includes advanced data tables to demonstrate the variability in the answers as a result of changing the beta or the exit multiple. The steps comprise sufficient inputs to calculate a free

cash flow to equity and to the company, formulate a method for computing a terminal value, setting out a suitable risk-adjusted discount rate, and then calculating the valuation and the return to investors and the organization. With a single-point answer in place, advanced data tables provide more management information on the possible spread of expected results.

Figure 8.22

Summary results

A	B	C	D	E	F	G	H	
4								
5	Current Share Price		20.00			Equity Injection	1,000.00	
6	Number of Shares Outstanding		200.00			Preferred Shares	-	
7	Current Debt Outstanding		1,000.00			Facility 1	2,000.00	
8	Other Costs (Banker, Legal etc.)		-			Facility 2	2,000.00	
9	Total Cost		5,000.00			Facility 3	-	
10						Total	5,000.00	
11								
12								
13	Results							
14			PV of CF	Investment	Valuation	IRR	Decision	
15	Equity Investors: Periodic WACC		5,634.90	(1,000.00)	4,634.90	36.16%	Accept	
16	All Investors: Periodic WACC		11,429.71	(5,000.00)	6,429.71	23.93%	Accept	
17								
18	Cashflow to Firm							
19	Average FCF		884.54					
20	Maximum FCF in period 10		1,099.78					
21	Minimum FCF in period 1		637.50					
22	Standard Deviation of FCF		143.83					
23								
24	Leverage							
25	Debt/Equity Ratio before Transaction		0.25					
26	Debt/Equity Ratio after Transaction		4.00					
27	Debt/Equity Ratio in Year 5		0.22					
28	Debt/Equity Ratio in Year 10		-					

Figure 8.23

Data tables

A	B	C	D	E	F	G	H	I	
30	Valuation Equity Investors: Periodic WACC: Sensitivity Table to Equity Injection Across and Organisation Beta (β) Down								
31									
32									
33	Organisation Beta (β)		1.13						
34		4,634.90	700.00	800.00	900.00	1,000.00	1,100.00	1,200.00	1,300.00
35	0.33	5,553.14	5,729.31	5,876.38	6,000.67	6,106.69	6,197.74	6,276.31	
36	0.93	5,053.41	5,231.49	5,381.09	5,508.27	5,617.32	5,711.47	5,793.12	
37	1.03	4,586.13	4,775.77	4,925.87	5,054.10	5,164.59	5,260.38	5,343.82	
38	1.13	4,162.90	4,368.21	4,507.10	4,634.90	4,745.45	4,841.67	4,925.78	
39	1.23	3,803.77	3,975.24	4,121.56	4,247.67	4,357.17	4,452.78	4,536.61	
40	1.33	3,457.26	3,623.67	3,768.31	3,889.71	3,997.21	4,091.35	4,174.12	
41	1.43	3,140.24	3,300.66	3,438.73	3,556.69	3,663.31	3,755.26	3,836.28	
42									
43	Valuation Equity Investors: Periodic WACC: Sensitivity Table to Equity Injection Across and Exit Cash Flow Multiple Down								
44									
45	Exit Cash Flow Multiple		15.00						
46		4,634.90	700.00	800.00	900.00	1,000.00	1,100.00	1,200.00	1,300.00
47	3.00	2,624.88	2,711.05	2,779.05	2,832.42	2,873.88	2,905.41	2,928.53	
48	11.00	3,144.22	3,260.12	3,355.06	3,433.25	3,497.74	3,550.62	3,594.26	
49	13.00	3,663.56	3,809.16	3,931.08	4,034.07	4,121.60	4,196.25	4,260.03	
50	15.00	4,182.90	4,368.21	4,507.10	4,634.90	4,745.45	4,841.67	4,925.78	
51	17.00	4,702.23	4,907.25	5,033.12	5,225.72	5,389.31	5,487.10	5,581.53	
52	19.00	5,221.57	5,456.29	5,659.14	5,836.54	5,993.17	6,132.52	6,257.28	
53	21.00	5,740.91	6,005.34	6,235.16	6,427.36	6,617.02	6,777.94	6,923.03	

Bonds

.....
Introduction

.....
Bond prices

.....
Interest rates

.....
Yield

.....
Duration and maturity

.....
Convexity

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Comparison

.....
Summary

File: MRM2_09

INTRODUCTION

This chapter reviews risk on fixed-income products. Bonds are instruments that usually pay interest (coupon) during the loan period and repay the capital on expiry. Bonds can be valued as the present value of the regular interest payments and the final principal payments discounted at a rate that reflects the risk of default. The level of the interest payments is fixed on issue and therefore an investor is purchasing the right to receive a set of regular coupon or interest payments together with the final return of the principal. The final cash flow includes the final interest payment and the principal. Governments and commercial institutions issue bonds as a form of financing and there are a range of possibilities based on convertibility, term and coupon payments.

BOND PRICES

For clarity, these terms are used in the bonds market:

- issue date – original issue date of the bond;
- settlement – pricing or yield date;
- maturity – date when principal and final coupon is due;
- redemption value – par value, usually 100;
- coupon (per cent) – interest rate fixed for the period of the bond;
- coupons per annum – usually paid once (annual) or twice (bi-annual) a year;
- basis – see Table 9.1;
- yield to maturity – inherent interest rate that varies during the period based on markets;
- price – price of bond based on yield to maturity.

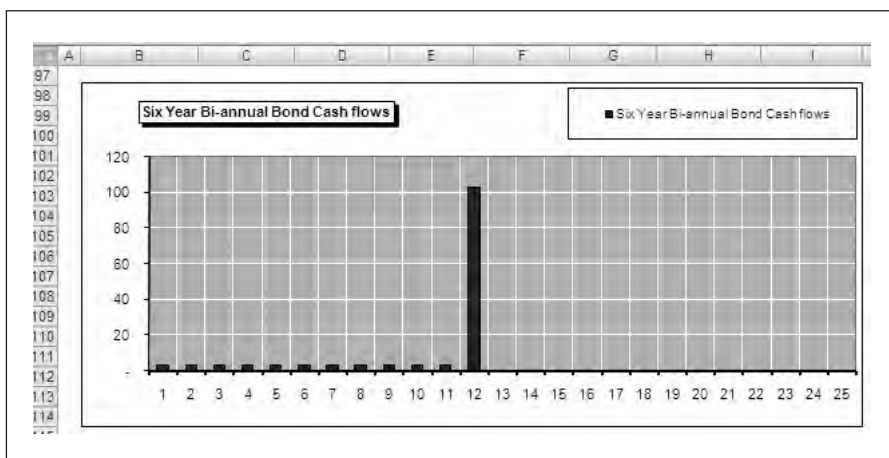
An example of bond cash flows showing final coupon and principal repayment is shown in Figure 9.1.

Since the payments are fixed, the price of a bond is inversely linked to the yield to maturity. As yield increases, the price of the bond must decline and vice versa. Bond pricing assumes:

- round periods rather than actual days, as used for other borrowing instruments;
- individual periods are regular;
- pricing is the compound net present value (NPV).

Figure 9.1

Bond cash flows showing the final coupon and principal repayment



If the pricing is required on the date a coupon is due, then there are no issues with accrued interest. Between periods, a seller expects to receive the accrued coupon within the period, while the buyer will only pay the present value of the future payments. The convention for quoting prices is:

- clean price – present value of the coupons and principal (dirty price – accrued coupon);
- dirty price – clean price plus the accrued interest (NPV of all cash flows).

Accrued interest on the coupon from the last payment date is payable using simple interest calculations. If there are 30 days from the start of the period and it is assumed there are 360 days in the year, then the interest would be calculated as $30/360 * \text{coupon rate}$. The first period could be less than the coupon periods depending on the purchase date, but thereafter coupons are payable annually, bi-annually or sometimes quarterly. The dates are the same, for example 15 September and 17 September for a bi-annual bond, and are not based on the exact number of days.

Day and year conventions vary and these are used in the various Excel functions. The methods are the number of days in the month and days in the year (see Table 9.1).

The conventions used in Excel functions are as below:

- 0 US (NASD) 30/360
- 1 Actual/actual
- 2 Actual/360
- 3 Actual/365
- 4 European 30/360

Table 9.1

Days	Actual	Actual number of calendar days
	30 (European)	Day 31 is changed to 30
	30 (American)	If the second day is 31 but the first date is not 31 or 30, then the day is not changed from 31 to 30
Year	365	Assumes 365 days in the year
	360	Assumes 360 days in year
	Actual	Actual including leap years

There are a number of defined bond functions in Excel, which are present in the Analysis Toolpak. Go to Tools, Add-ins and ensure that the add-in is ticked. This is a complete list of security-related functions:

- ACCRINT – accrued interest for a security that pays periodic interest;
- ACCRINTM – accrued interest for a security that pays interest at maturity;
- AMORDEGRC – depreciation for each accounting period by using a depreciation;
- COUPDAYBS – number of days from the beginning of the coupon period to the settlement date;
- COUPDAYS – number of days in the coupon period that contains the settlement date;
- COUPDAYSNC – number of days from the settlement date to the next coupon date;
- COUPNCD – next coupon date after the settlement date;
- COUPNUM – number of coupons payable between the settlement date and maturity date;
- COUPPCD – previous coupon date before the settlement date;
- CUMIPMT – cumulative interest paid between two periods;
- CUMPRINC – cumulative principal paid on a loan between two periods;
- DURATION – annual duration of a security with periodic interest payments;
- MDURATION – Macaulay modified duration for a security with an assumed par value of \$100;
- ODDFPRICE – price per \$100 face value of a security with an odd first period;
- ODDFYIELD – yield of a security with an odd first period;
- ODDLPRICE – price per \$100 face value of a security with an odd last period;
- ODDLYIELD – yield of a security with an odd last period;
- PRICE – price per \$100 face value of a security that pays periodic interest;
- PRICEDISC – price per \$100 face value of a discounted security;
- PRICEMAT – price per \$100 face value of a security that pays interest at maturity;

- TBILLEQ – bond-equivalent yield for a US Treasury bill;
- TBILLPRICE – price per \$100 face value for a US Treasury bill;
- TBILLYIELD – yield for a US Treasury bill.

The main functions used in the file are:

- PRICE – price of a bond;
- YIELD – yield to maturity;
- DURATION – duration discussed later;
- MDURATION – modified duration.

INTEREST RATES

Bond prices change with rises or falls in the required rate of return. As a bond's credit status falls, the rate investors are required to accept the risk of the future cash flows increases and therefore the price of the bond falls. The issue for investors is to assess the sensitivity of the bond to changes in interest rates. The price of the bond is simply the present value of future cash flows discounted at a periodic nominal rate.

This is an example of a bi-annual bond with six years remaining priced at 10 per cent with an annual coupon rate of 6 per cent. Combo boxes offer selection of the periodicity and payment convention as set out in the previous section (see Figure 9.2).

Figure 9.2

Inputs

The screenshot shows an Excel spreadsheet with columns A through E and rows 4 through 15. The data is as follows:

Row	Column A	Column B	Column C	Column D	Column E
4					
5		Reference	Six Year Bi-annual Bond		
6		Amount:	1,000.0		
7		Issue date:	1-Jan-10		
8		Settlement:	1-Jan-14		
9		Maturity 6 years:	1-Jan-20		
10		Redemption value:	100.000		
11		Coupon %:	6.000		
12		Yield to maturity:	10.000		
13		Price:	100.000		
14		Coupons per annum:	2: Bi-annual		
15		Basis:	US (NASD) 30/360		

The resulting cash flows can be discounted at 5 per cent per period to form a price of 82.27 (see Figure 9.3).

Cash flows

Figure 9.3

	A	B	C	D	E
62		Six Year Bi-annual Bond Cash flows			
63					
64		Period	Date	Cashflow	PV
65			1-Jan-14	-	
66		1.00	1-Jul-14	3.0000	2.8571
67		2.00	1-Jan-15	3.0000	2.7211
68		3.00	1-Jul-15	3.0000	2.5915
69		4.00	1-Jan-16	3.0000	2.4681
70		5.00	1-Jul-16	3.0000	2.3506
71		6.00	1-Jan-17	3.0000	2.2386
72		7.00	1-Jul-17	3.0000	2.1320
73		8.00	1-Jan-18	3.0000	2.0305
74		9.00	1-Jul-18	3.0000	1.9338
75		10.00	1-Jan-19	3.0000	1.8417
76		11.00	1-Jul-19	3.0000	1.7540
77		12.00	1-Jan-20	103.0000	57.3543
78		13.00	-	-	-
79		14.00	-	-	-
80		15.00	-	-	-
81		16.00	-	-	-
82		17.00	-	-	-
83		18.00	-	-	-
84		19.00	-	-	-
85		20.00	-	-	-
86		21.00	-	-	-
87		22.00	-	-	-
88		23.00	-	-	-
89		24.00	-	-	-
90		25.00	-	-	-
91				136.0000	82.2735

PRICE function

Figure 9.4

Function Arguments

PRICE

Settlement = 41640

Maturity = 43831

Rate = 0.06

Yld = 0.1

Redemption = 100

= 82.27349673

Returns the price per \$100 face value of a security that pays periodic interest.

Settlement is the security's settlement date, expressed as a serial date number.

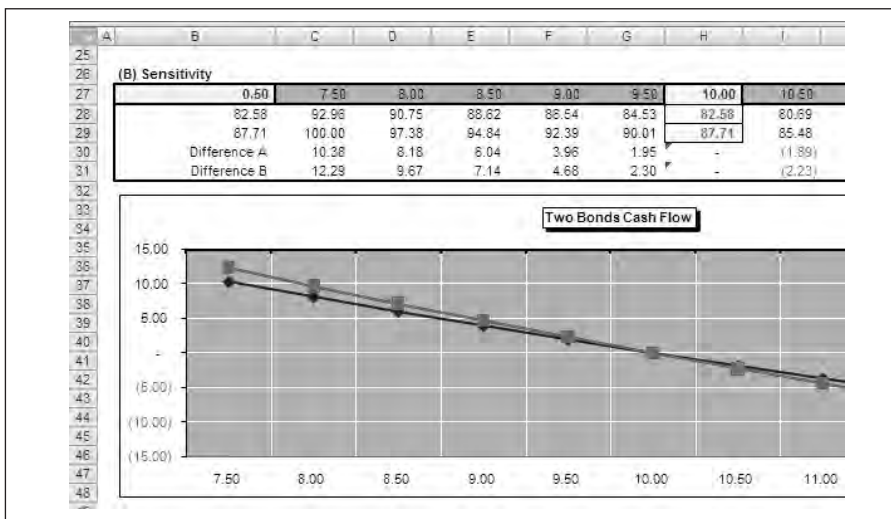
Formula result = 82.2735

[Help on this function](#)

Figure 9.4 shows the bond with 12 coupons remaining and the price is calculated by adding the periodic discounted cash flows. An alternative would be to use the PRICE Excel function.

Figure 9.5

Sensitivity



Office 2007 – Formulas, Function Library, Financial (Excel 2003 – Insert, Function, Financial)

The bond price responds inversely to changes in yield. As the yield increases, so the price of the bond falls as shown by Figure 9.5 – a table of two bonds on the Cash Flow sheet. This example shows a five- and ten-year bond with the same coupon rate.

YIELD

Yield to maturity

The bond calculator includes various measures of yield. If you know the yield of a bond, you can calculate the market price; if you know the price, then you can compute the yield. There are a number of derivations and they are usually referred to as:

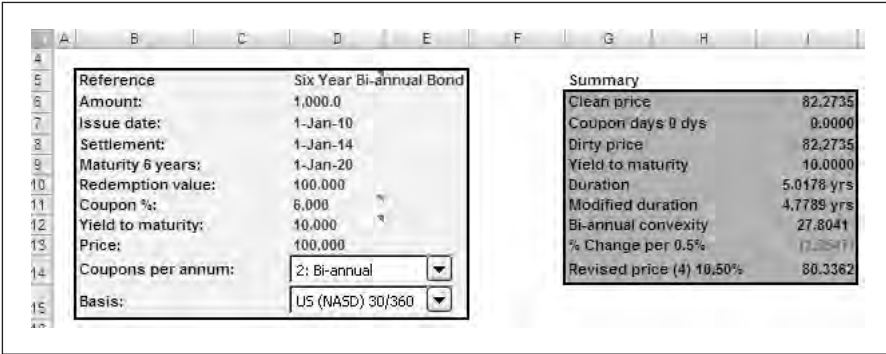
- yield to maturity (YTM);
- yield;
- redemption yield;
- gross redemption yield (GRY).

The yield is an iterative formula, which like the internal rate of return (IRR), assumes that all cash flows can be reinvested at the same rate. This is a failing with internal rates of return since this may not always be true; nevertheless this is a simple concept and most investors understand the implied return on an investment.

The yield measures are in the Model sheet with the summary answers as shown in Figure 9.6. All the examples are saved as scenarios using Data, Data Tools, What-if Analysis (Excel 2003: Tools, Scenarios, New) and can be accessed using the combo box control to the right of the sheet.

Bond calculator

Figure 9.6



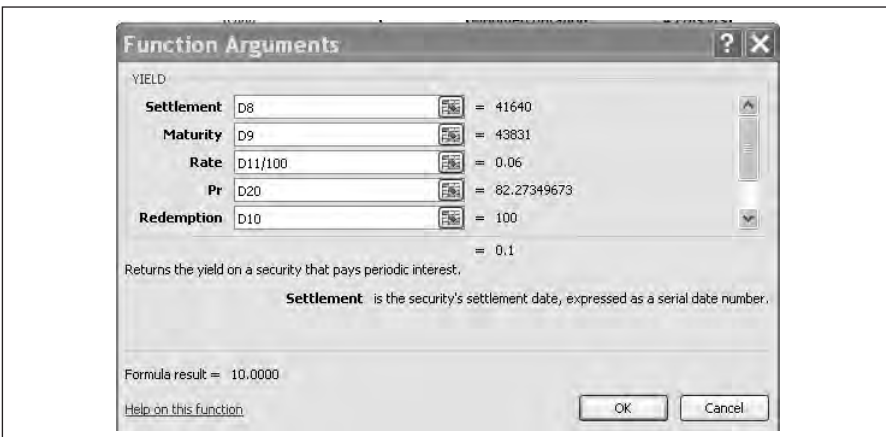
Workings

Figure 9.7



YIELD function

Figure 9.8



The model calculates the clean price as 82.27 – the present value of the coupons and principal. There are no coupons accrued and therefore the dirty price is the same as the clean price. The yield workings are shown in Figure 9.7.

Current yield

This is a simple measure and is calculated as:

$$\text{Current yield} = \text{Coupon rate}/(\text{Clean price}/100)$$

In this case, it is $6\%/(82.27/100) = 7.2927\%$. The method ignores the time value of money and therefore it cannot be used for comparing different maturity dates and coupon periods.

Simple yield to maturity

The simple yield to maturity again does not consider time value of money:

$$\{ \text{Coupon} + ((\text{Redemption} - \text{Clean})/\text{Years to maturity}) \} / \{ \text{Clean}/100 \}$$

The example is paying annual 6 per cent coupons and is priced at 82.27 with the simple yield computed as 10.88 per cent.

Yield to maturity

The yield to maturity function uses the settlement and maturity dates, the rate and number of payments per annum, the redemption value and the payment convention, to return the annual yield (see Figure 9.8).

DURATION AND MATURITY

There are four measures of sensitivity that are commonly used to measure risk in a bond. These are:

- 1 simple maturity
- 2 duration
- 3 modified duration
- 4 convexity.

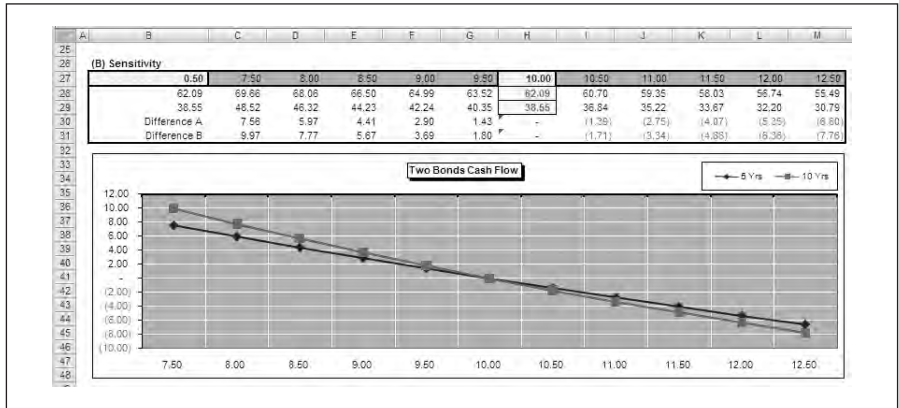
Simple maturity

Simple maturity is the time left on the bond. Since risk increases with time, then a long-dated bond is more risky than one which is due to mature

sooner. Since the principal is paid back on expiry, bonds are dissimilar to loans where a portion of the principal is paid with each instalment. Figure 9.9 shows two zero coupon bonds: the first is five years and the second ten years. The series plots the changes to the price as interest rates rise. The interest rise has a greater impact on the bond with the longer maturity.

Zero coupons

Figure 9.9



Duration

The maturity of a bond is not a suitable indicator of risk since the cash flows occur during the period to and at maturity. A bond with a longer maturity is more risky owing to the possibility of adverse yield changes over a longer period. Duration attempts to provide a weighted measure of maturity in the formula:

$$Duration = \frac{\bullet PV\ of\ cashflow * Period\ no}{Price}$$

This is the value-weighted average of the timing of the included cash flows. The cash flow schedule multiplies out the present value cash flow by its weighting and then adds them at the bottom of the schedule (see Figure 9.10). There is also a function for duration as in cell D31:

```
=DURATION(D8, D9, D11/100, IF(D12=0, D28, D12)/100, C134, F139)
=DURATION(Settlement, Maturity, Coupon, Yield, Frequency, Basis)
```

If the bond carries no coupon, as in a zero coupon bond, then the duration will always be its maturity. Duration can be applied to any groups of cash flows and is useful when linked to the concept of immunization. If yields fall, then the following occurs:

- earnings on reinvesting coupons will fall;
- the price of the bond rises if held to maturity.

Figure 9.10

Duration cash flows

	A	B	C	D	E	F	G
81							
82		Six Year Bi-annual Bond Cash flows					
83							
84		Period	Date	Cashflow	PV	Weighting	Duration
85			1-Jan-14	-			
86		1.00	1-Jul-14	3.0000	2.8571	0.0347	0.0347
87		2.00	1-Jan-15	3.0000	2.7211	0.0331	0.0661
88		3.00	1-Jul-15	3.0000	2.5915	0.0315	0.0945
89		4.00	1-Jan-16	3.0000	2.4681	0.0300	0.1200
90		5.00	1-Jul-16	3.0000	2.3506	0.0286	0.1428
91		6.00	1-Jan-17	3.0000	2.2386	0.0272	0.1633
92		7.00	1-Jul-17	3.0000	2.1320	0.0259	0.1814
93		8.00	1-Jan-18	3.0000	2.0305	0.0247	0.1974
94		9.00	1-Jul-18	3.0000	1.9338	0.0235	0.2115
95		10.00	1-Jan-19	3.0000	1.8417	0.0224	0.2239
96		11.00	1-Jul-19	3.0000	1.7540	0.0213	0.2345
97		12.00	1-Jan-20	103.0000	57.3543	0.6971	8.3654
98		13.00	-	-	-	-	-
99		14.00	-	-	-	-	-
100		15.00	-	-	-	-	-
101		16.00	-	-	-	-	-
102		17.00	-	-	-	-	-
103		18.00	-	-	-	-	-
104		19.00	-	-	-	-	-
105		20.00	-	-	-	-	-
106		21.00	-	-	-	-	-
107		22.00	-	-	-	-	-
108		23.00	-	-	-	-	-
109		24.00	-	-	-	-	-
110		25.00	-	-	-	-	-
111				136.0000	82.2736	1.0000	10.0356

At some point between the date and maturity, the loss of interest returns, and the capital gains from a higher bond price balance or cancel each other out if an investor devises an immunized portfolio where:

- present value of assets equals the present value of liabilities;
- duration of assets is equal to the duration of liabilities.

Modified duration

The model also includes a calculation of modified duration which is a more accurate measure of the link between interest rates and bond prices. This is defined as:

$$D = - \frac{1}{P} \times \frac{\Delta P}{\Delta Y}$$

where:

$P = \text{bond price}$

$\Delta P = \text{change in price}$

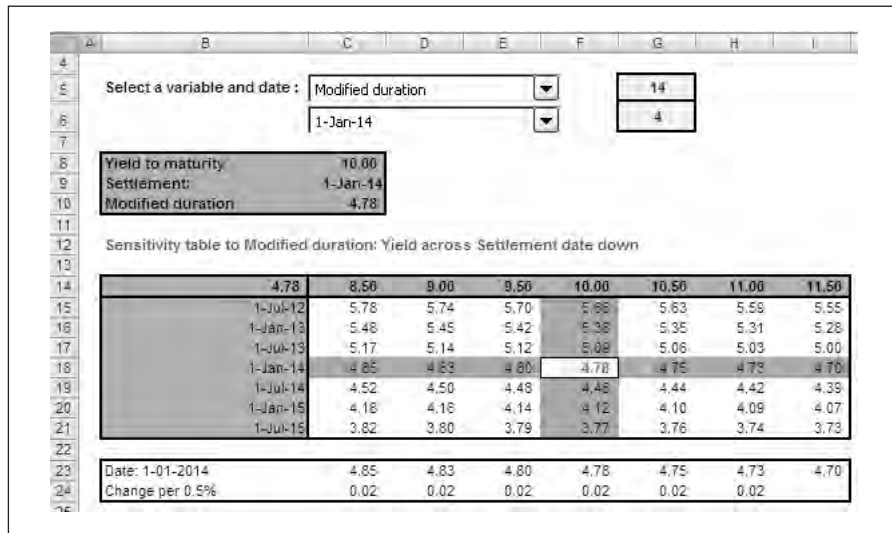
$\Delta P = \text{change in the yield to maturity.}$

=MDURATION(D8, D9, D11/100, IF(D12=0, D28, D12)/100, C134, F139)

=MDURATION(Settlement, Maturity, Coupon, Yield, Frequency, Basis)

Sensitivity selection

Figure 9.11



This is equivalent to:

=((1/(1+Yield to Maturity/100/Pmts per Year))*Duration)

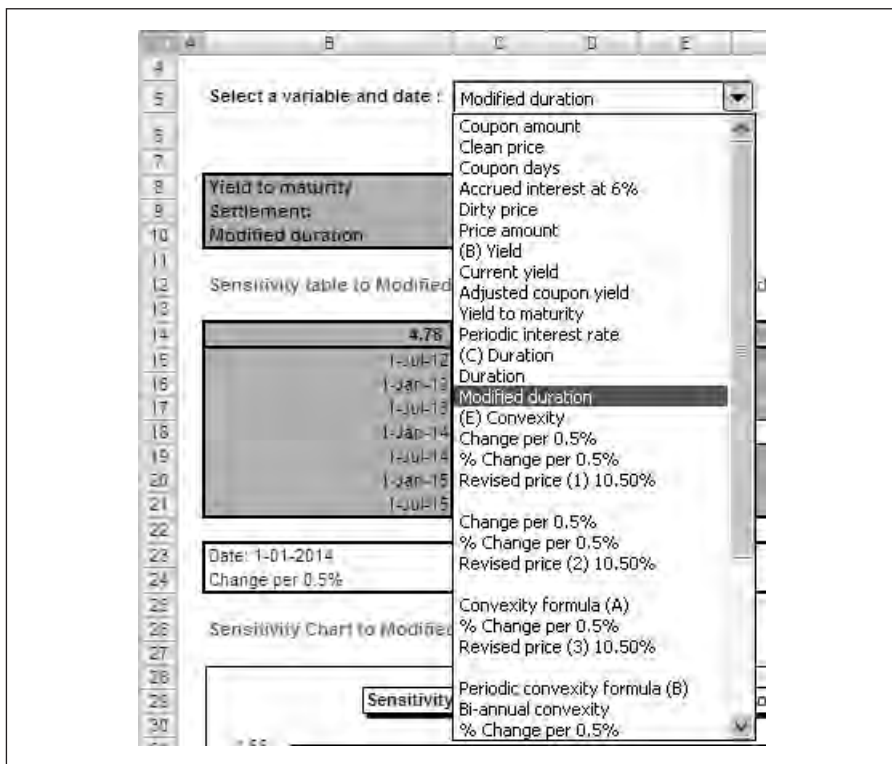
Duration varies with yield and time, and the model has a Sensitivity sheet for reviewing the effect of these two variables on a number of answers. This is a dynamic table enabling the selection of multiple lines, which updates the charts (see Figure 9.11).

The selection for the combo box is the range D18 to D55 on the Model sheet (see Figure 9.12). Making the data table dynamic increases the potential range of information. The second combo box selects a row from the two-dimensional data table for the chart. Since the variables are located on the Model sheet, the actual data table is contained in workings and looked up on the Sensitivity sheet. The cell at the top left of the table uses an OFFSET function to return the value for the row selected by the combo box.

=OFFSET(D18,Sensitivity!G5,0)

Figure 9.12

Combo box selection



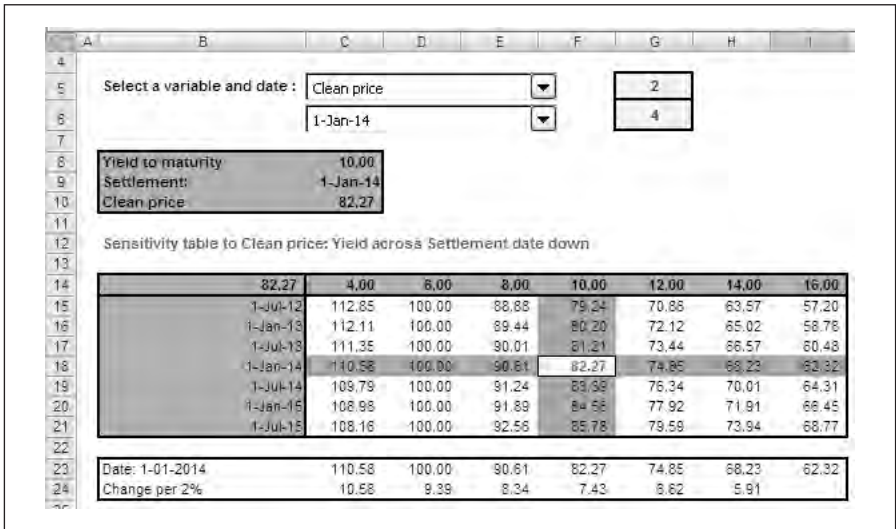
The table in Figure 9.13 shows duration and therefore risk declining as the time moves towards maturity. Duration also increases as the yield declines. The chart in Figure 9.13 plots the middle series of the table as an XY scatter and draws the answer as a single point with a data label. Duration assumes that the relationship between the bond price and yield to maturity is linear whereas the true relationship is not linear. The strict relationship is only true over small changes in yield or price. In practice, the line is slightly curved as shown in Figure 9.13 since the slope changes as you move along it.

CONVEXITY

Duration and modified duration do not fully explain the link between prices and yield, and convexity provides a partial solution to predicting prices. The actual change depends on the amount of curvature of the price line and this is known as convexity. The Model sheet contains three formulas of calculating convexity and the sensitivity is explored on a second sheet called Convexity.

Sensitivity to duration

Figure 9.13



Formula 1

The first formula is an approximation to be used for small changes since it still assumes a linear relationship. The formula calculates the price movement based on a 1 per cent yield change. The coupon rate is the periodic rate rather than the annual rate. This is the formula for a 1 per cent change:

$$1 - Duration * Price * \{1/(1 + Periodic coupon rate)\} * 0.01$$

Cell D34: =-D\$31*\$D\$20*(1/(1! ((\$D\$28/\$C\$134)/100)))*C120/100

This is derived as -7.8635 (cell G52) or 9.55 per cent for an increase to a 12 per cent yield. The answer is revised price (1) which is 74.4100 (see Figure 9.14).

Formula 2

The modified duration can also be used for calculating the price change per 1 per cent of yield using the formula:

$$- Dirty price * Change in yield * Modified duration$$

This results in the same answer for the 12 per cent yield. Again, this assumes a linear relationship and will become progressively inaccurate.

Figure 9.14

Convexity

	A	B	C	D	E	F	G	H	I
30		(C) Duration							
31		Duration		5.0178 yrs		Maturity: 6.00 years			
32		Modified duration		4.7769 yrs		Duration / (1+Yield / No of Coupons) = Slope of series			
33		(E) Convexity							
34		Change per 2%		(7.8635)		Duration * Price * [1/1+ln[] * 2.00%			
35		% Change per 2%		(9.5577)		Change*(Par/Price)			
36		Revised price (1) 12.00%		74.4100		Price+Change			
37									
38		Change per 2%		(7.8635)		Percentage change			
39		% Change per 2%		(9.5577)		Modified duration * Δ yield			
40		Revised price (2) 12.00%		74.4100		Price+Change			
41									
42		Convexity formula (A)		27.8041		Formula: [(ΔP (-1) / P) - (ΔP (-1) / P)] * 10 ⁸			
43		% Change per 2%		(9.0017)		Variance to simple formula: 0.5561			
44		Revised price (3) 12.00%		74.8675		Price+Change			
45									
46		Periodic convexity formula (B)		111.2165		PV convexity cash flow			
47		Bi-annual convexity		27.8041		Periodic = annual / (N periods ^ N periods)			
48		% Change per 2%		(9.0017)		Variance to simple formula: 0.5561			
49		Revised price (4) 12.00%		74.8675		Price+Change			
50									
51		Data table change per 2%		(8.9770)		Variance to simple formula: 0.5807			
52		Revised price (5) 12.00%		74.8878		Actual Price: 74.8485 (0.0902)			
53		(D) Dates							
54		Days to next coupon		181 days		Days remaining in this coupon period			
55		Interest remaining		(3.0157)		Interest still to be accrued in period			
56		Ex dividend price		79.2568		Clean price minus interest remaining in period			
57		Next coupon date		1-Jul-14		Next coupon date (Bi-annual)			
58		No of remaining coupons		12		Number until maturity			
59		Total coupon amount paid		24.0497		Coupon amounts paid since issue date			
60									

Formula 3

The first convexity formula is:

$$C = 10^8 \left\{ \frac{\Delta P_{d+1}}{P_d} + \frac{\Delta P_{d-1}}{P_d} \right\}$$

This involves calculating the price change for plus and minus 100 basis points using a data table in workings on the right-hand side (see Figure 9.15). Convexity is calculated as:

Cell D43: = ((N35/D20) + (P35/D20)) * 10^8)

The formula for a change in price is then:

$$\Delta Price = - Modified\ duration * \Delta Yield + \frac{Convexity}{2} * \Delta Yield^2$$

Cell D43: = (-\$D\$32 * (\$C\$124/100) + 0.5 * D42 * (\$C\$124/100)^2) * 100

The final result owing to the curvature is 74.8485 rather than 74.4100 by the simpler linear formula.

Convexity working

Figure 9.15

	L	M	N	O	P	Q
31						
32		Convexity Workings				
33		9.99	10.00	10.01	12.00	
34		82.2735	82.3128	82.2735	82.2342	74.84847
35		Change	0.0393		(0.0393)	(7.3857)
36		%	0.0478		(0.0478)	(8.9770)
37		(4) Variances				
38		Data table to convexity			0.0203	
39		Data table to simple formula			0.4778	
40		Convexity to simple formula			0.4575	
41						

Formula 4

The model also includes the full convexity formulas in the cash flow on the model sheet (see Figure 9.16) build up as a schedule using the formula below:

$$Convexity = \frac{1}{p} \cdot \frac{\Delta^2 P}{(\Delta y)^2} \cdot \frac{1}{(1+y)^2} \cdot \sum_{t=1}^r t \cdot (t+1) \cdot \frac{C_t}{(1+y)^t} / P$$

The weightings column is the present value in column E of Figure 9.16 divided by the sum of the cash flows in cell E91. The duration is the period number multiplied by the weighting. The convexity for the period is:

```
Period+Next Period*Weighting*(1/1+Periodic Yield)^2
Cell H66=B66*B67*F66*(1/(1+($D$28/Pmt_Year/100))^2)
```

At the bottom of the schedule the periodic convexity results are added:

```
Cell H91: =SUM(H66:H90)
```

The annual rate is the sum divided by (payments per year ^ payments per year). The convexity is 27.80 and with this factor the change in the bond price can be derived from:

$$\Delta \text{ Price} = - \text{Modified duration} * \Delta \text{Yield} + \frac{\text{Convexity}}{2} * \Delta \text{Yield}^2$$

The value is 74.8675 (see Figure 9.17). The schedule also includes data table workings for comparison to the calculated values and this is 74.8878 (see Figure 9.17).

COMPARISON

The Convexity sheet calculates the bond price at each of the yield to maturities on the left using a PRICE function.

Figure 9.16

Convexity workings

	A	B	C	D	E	F	G	H
61								
62		Six Year Bi-annual Bond Cash flows						
63								
64		Period	Date	Cashflow	PV	(Weighting	Duration	Convexity
65			1-Jan-14	-				
66		1.00	1-Jul-14	3.0000	2.8571	0.0347	0.0347	0.0629
67		2.00	1-Jan-15	3.0000	2.7211	0.0331	0.0661	0.1800
68		3.00	1-Jul-15	3.0000	2.5915	0.0315	0.0945	0.3428
69		4.00	1-Jan-16	3.0000	2.4681	0.0300	0.1200	0.5442
70		5.00	1-Jul-16	3.0000	2.3506	0.0286	0.1429	0.7774
71		6.00	1-Jan-17	3.0000	2.2386	0.0272	0.1633	1.0366
72		7.00	1-Jul-17	3.0000	2.1320	0.0259	0.1814	1.3163
73		8.00	1-Jan-18	3.0000	2.0305	0.0247	0.1974	1.6118
74		9.00	1-Jul-18	3.0000	1.9338	0.0235	0.2115	1.9188
75		10.00	1-Jan-19	3.0000	1.8417	0.0224	0.2239	2.2335
76		11.00	1-Jul-19	3.0000	1.7540	0.0213	0.2345	2.5526
77		12.00	1-Jan-20	103.0000	57.3543	0.6971	3.3654	98.6397
78		13.00	-	-	-	-	-	-
79		14.00	-	-	-	-	-	-
80		15.00	-	-	-	-	-	-
81		16.00	-	-	-	-	-	-
82		17.00	-	-	-	-	-	-
83		18.00	-	-	-	-	-	-
84		19.00	-	-	-	-	-	-
85		20.00	-	-	-	-	-	-
86		21.00	-	-	-	-	-	-
87		22.00	-	-	-	-	-	-
88		23.00	-	-	-	-	-	-
89		24.00	-	-	-	-	-	-
90		25.00	-	-	-	-	-	-
91				-136.0000	82.2735	1.0000	10.0356	111.2165
92								
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Column F of Figure 9.18 repeats formula 2 (–dirty price * change in yield * modified duration) as the duration multiplied by the change in yield to obtain the percentage change. This can then be multiplied out against the existing price. Column I uses formula 4 to obtain the percentages and these are added in column J. You can see that the differences are small when close to the current yield to maturity but owing to convexity, become more pronounced as you move further from the existing price.

Summary table

Figure 9.18

Convexity: Predicted and Actual										
Interval		1.00								
Yield to maturity	Change in yield	Actual change %	Clean price	-D*Δ in yield %	Revised price (2) 12.00%	Difference (2)	Periodic convexity formula (B)	Revised price (4) 12.00%	Difference (4)	
2.00	(8.0000)	48.9080	122.5102	38.2310	113.7275	8.7827	47.1283	121.0476	1.4625	
3.00	(7.0000)	41.4323	116.3813	33.4521	109.7957	6.5855	40.2641	115.4002	0.9611	
4.00	(6.0000)	34.3997	110.5753	28.6732	105.9640	4.7114	33.6780	109.9816	0.5938	
5.00	(5.0000)	27.7798	105.1289	23.8944	101.9322	3.1987	27.3698	104.7917	0.3372	
6.00	(4.0000)	21.5458	100.0000	19.1155	98.0005	1.9995	21.3398	99.6305	0.1695	
7.00	(3.0000)	15.6731	95.1683	14.3366	94.0687	1.0996	15.5878	95.0881	0.0702	
8.00	(2.0000)	10.1387	90.6149	9.5577	90.1370	0.4779	10.1138	90.5945	0.0204	
9.00	(1.0000)	4.9209	86.3221	4.7788	86.2052	0.1169	4.9178	86.3196	0.0025	
10.00	-	0.0000	82.2735	-	82.2735	0.0000	-	82.2735	0.0000	
11.00	1.0000	(4.6428)	78.4537	(4.7789)	78.3417	0.1120	(4.8399)	78.4561	(0.0024)	
12.00	2.0000	(9.0248)	74.8485	(9.5577)	74.4100	0.4385	(9.0017)	74.8675	(0.0190)	
13.00	3.0000	(13.1622)	71.4445	(14.3366)	70.4783	0.9662	(13.0954)	71.5077	(0.0832)	
14.00	4.0000	(17.0702)	68.2293	(19.1155)	66.5465	1.6827	(16.8912)	68.3765	(0.1473)	
15.00	5.0000	(20.7828)	65.1912	(23.8944)	62.6148	2.5765	(20.4169)	65.4742	(0.2829)	
16.00	6.0000	(24.2631)	62.3196	(28.6732)	58.8830	3.6388	(23.8695)	62.8006	(0.4810)	
17.00	7.0000	(27.5538)	59.6042	(33.4521)	54.7513	4.8530	(26.8401)	60.3557	(0.7515)	
18.00	8.0000	(30.6756)	57.0356	(38.2310)	50.8195	6.2161	(29.3337)	58.1397	(1.1040)	

Two further charts illustrate the table (see Figures 9.19 and 9.20). Figure 9.19 plots the actual and predicted changes in amounts from formulas 2 and 4. The convexity formula rather than the duration-based formula is more accurate in tracking the actual price changes. The periodic convexity follows the actual change closely.

Figure 9.20 plots the percentage differences against the predicted actual prices. The duration-based formula becomes progressively less accurate away from the current yield of 10 per cent. By contrast, formula 4, based on the convexity cash flows, remains more accurate further from the current yield.

Figure 9.19

Convexity chart

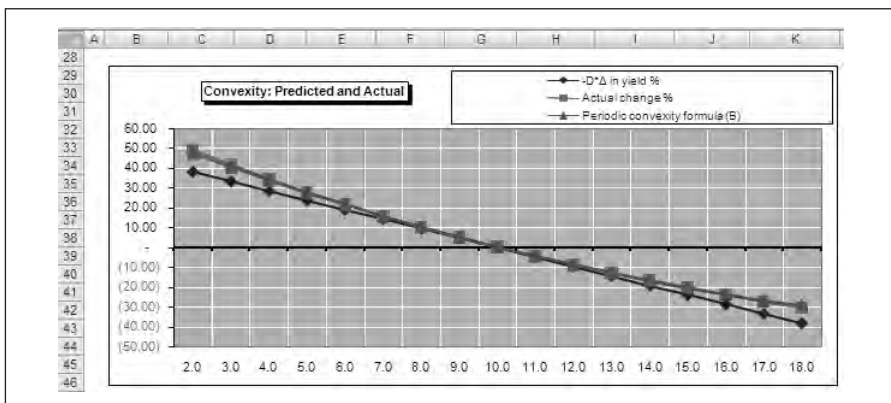
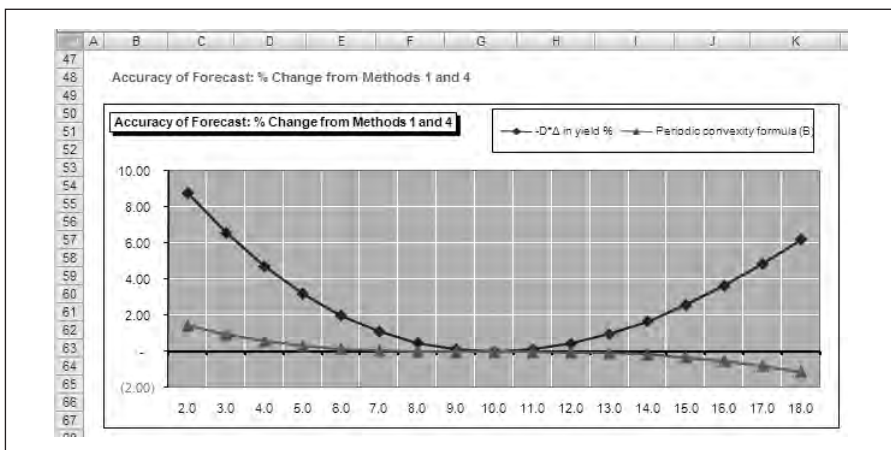


Figure 9.20

Percentage differences to actual prices



SUMMARY

Bond mathematics provides a method of assessing risk in fixed income products. The requirements include assessing price, yield and risk. Since the value of a bond varies inversely with the yield, this chapter has provided methods of assessing the sensitivity of a bond's value to changes in interest rates. The main methods are duration and convexity, which provide a standardized measure of risk in the product. Using these measures, it is possible to assess the sensitivity to interest rate changes which will affect the value of the bond cash flows.

INTRODUCTION

This chapter introduces options models, and maps the pricing and pay-offs whereby the holders can use these instruments to reduce downside risk upon payment of premiums. The models show how downside risk is removed and how combinations of options can deal with varying expectations of future volatility in the markets. Definitions of options are as follows.

- An *option* provides an opportunity to buy or sell a specified quantity of an underlying asset at or before an expiry date at a strike or exercise price.
- A *call option* is a contract giving its holder the right (but not the obligation) to buy at a fixed price at any time on or before a given date. The premium is paid at the beginning and if at expiration, the asset value is less than the strike price, then the option is worthless and the holder would decide not to exercise the option. If it is greater, the holder would exercise the option and purchase at the exercise price. The variance between the asset price and the exercise price would constitute a profit less the initial price for the option.
- A *put option* is a contract giving its holder the right (but not the obligation) to sell at a fixed price at any time on or before a given date. The holder pays the premium. On expiry, if the price of the asset is greater than the strike price, the option would not be exercised. If the price is less than the strike price, the put option would be exercised and stock sold at the strike price. The difference between the strike price and the expiry market value of the asset would represent a profit on the transaction.

American options use the above definitions whereas European options can only be exercised on the expiry date. Since you can allow an option to lapse if it is worthless, options can be useful in covering possible downside risk. Since there are two sides to the bargain, the pricing reflects perceptions of risk and uncertainty in the underlying asset. The pricing of options is determined by:

- volatility of variance in the price of the underlying asset since the uncertainty has to be priced into the contract;
- initial value of the underlying asset;
- strike price at expiry;
- time to expiry since risk usually increases with time;
- risk less interest rate for the period of the option.

Table 10.1 shows the effects on call and put values of various variables.

Table 10.1

Variable	Effect on call value	Effect on put value
Increase in volatility	Increase	Increase
Increase in asset price	Increase	Decrease
Increase in strike price	Decrease	Increase
Increase in time to expiry	Increase	Increase
Increase in risk-free rate	Increase	Decrease

OPTIONS

The sheet called Call_Put_Option demonstrates the workings of an option. The scenario called Example 1 contains the example shown in Figure 10.1. The option is the right to buy shares at 5.00 over a period ending in June. The underlying price at the time of writing the contracts is 5.00 and the price of the option is 0.78. This fixes the maximum loss at 0.78 since this is a right and not an obligation to buy. Likewise, the maximum loss on the put options is limited to 0.38. The possible courses of action are:

- the price rises – sell the option in the market or exercise the option on expiry;
- the price falls – allow the option to lapse as it is worthless.

Figure 10.1

Option inputs

	A	B	C	D	E	F	G	H	
7									
8		Commodity	Contract Size	Exercise or Strike Price	Total	June Call	June Put	Current Price	
9									
10		Shares	1,000	5.00	5,000.00	0.78	0.38	5.25	
11		Interest Rate for Period	3.00%						
12									
13		Call (Buy) or Put (Sell):	Call						
14									
15		Cost with Option	5,780.00						
16									
17		Maximum Loss	(780.00)						
18									
19		Put-call Parity Formula	S + P = C + Present Value of Exercise Price					Current Price	
20		S + P	5.83					5.40	
21		C	0.78					0.78	
22		PV	4.85					4.85	
23		C + PV	5.63					5.63	
24		Error	(0.00)						
25		Error on Parity	None: S + P = C + Present Value of Exercise Price						

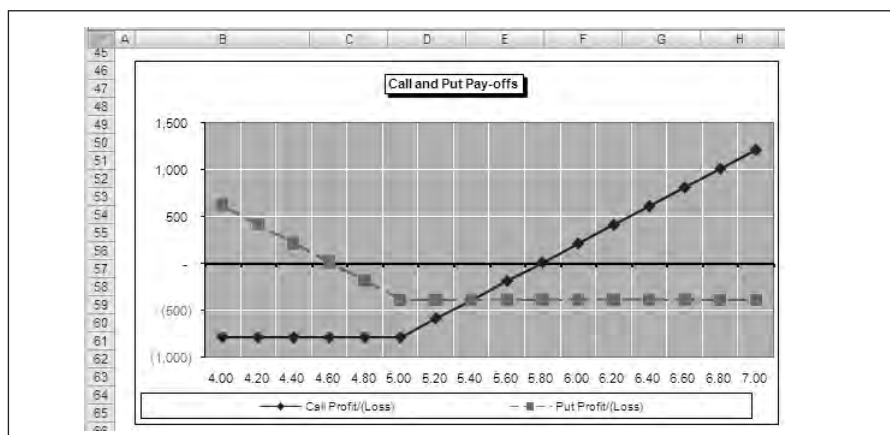
Figure 10.2

Call option table and pay-off diagrams

	A	B	C	D	E	F	G	H
26								
27		Interval for Graph and Table	0.20	Cost with option	Adopt	Cost without Option		Profit / (Loss)
28		Expiry Security Price	4.00	4,780.00	4,780.00	4,000.00		(780.00)
29			4.20	4,980.00	4,980.00	4,200.00		(780.00)
30			4.40	5,180.00	5,180.00	4,400.00		(780.00)
31			4.60	5,380.00	5,380.00	4,600.00		(780.00)
32			4.80	5,580.00	5,580.00	4,800.00		(780.00)
33			5.00	5,780.00	5,780.00	5,000.00		(780.00)
34			5.20	5,980.00	5,780.00	5,200.00		(580.00)
35			5.40	6,180.00	5,780.00	5,400.00		(380.00)
36			5.60	6,380.00	5,780.00	5,600.00		(180.00)
37			5.80	6,580.00	5,780.00	5,800.00		20.00
38			6.00	6,780.00	5,780.00	6,000.00		220.00
39			6.20	6,980.00	5,780.00	6,200.00		420.00
40			6.40	7,180.00	5,780.00	6,400.00		620.00
41			6.60	7,380.00	5,780.00	6,600.00		820.00
42			6.80	7,580.00	5,780.00	6,800.00		1,020.00
43			7.00	7,780.00	5,780.00	7,000.00		1,220.00

Pay-off chart

Figure 10.3



The inputs section checks the pricing of the call and put options since the pricing should, in theory, equate to call put parity through this formula:

$$\text{Spot Price} + \text{Put} = \text{Call} + \text{Present value of exercise price}$$

The present value is calculated in the model using the basic formula $1/(1 + \text{Interest rate})$ using the periodic interest rate entered in cell C11. Plotting the pay-offs for a call and a put are clearer in Excel and this schedule contains tables and charts (see Figures 10.1, 10.2 and 10.3).

If the share price was below the strike price of 5.00 plus the cost of the option of 0.78, Figure 10.2 shows losses and the options would not be exercised. The maximum loss is fixed at 0.78 per unit. Above 5.78, the profits increase since the strike plus premium price remains at 5.78.

The reverse is true for the put option where the losses increase as the price rises. The break even is 5.00 less the price of the option of 0.38 per unit (see Figure 10.4).

Put option

Figure 10.4

Interval for Graph and Table	0.20	Cost with option	Adopt	Cost without Option	Profit/(Loss)
Expiry Security Price	4.00	4,620.00	4,620.00	4,000.00	620.00
	4.20	4,620.00	4,620.00	4,200.00	420.00
	4.40	4,620.00	4,620.00	4,400.00	220.00
	4.60	4,620.00	4,620.00	4,600.00	20.00
	4.80	4,620.00	4,620.00	4,800.00	(180.00)
	5.00	4,620.00	4,620.00	5,000.00	(380.00)
	5.20	4,620.00	4,620.00	5,200.00	(580.00)
	5.40	4,620.00	4,620.00	5,400.00	(780.00)
	5.60	4,620.00	4,620.00	5,600.00	(980.00)
	5.80	4,620.00	4,620.00	5,800.00	(1,180.00)
	6.00	4,620.00	4,620.00	6,000.00	(1,380.00)
	6.20	4,620.00	4,620.00	6,200.00	(1,580.00)
	6.40	4,620.00	4,620.00	6,400.00	(1,780.00)
	6.60	4,620.00	4,620.00	6,600.00	(1,980.00)
	6.80	4,620.00	4,620.00	6,800.00	(2,180.00)
	7.00	4,620.00	4,620.00	7,000.00	(2,380.00)

The chart is driven by the workings area on the right, which calculates both series simultaneously (see Figure 10.5). The code uses simple IF statements to decide whether to adopt the result or not. This means, for example, that the call option will adopt the 5.78 figure.

Figure 10.5

Workings

	L	M	N	O	P	Q	R
26	Workings - Graph						
27		Call	Adopt	Call Profit/(Loss)	Put	Adopt	Put Profit/(Loss)
28		4,780.00	4,780.00	(780.00)	4,620.00	4,620.00	620.00
29		4,980.00	4,980.00	(780.00)	4,620.00	4,620.00	420.00
30		5,180.00	5,180.00	(780.00)	4,620.00	4,620.00	220.00
31		5,380.00	5,380.00	(780.00)	4,620.00	4,620.00	20.00
32		5,580.00	5,580.00	(780.00)	4,620.00	4,620.00	(120.00)
33		5,780.00	5,780.00	(780.00)	4,620.00	4,620.00	(380.00)
34		5,980.00	5,780.00	(580.00)	4,620.00	4,620.00	(380.00)
35		6,180.00	5,780.00	(380.00)	4,620.00	4,620.00	(380.00)
36		6,380.00	5,780.00	(180.00)	4,620.00	4,620.00	(380.00)
37		6,580.00	5,780.00	20.00	4,620.00	4,620.00	(380.00)
38		6,780.00	5,780.00	220.00	4,620.00	4,620.00	(380.00)
39		6,980.00	5,780.00	420.00	4,620.00	4,620.00	(380.00)
40		7,180.00	5,780.00	620.00	4,620.00	4,620.00	(380.00)
41		7,380.00	5,780.00	820.00	4,620.00	4,620.00	(380.00)
42		7,580.00	5,780.00	1,020.00	4,620.00	4,620.00	(380.00)
43		7,780.00	5,780.00	1,220.00	4,620.00	4,620.00	(380.00)

OPTIONS EXAMPLE

This Options_Example sheet allows you to choose a call or a put and view the net pay-offs at different strike prices. The data inputs are shown in Figure 10.6.

The controls allow you to select a call or a put and to select the option to be drawn in the chart at the bottom of the schedule. This is the code in cell C25, which contains a first IF statement using cell C75 (the result cell from the Call/Put control).

```
=IF($C$75=1, IF($B25>C$22, $B25 - C$22 - C$23, - C$23), IF($B25<C$22, C$22 - $B25 - C$23, - C$23))
```

With the call, if the market price is greater than the contract price it calculates a profit, otherwise the loss is the maximum, which is the option premium. With a put option, the opposite is true and a margin is available if the market price is below the contract price.

Below the inputs, there is a table showing the results from a put option on market prices between 95.00 and 110.00 (see Figure 10.7). There are workings for the chart on the right-hand side and column K displays the

results from the 'do nothing' alternative. At the strike price of 103.00, the only loss is the premium, but below this figure, the losses mount.

Inputs and prices

Figure 10.6

(A) Call Options			(B) Put Options			Units \$0
Strike Price	Premium (points)		Strike Price	Premium (points)		
Price less 3.0	100.00	3.50	100.00	0.60		
Price less 2.0	101.00	2.80	101.00	0.85		
Price less 1.0	102.00	2.15	102.00	1.20		
At-the-money	103.00	1.50	103.00	1.50		
Price plus 1.0	104.00	1.20	104.00	2.20		
Price plus 2.0	105.00	0.85	105.00	2.80		
Price plus 3.0	106.00	0.70	106.00	3.65		

Options example

Figure 10.7

Options Example: Put : At-the-money : 103.00 : Premium 1.50

Select:

Strike:

Interval: 1.00

Market Price	100.00	101.00	102.00	103.00	104.00	105.00	106.00
Put	0.60	0.85	1.20	1.50	2.20	2.80	3.65
95.00	4.40	5.15	5.80	6.50	6.80	7.20	7.35
96.00	3.40	4.15	4.80	5.50	5.80	6.20	6.35
97.00	2.40	3.15	3.80	4.50	4.80	5.20	5.35
98.00	1.40	2.15	2.80	3.50	3.80	4.20	4.35
99.00	0.40	1.15	1.80	2.50	2.80	3.20	3.35
100.00	(0.60)	0.15	0.80	1.50	1.80	2.20	2.35
101.00	(0.80)	(0.65)	(0.20)	0.50	0.80	1.20	1.35
102.00	(0.60)	(0.65)	(1.20)	(0.50)	(0.20)	0.20	0.35
103.00	(0.60)	(0.65)	(1.20)	(1.50)	(1.20)	(0.80)	(0.65)
104.00	(0.60)	(0.65)	(1.20)	(1.50)	(2.20)	(1.80)	(1.65)
105.00	(0.80)	(0.65)	(1.20)	(1.50)	(2.20)	(2.80)	(2.65)
106.00	(0.60)	(0.65)	(1.20)	(1.50)	(2.20)	(2.80)	(3.65)
107.00	(0.60)	(0.65)	(1.20)	(1.50)	(2.20)	(2.60)	(3.65)
108.00	(0.60)	(0.65)	(1.20)	(1.50)	(2.20)	(2.80)	(3.65)
109.00	(0.60)	(0.65)	(1.20)	(1.50)	(2.20)	(2.80)	(3.65)
110.00	(0.60)	(0.65)	(1.20)	(1.50)	(2.20)	(2.80)	(3.65)

The chart plots several of the price lines to illustrate the trade-off on the put option (see Figure 10.8). The losses are limited to the premium paid for the put.

The chart is reversed with a call option where there are gains below the mid-price of 103.00 (see Figure 10.9). This method of charting pay-off diagrams makes it easier to understand the profit and losses under different prices. It is also another method of auditing the model to ensure that it produces plausible values.

Figure 10.8

Put options chart

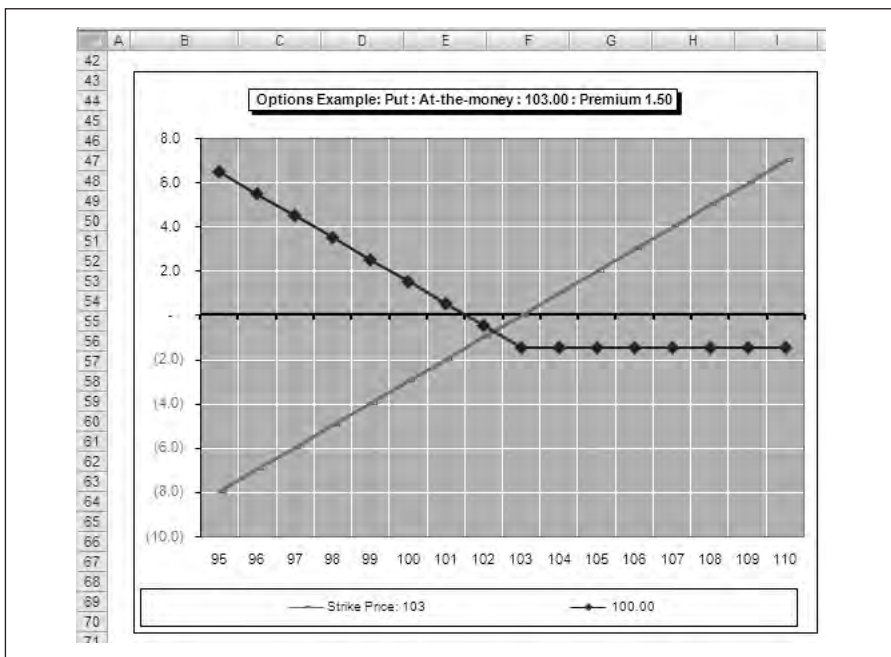
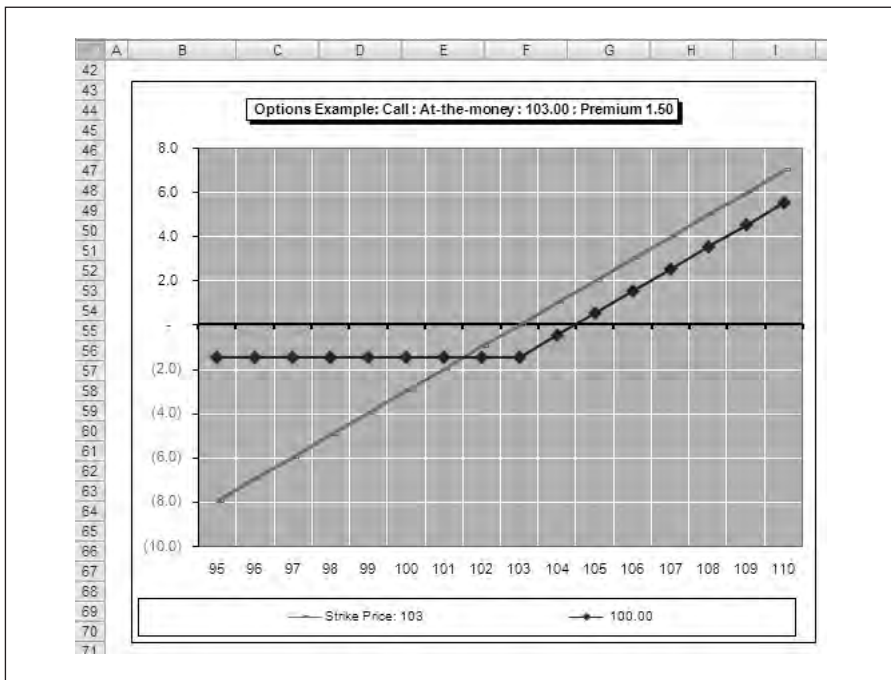


Figure 10.9

Call option chart



OPTIONS HEDGING STRATEGY

The strategy sheet allows the investigation of options strategies since there are inputs for up to two strike prices of:

- buy call
- buy put
- sell/write call
- sell/write put.

The spreadsheet uses a series of eight blocks of workings on the right which collect data from the inputs area (see Figure 10.10). This is to allow strategies such as so-called butterflies with options purchased at different rates.

Strategy inputs

Figure 10.10

	A	B	C	D	E	F	G	H	I	J	K
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											

	Number	Price	Premium
Buy Call	1	103.00	1.50
Buy Put	1	105.00	0.85
Write Call	1	104.00	1.20
Write Put	0	-	-
Interval		1.00	

	Strike	Call	Put
Price less 4.0	100.00	3.50	0.60
Price less 3.0	101.00	2.80	0.85
Price less 2.0	102.00	2.15	1.20
At-the-money	103.00	1.50	1.50
Price plus 0.0	104.00	1.20	2.20
Price plus 1.0	105.00	0.85	2.80
Price plus 2.0	106.00	0.70	3.65

Units 50

In each case, the workings use the number of options, the price and premium paid, if received, to work out if the options is in or out of the money (see Figure 10.11). This decides whether the option is worth exercising or not and then the block derives the amount, and removes the premium to leave the net pay-off for the underlying expiry price.

The calculations can be checked to show the net sum from writing and buying a put or a call. Figures 10.12 and 10.13 show the charts from both methods with a zero pay-off since both options are at the same price of 103.0. The net position series runs along the x -axis. Using the grid, the next section considers option strategies in stable and volatile environments.

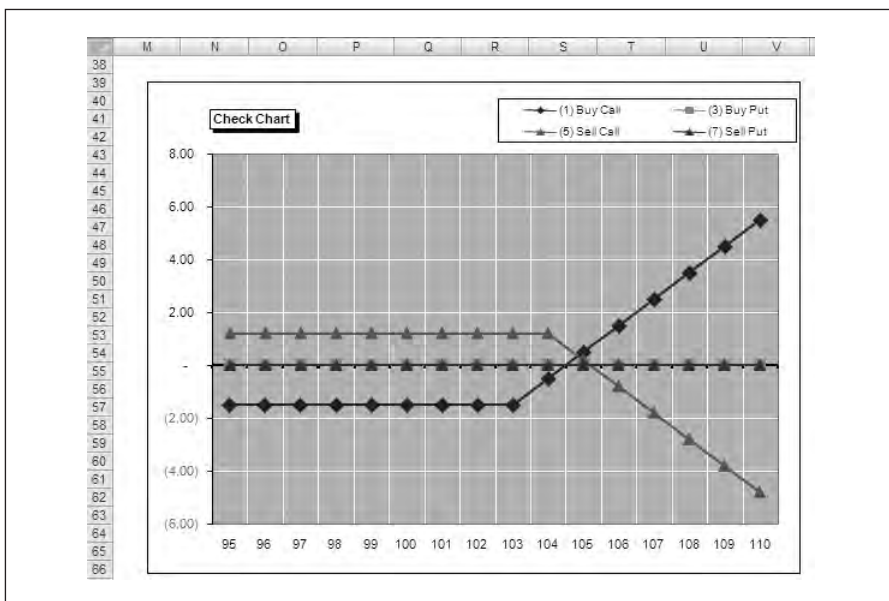
Figure 10.11

Workings

	L	M	N	O	P
11					
12					No 1.00
13					Price 103.00
14			(1) Buy Call		Premium 1.50
15					
In/Out	Buyer	Premium	Net Put		
17					
18	N	-	(1.50)	(1.50)	
19	N	-	(1.50)	(1.50)	
20	N	-	(1.50)	(1.50)	
21	N	-	(1.50)	(1.50)	
22	N	-	(1.50)	(1.50)	
23	N	-	(1.50)	(1.50)	
24	N	-	(1.50)	(1.50)	
25	N	-	(1.50)	(1.50)	
26	N	-	(1.50)	(1.50)	
27	Y	1.00	(1.50)	(0.50)	
28	Y	2.00	(1.50)	0.50	
29	Y	3.00	(1.50)	1.50	
30	Y	4.00	(1.50)	2.50	
31	Y	5.00	(1.50)	3.50	
32	Y	6.00	(1.50)	4.50	
33	Y	7.00	(1.50)	5.50	
34					
					0.25
					2.38
35					
36					
37					

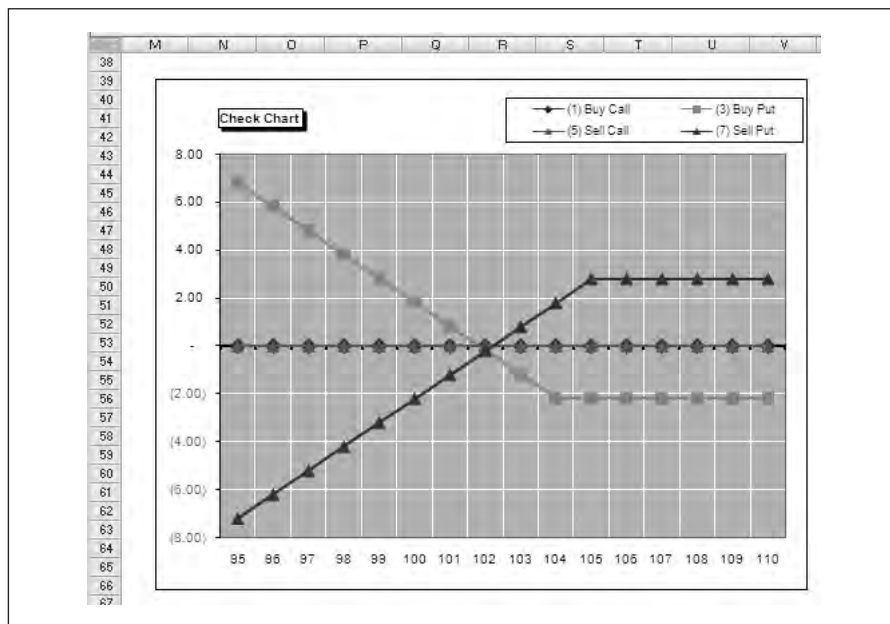
Figure 10.12

Buy and write a call



Buy and write a put

Figure 10.13



Neutral – sell straddle

Each of the following strategies are saved as scenarios to the model to allow easy loading of the values. The expectation with a sell straddle is for a stable environment where prices are likely to fluctuate in a very narrow range (see Figure 10.14). A call option and a put option are sold with the same strike price since the expected is not likely to move. There is a profit if the market stays within a narrow range but losses on both sides if there is greater fluctuation.

Office 2007 – Data, Data Tools, What-if Analysis (Excel 2003 – Tools, Scenarios)

The lower point will be the strike minus the value of two premiums received and the upper point will be the strike plus the two premiums received. There is, of course, unlimited downside risk if the market rises or falls outside the band.

Neutral – sell strangle

Prices here are expected to fluctuate in a broader range (see Figure 10.15). A put option is sold with a strike price at the money and a call option is sold with the higher strike price. The breakeven will be the lower strike minus

the two premiums received and the upper point will be the higher strike plus the two premiums received. Again, the downside risk is unlimited outside the bands chosen.

Figure 10.14

Sell straddle

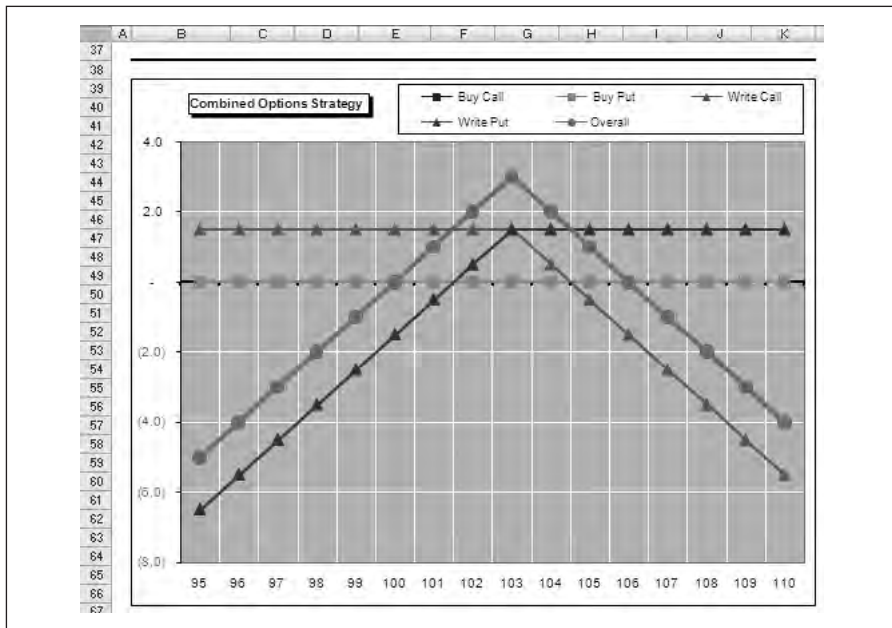
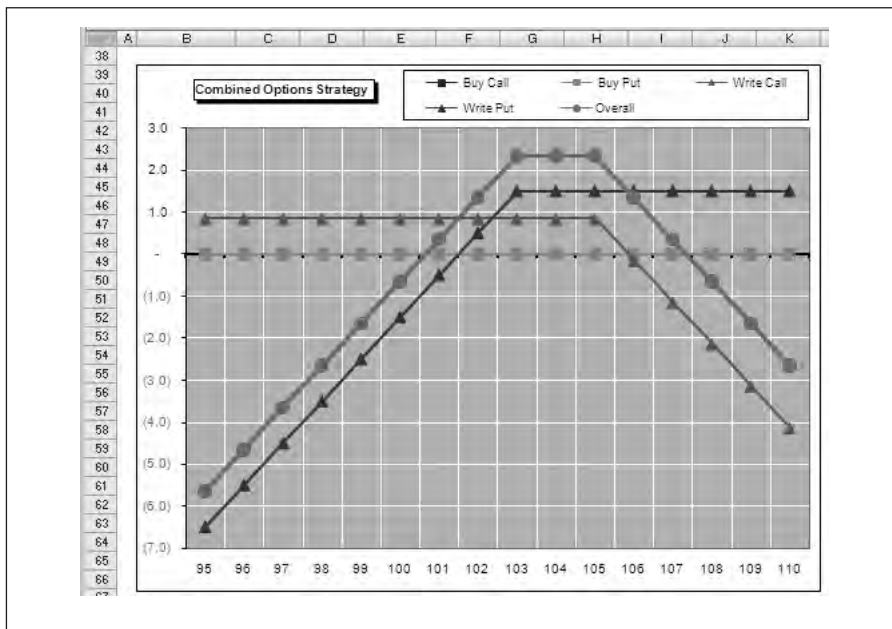


Figure 10.15

Sell strangle



Neutral – long butterfly

Here investors are moderately certain that prices will not fluctuate much outside the current band (see Figures 10.16 and 10.17). Investors think that the market will not be volatile during the term, but wants to cap the downside risk. A call option with low strike is bought, two call options with medium strike are sold, and a call option with high strike is bought. The upside potential is limited to the difference between the lower and middle strikes minus the net debit of establishing the spread. The downside risk is limited to the initial net debit of establishing the spread.

Neutral – long butterfly

Figure 10.16

	A	B	C	D	E	F	G	H	I	J	K
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											

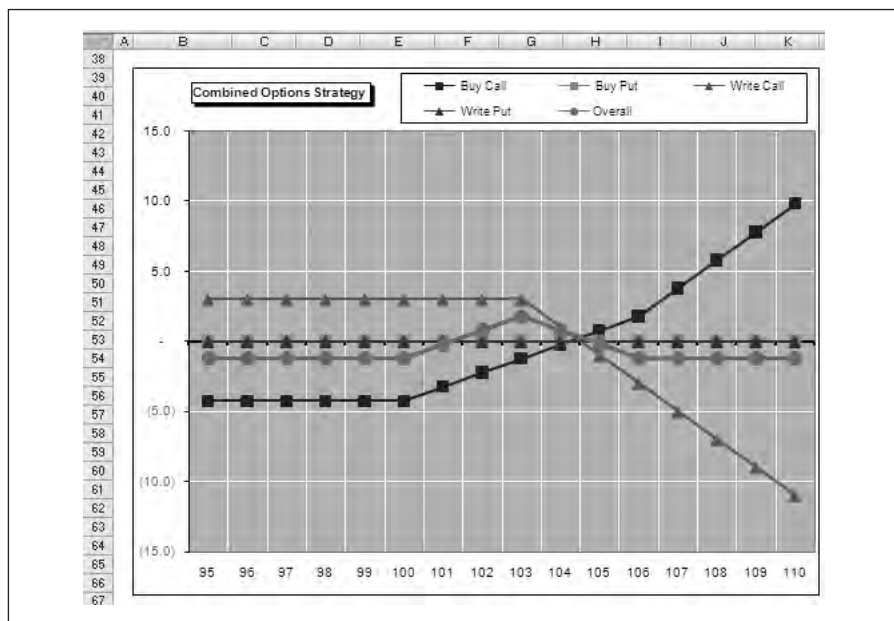
	Number	Price	Premium
Buy Call	1	100.00	3.50
Buy Put	1	106.00	0.70
Write Call	1	103.00	1.50
Write Put	0	-	-
Interval		1.00	

	Strike	Call	Put
Price less 3.0	100.00	3.50	0.60
Price less 2.0	101.00	2.80	0.85
Price less 1.0	102.00	2.15	1.20
At-the-money	103.00	1.50	1.50
Price plus 1.0	104.00	1.20	2.20
Price plus 2.0	105.00	0.85	2.80
Price plus 3.0	106.00	0.70	3.65

Units: \$0

Neutral – long butterfly chart

Figure 10.17

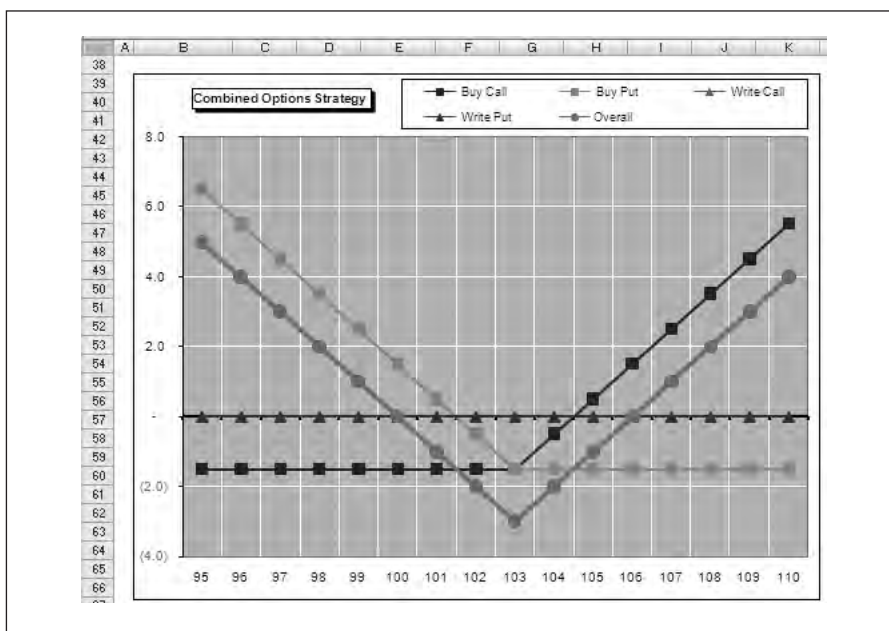


Volatile – buy straddle

Investors expect prices to be very volatile and want to be protected against extreme movements (see Figure 10.18). The position will lose if prices do not fluctuate outside the narrow range. A call option and put option are bought with the same strike price, usually at-the-money. There is upside potential at expiry away from the strike prices and the lower point is the strike minus the two premiums paid while the upper position is the strike plus the two premiums. The downside is limited to the total of the two premiums paid.

Figure 10.18

Volatile – buy straddle

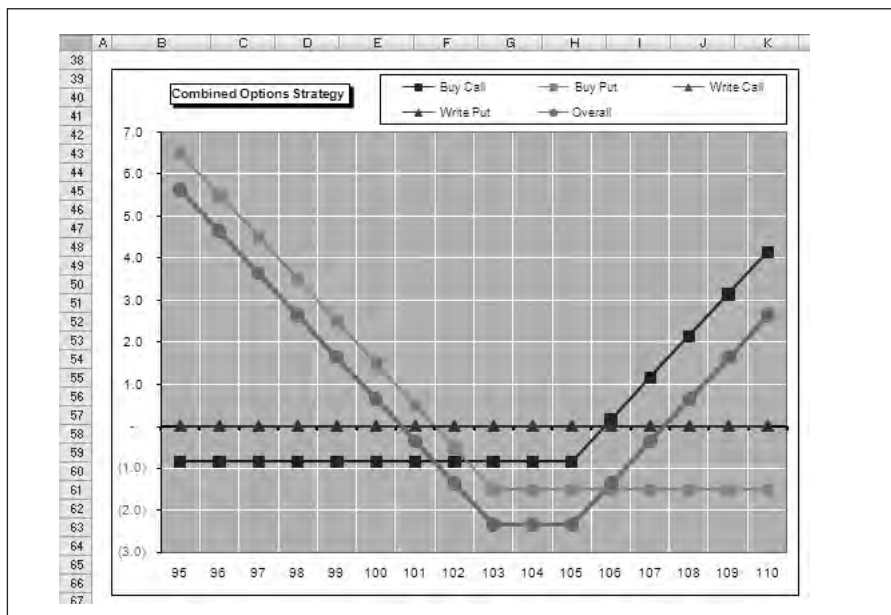


Volatile – buy strangle

Prices are expected to be volatile and the investor therefore purchases a put option with low strike price (103 as shown in Figure 10.19) and a call option is bought with at a higher strike price (105 as shown in Figure 10.19). The upside potential is unlimited if the market falls or rises greatly. The downside is limited to the two premiums paid.

Volatile – buy strangle

Figure 10.19



Volatile – short butterfly

Investors here expect prices to be moderately volatile (see Figures 10.20 and 10.21). A call option is sold with a low strike price, two call options are bought with a medium strike price, and a call option is sold with a higher strike price. The upside is limited to initial credit received while the downside is limited to the difference between the lower and middle strikes minus the initial spread credit.

Volatile – short butterfly inputs

Figure 10.20

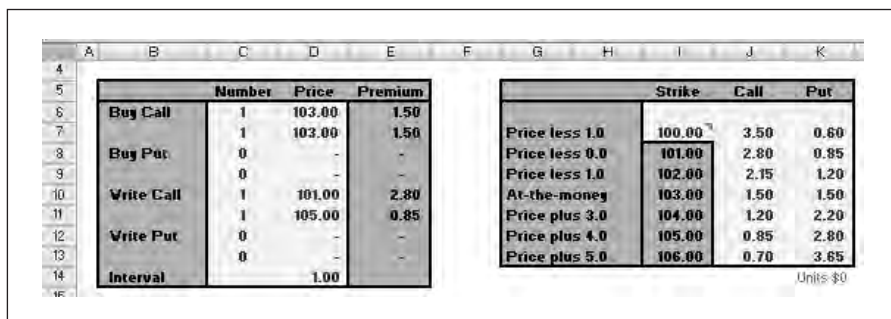
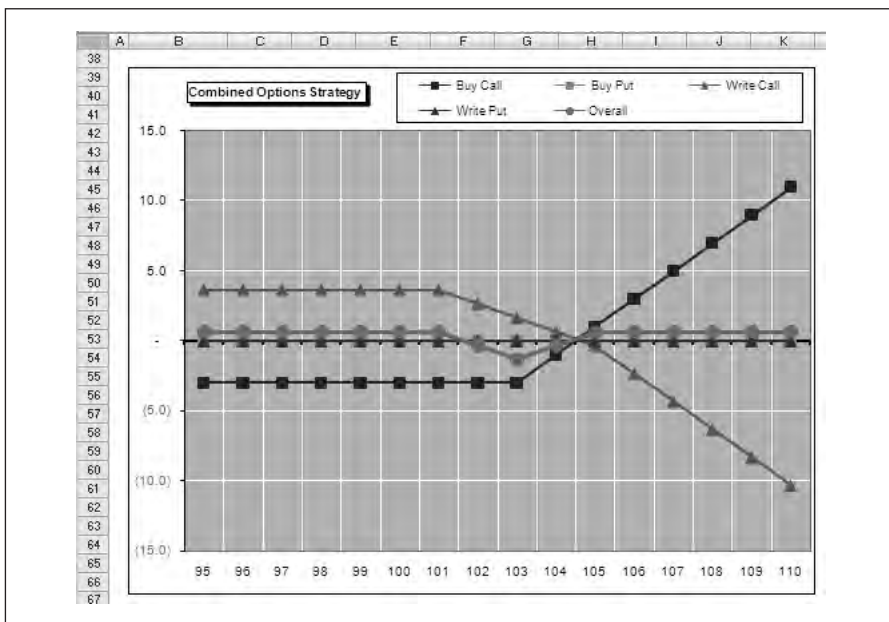


Figure 10.21

Volatile – short butterfly chart



BLACK-SCHOLES

The Black-Scholes schedule uses the standard option pricing model which was outlined in the paper written by F. Black and M. Scholes in 1973, 'The pricing of options and corporate liabilities' in the *Journal of Political Economy* (May/June, pp.637-54). This paper was a breakthrough since the model appeared to price risk correctly and used a limited number of observable quantities such as:

- maturity date (T)
- domestic interest rate (Int)
- volatility of the share price as measured by standard deviation (S)
- current stock price (P)
- exercise price (X).

The main assumptions for the model are:

- Relative price rises in the future are independent of changes in the current price.
- Interest rates and volatility remain constant during the period and assume that future volatility equals past volatility in prices. This may not be true since volatility reduces as you near the maturity date.

- The probability distribution of relative price changes is lognormal, which means that there is a smaller probability of significant deviations from the mean.
- There are no transaction costs to distort the pricing patterns.

The workings for a call and put options are located at the bottom of the Black–Scholes schedule (see Figure 10.22). To make the workings more understandable, the cells have been named as in cells C115 to C120 and this shows how the formula is built up.

Black–Scholes workings

Figure 10.22

	A	B	C	D	E	F	G	H	I
115		Days in current year		365.0					
116		T		0.499 yrs		Time to maturity expressed as a decimal of a year			
117		r (Int)		8.00%		Risk-free rate of interest			
118		S		12.00%		Stock volatility			
119		P		220.0000		Current stock (share) price			
120		X		225.0000		Exercise price			
121									
122		(1) Call Option							
123		d1		0.2479		$(\ln(S/X) + (r + 0.5\sigma^2)T) / (\sigma\sqrt{T})$			
124		d2		0.1632		$d_1 - \sigma\sqrt{T}$			
125		N(d1)		0.5979		Formula NormSDist(d1)			
126		N(d2)		0.5648		Formula NormSDist(d2)			
127		Call price		9.4251		$P \cdot N(d1) - X \cdot \exp(-rT) \cdot N(d2)$			
128									
129		(2) Put Option							
130		-d1		(0.2479)					
131		-d2		(0.1632)					
132		N(-d1)		0.4021		Formula NormSDist(-d1)			
133		N(-d2)		0.4352		Formula NormSDist(-d2)			
134		Put price		5.6264		$P \cdot N(-d1) - X \cdot \exp(-rT) \cdot N(-d2)$			
135									
136		(3) Check Put-call Parity Formula							
137		Formula				$S + P = C + \text{Present Value of Exercise Price}$			
138		P + Put		225.6264					
139		Call Price		9.4251					
140		PV of X		216.5292					
141		C + PV		225.9543					
142		Variance		(0.3279)					
143		Error on Parity		(0.33)					

The inputs for the example are as shown in Figure 10.23, saved as a scenario called Example 1. The workings for the pricing are at the base of the schedule and summarized on the right.

The results from the workings are repeated as a management summary at the top and there are two Sensitivity tables, one each for calls and puts (see Figure 10.24). The two axes are the exercise price across and the volatility down, and the answers are highlighted by conditional formatting. An update table macro is linked to the button at the top and this code copies down the share price and volatility to the inputs on each table.

Figure 10.23

Black-Scholes inputs

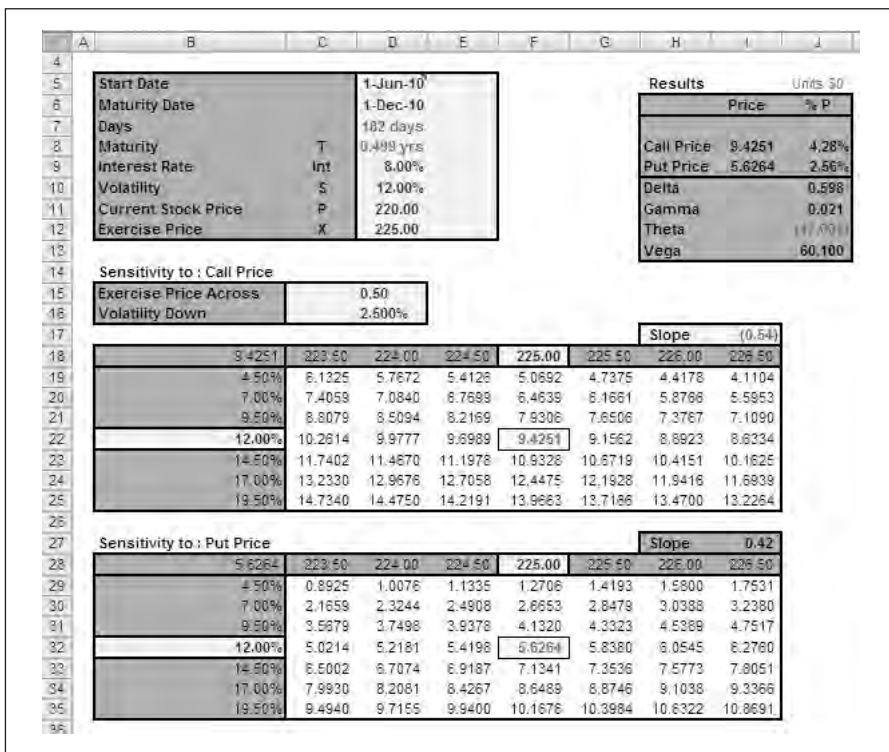
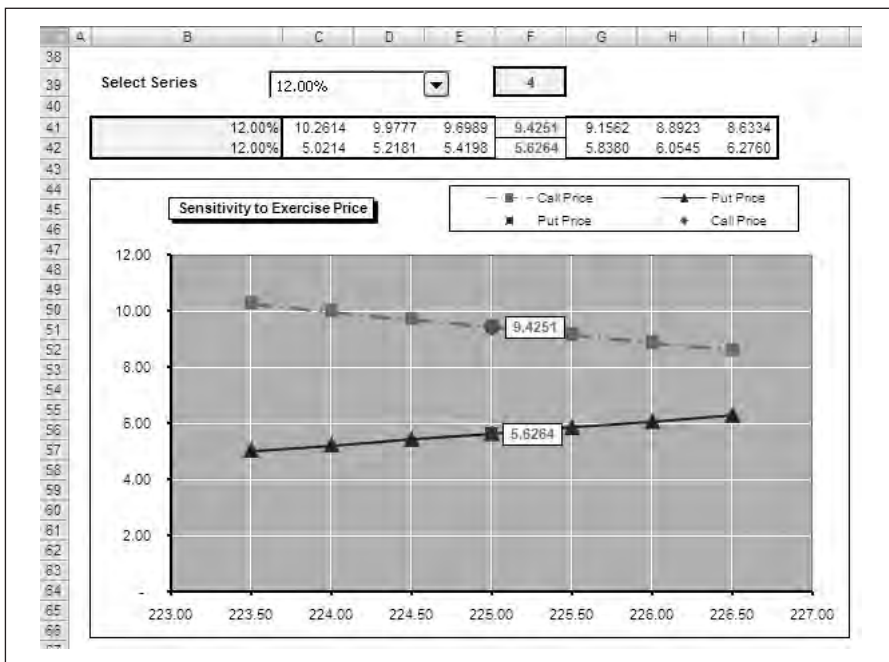


Figure 10.24

Black-Scholes chart



The chart at the bottom gives a representation of the two options in the centre of the tables. The selection is linked to a pull-down control and an OFFSET function to find the data. This is an XY scatter chart with lines, and the put and call options are plotted as individual series.

There are two important advantages with using the Black–Scholes formula to value the option and this information can be useful in formulating hedging strategies.

- There is no requirement to forecast the price on expiry.
- You can deduct mathematically the price sensitivities since as a call increases:
 - the exercise price decreases;
 - the time to expiry increases;
 - the stock price increases;
 - the interest rate increases;
 - the volatility increases.

These sensitivities are sometimes known as the ‘Greeks’, and these formulas are modelled in the workings together with notes on their derivation (see Figures 10.25 and 10.26).

Greeks workings

Figure 10.25

	A	B	C	D
144				
145		(4) Delta		
146		N(d1)		=D125
147				
148		(5) Gamma		
149		Ln(P/X)		=LN(P/X)
150		Adjusted return		=(ln(S^2/2)/T)
151		Time adjusted volatility		=S^T*0.5
152		σ2		=(D149-D150)/D151
153		σ1		=D151+D152
154		Coefficient		=(2*P1)^-0.5
155		(d1^2/2)		=D153^2/2
156		Exp-(d1^2/2)		=EXP(-D155)
157		N(d1)		=D154*D156
158		N(d1)/(P*Time_Adj_Volatility)		=D157/(P*D151)
159				
160		(6) Theta		
161		σ1 at 0% Interest		=(LN(P/X)-(0.5*S^2)/T)/(S*SQRT(T))
162		r*Call-r*P*Delta-0.5*(S^2)/(P^2)*Gamma		=ln*18-(ln(P)*D146-0.5*(S^2)/(P^2)*D158
163				
164		(7) Vega		
165		N(d1)		=NORMDIST(D123,0,1,FALSE)
166		P*Sqrt(T)*N(d1)		=P*SQRT(T)*D165

The definitions of the factors are:

- delta measures how much the option’s price will change when there is a change in the price of the underlying asset;
- gamma measures the rate at which the delta changes – a high gamma value means that a moderate change in the underlying price results in a larger change in delta;

- theta measures the change in value over time;
- vega is the change in the option value which results from increased volatility and this is always a positive value. Increases in volatility increase the value of options since it is the risk or volatility that contributes to the price.

Figure 10.26

Greeks results

	A	B	C	D	E	F	G	H	I
144									
145		(4) Delta							Change in price when underlying price changes
146		N(d1)		0.5979					
147									
148		(5) Gamma							Rate at which delta changes
149		Ln(P/X)		(0.0225)					Gamma highest when option at the money and
150		Adjusted return		0.0363					reduces away from the price
151		Time adjusted volatility		0.0847					
152		d2		0.1632					Writer is always negative gamma
153		d1		0.2479					
154		Coefficient		0.3989					
155		(d1 ² /2)		0.0307					
156		Exp ⁻ (d1 ² /2)		0.9697					
157		N'(d1)		0.3869					
158		N'(d1)/(P*Time_Adj_Volatility)		0.0208					
159									
160		(6) Theta							
161		d1 at 0% Interest		(0.2225)					Minimum when share price equals exercise price
162		r*Call-r*P*Delta-0.5*(S ²)*(P ²)*Gamma		(17.0009)					For every 1/100 of a year premium moves by -17.001
163									
164		(7) Vega							
165		N'd1		0.3869					Sensitivity of an option to a change in volatility
166		P*Sqrt(T)*N'd1		60.1001					Most sensitive when at the money

In order to show the sensitivity, there is a table of each of the values plotted against volatility (see Figure 10.27).

Figure 10.27

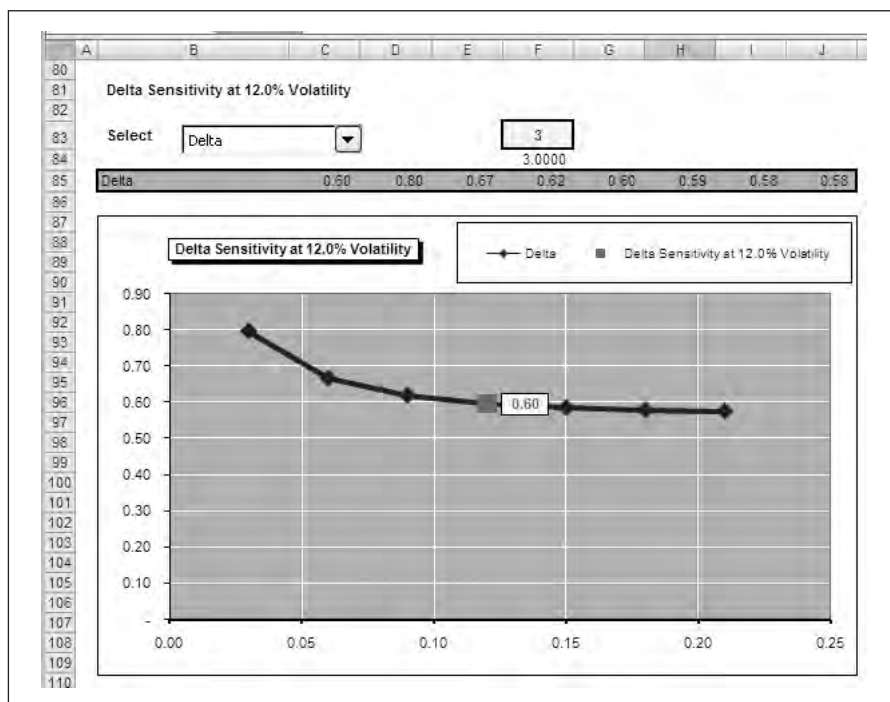
Sensitivity of Greeks to volatility

	A	B	C	D	E	F	G	H	I	J	
69		Sensitivity Table of Answers to Volatility Across									
70											
71		Interval Across:	3.00%								
72											
73				3.00%	6.00%	9.00%	12.00%	15.00%	18.00%	21.00%	
74		Call	9.43	4.33	5.89	7.63	9.43	11.24	13.05	14.88	
75		Put	5.63	0.63	2.09	3.64	5.63	7.44	9.26	11.08	
76		Delta	0.60	0.60	0.67	0.62	0.60	0.59	0.58	0.58	
77		Gamma	0.02	0.06	0.04	0.03	0.02	0.02	0.01	0.01	
78		Theta	(17.00)	(15.01)	(14.67)	(15.54)	(17.00)	(18.52)	(20.12)	(21.76)	
79		Vega	60.10	43.81	56.45	59.14	60.10	60.53	60.74	60.85	
80											

The chart includes a combo box for selecting multiple lines from the Sensitivity table (see Figure 10.28).

Delta volatility chart

Figure 10.28



SIMULATION OPTIONS PRICING

This is an alternative to the Black–Scholes, which although time-consuming will produce a similar result. The Simulation sheet is set to run 1,000 scenarios using an input volatility value and standard deviation. The rest of the data is looked up from the Black–Scholes sheet. The volatility is randomized within the standard deviation limits, entered on the Black–Scholes sheet and recalculated. The model recalculates 1000 times and notes the volatility, call and put results for each scenario. These are then pasted as a table on the right (see Figure 10.29). The application then updates the scatter chart and a histogram together with the workings for the call and put. Finally, the results are compared against the Black–Scholes formula pricing in the summary table and the variances noted.

The results are reasonably close between the two methods. If you were to run the model for 2000 or 3000 attempts, then the margin of error between the two methods would reduce further.

The variance between the two is 0.075. The difference will vary each time you rerun the simulation. The results from the table on the right of Figure 10.29 are plotted on the scatter chart, and there are two parallel series for the call and one for the put (see Figure 10.30).

Figure 10.29

Simulation options pricing

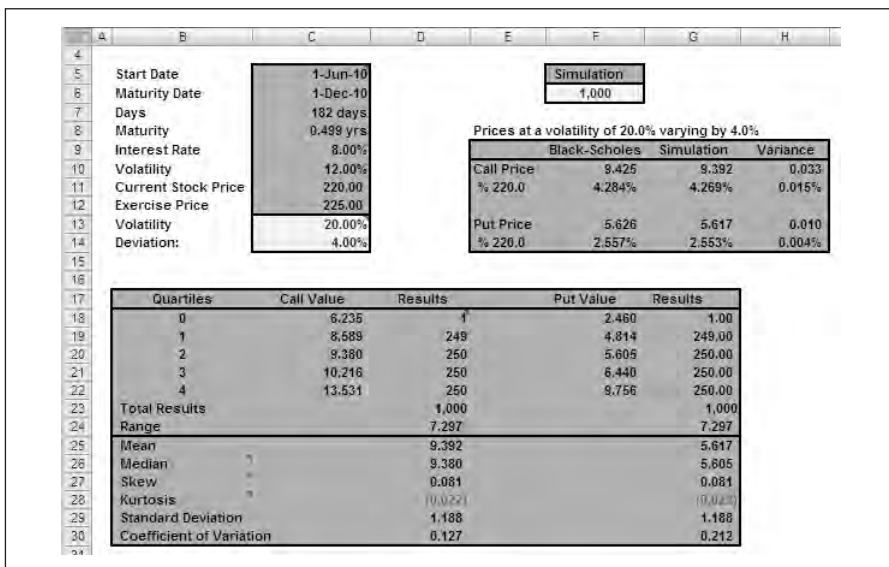
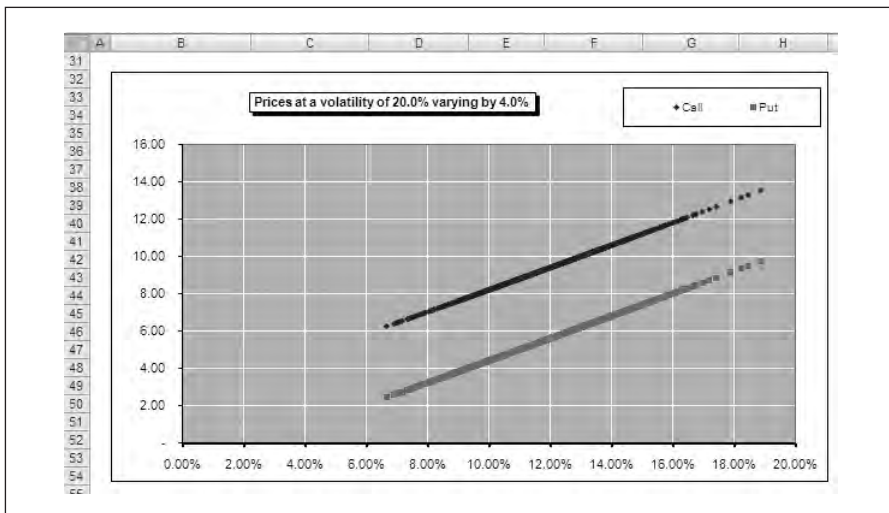


Figure 10.30

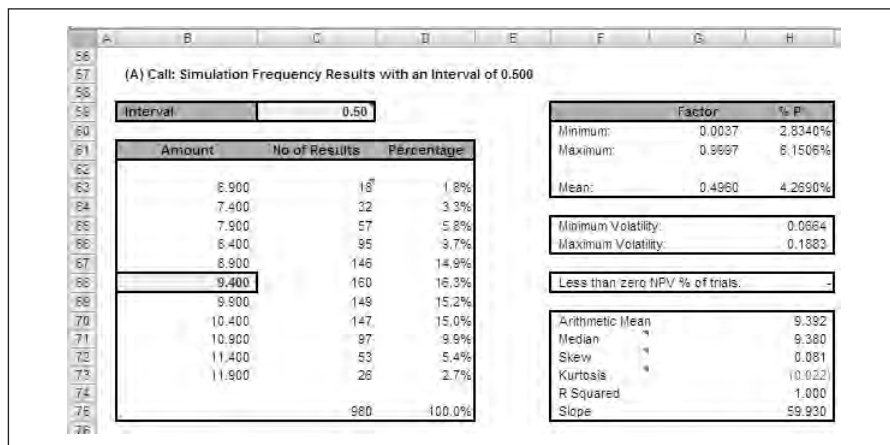
Simulation results



The call results show the number and percentage in each of the frequency bins. The simulation macro updates the mid-point and you can vary the interval manually. The call price is the arithmetic mean in the table on the right of Figure 10.31. The other statistics of median, skew and kurtosis are also calculated using the MEDIAN, SKEW and KURTOSIS functions.

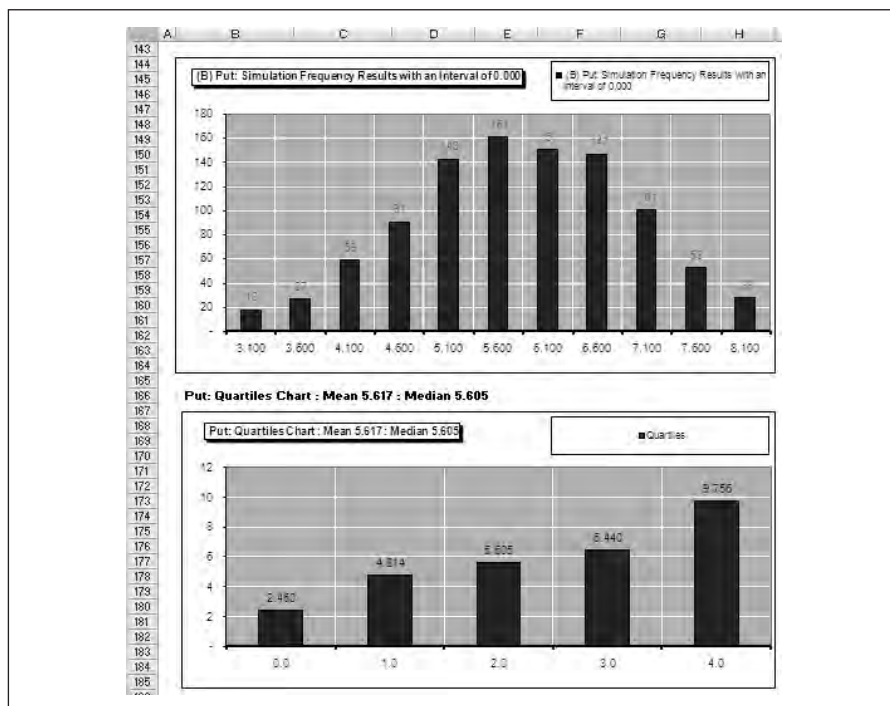
Office 2007 – Functions, Function Library, Statistical (Excel 2003 – Insert, Function)

Frequency results

Figure 10.31


The histogram shown in Figure 10.32 provides an illustration of the range of values with the majority of values clustered around the mean. The quartiles chart demonstrates the high and low values and the borders between each 25 per cent band.

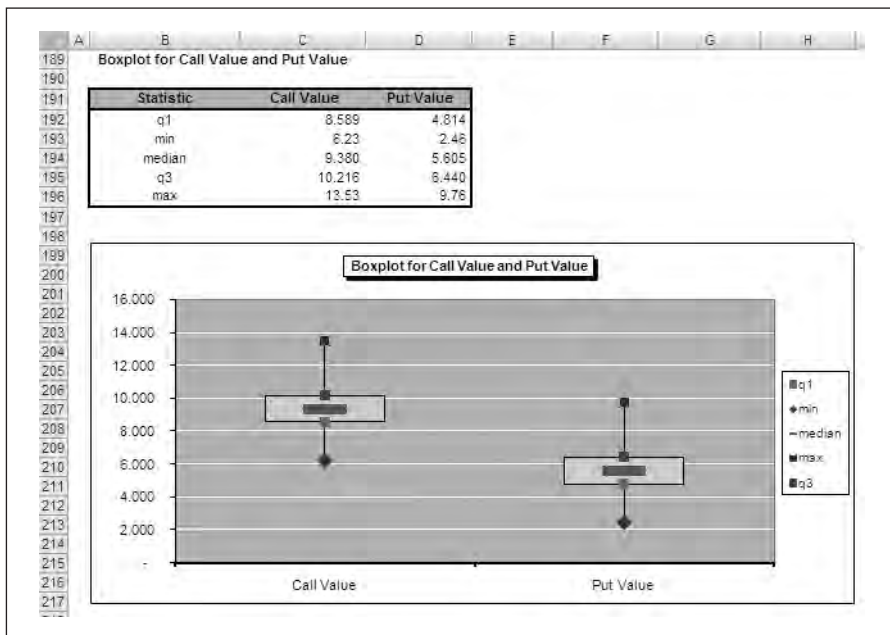
Call simulation histogram

Figure 10.32


There is also a box plot as an alternative form of chart to display a box for each series consisting of a minimum, first quartile, media, third quartile and maximum (see Figure 10.33). This can be helpful in displaying the shape and characteristics of a distribution.

Figure 10.33

Box plots and data



The method is as follows:

- Set up the data exactly in the order in Figure 10.33.
- Highlight the whole table, including figures and series labels.
- Click on Insert, Charts, Line Chart (Excel 2003 – Chart Wizard).
- Select a Line Chart.
- At Step 2 plot by Rows (the default is Columns), then press Finish.
- Select each of the data series in turn.
- Use Format Data Series to remove each of the connecting lines.
- Select any of the data series and go to Format Data Series.
- Select the Options tab and switch on the checkboxes for High–Low lines and Up–Down bars.

BINOMIAL MODEL

The binomial model is an alternative to the Black–Scholes model for options pricing and is based on the fact that asset prices can move up or down at the end of a time period (see Figures 10.34 and 10.35). This is the view that prices follow binomial paths and there is a probability of moving in one direction or another. The model checks the calculations against the Black–Scholes model.

The formulas for the call and put options are:

```
Call =IF(B98<= $E$12, COMBIN($E$12, $B98) * $C$19^$B98 * $C$20^($E$12-$B98)
* MAX($E$7 *
$C$15^$B98 * $C$16^($E$12-$B98) - $E$10, 0), 0)
Call Previous Result + COMBIN(N, Period) * Q up^ Period * Q down ^ (N -
Period) * Max(Strike *Up ^ Period * Down ^ (N - Period) - Exercise, 0)
```

```
Put =IF(B98<= $E$12, COMBIN($E$12, $B98) * $C$19^$B98 * $C$20^($E$12-$B98)
* MAX($E$10 - $C$15^$B98 * $C$16^($E$12-$B98) * $E$7, 0), 0)
Put = Previous Result + Combin(N, Period) * Q up^Period * Q down ^ (N -
Period) * Max(Exercise -Up ^ Period * Down ^ (N - Period) * Strike, 0)
```

The function COMBIN is used to return the number of combinations for a given number of items. Here the function determines the total possible number of groups from the period number and the total number of periods. The COMBIN formulas are as follows:

$$\frac{n}{k} = \frac{P_{k,n}}{k!} = \frac{n!}{k!(n-k)!}$$

where:

$$P_{k,n} = \frac{n!}{(n-k)!}$$

Binomial inputs

Figure 10.34

	A	B	C	D	E	F	G	H	I	
4										
5										
6		Inputs						Results		
7		Option Type:		Call				Selected Call Option		9.4322
8		Stock Price Now	P		220			Call	1	9.4322
9		Volatility	S		12%			Put	2	5.6098
10		Riskfree Rate / Period	Int		8%					
11		Exercise Price	X		225					
12		Time To Maturity (Years)	T		0.5000					
13		Number of Periods	N		25					
14		Delta		0.0200	T/N					
15		Up		1.0171	Exp(S*sqrt(Delta))					
16		Down		0.9832	Exp(-S*sqrt(Delta))					
17		R factor		1.0016	Exp(Int*Delta)					
18										
19		Q up		0.5421	(R factor-Down)/(R factor*(Up-Down))					
20		Q down		0.4563	1/R factor-Q up					

Figure 10.35

Factor workings

	A	B	C	D
13				
14		Delta	=E11/E12	7/11
15		Up	=EXP(E8*SQRT(C14))	Exp(S*sqrt(Delta))
16		Down	=EXP(-E8*SQRT(C14))	Exp(-S*sqrt(Delta))
17		R factor	=EXP(E9*C14)	Exp(r*sqrt(Delta))
18				
19		Q up	=(C17-C16)/(C17*(C15-C16))	(R factor-Down)/R factor
20		Q down	=1/C17-C19	1/R factor-Q up
21				

Office 2007 – Functions, Function Library, Maths & Trig (Excel 2003 – Insert, Function)

The schedule sets out the cumulative results for the number of steps in the binomial lattice. The maximum number of steps is 25 and, using IF statements, the model will accept a lesser number (see Figure 10.36).

Figure 10.36

Call and put schedule

	A	B	C	D	E	F	G	H	I
96									
97		Period	Call	Black Scholes	Variance	Put	Black Scholes	Variance	
98		1	0	9.4350	(9.4350)	0.0000	5.6260	(5.6260)	
99		2	0	9.4350	(9.4350)	0.0001	5.6260	(5.6269)	
100		3	0	9.4350	(9.4350)	0.0009	5.6260	(5.6251)	
101		4	0	9.4350	(9.4350)	0.0055	5.6260	(5.6205)	
102		5	0	9.4350	(9.4350)	0.0262	5.6260	(5.5998)	
103		6	0	9.4350	(9.4350)	0.0995	5.6260	(5.5265)	
104		7	0	9.4350	(9.4350)	0.3062	5.6260	(5.3197)	
105		8	0	9.4350	(9.4350)	0.7767	5.6260	(4.8493)	
106		9	0	9.4350	(9.4350)	1.6421	5.6260	(3.9839)	
107		10	0	9.4350	(9.4350)	2.9125	5.6260	(2.7135)	
108		11	0	9.4350	(9.4350)	4.3434	5.6260	(1.2928)	
109		12	0	9.4350	(9.4350)	5.4272	5.6260	(0.1983)	
110		13	0	9.4350	(9.4350)	5.6099	5.6260	(0.0161)	
111		14	0.9777	9.4350	(8.4572)	5.6098	5.6260	(0.0161)	
112		15	2.8781	9.4350	(6.5568)	5.6099	5.6260	(0.0161)	
113		16	5.0945	9.4350	(4.3405)	5.6098	5.6260	(0.0161)	
114		17	7.0123	9.4350	(2.4227)	5.6099	5.6260	(0.0161)	
115		18	8.3110	9.4350	(1.1240)	5.6099	5.6260	(0.0161)	
116		19	9.0089	9.4350	(0.4261)	5.6099	5.6260	(0.0161)	
117		20	9.3054	9.4350	(0.1296)	5.6099	5.6260	(0.0161)	
118		21	9.4032	9.4350	(0.0317)	5.6099	5.6260	(0.0161)	
119		22	9.4275	9.4350	(0.0075)	5.6099	5.6260	(0.0161)	
120		23	9.4317	9.4350	(0.0032)	5.6099	5.6260	(0.0161)	
121		24	9.4322	9.4350	(0.0028)	5.6098	5.6260	(0.0161)	
122		25	9.4322	9.4350	(0.0027)	5.6099	5.6260	(0.0161)	

The Black–Scholes results are calculated on the schedule shown in Figure 10.37. The formulas used are the same as before.

Black–Scholes calculation

Figure 10.37

	A	B	C	D	E	F	G
22							
23		Black Scholes Calculations					
24		Call					
25		d1	0.2490	=LN(S/X)+(r+0.5*SV^2)*T)/(sigma*SQRT(T))			
26		d2	0.1641	=d1-SV*SQRT(T)			
27		N(d1)	0.5983	=Formula NormSDist(d1)			
28		N(d2)	0.5652	=Formula NormSDist(d2)			
29		Call	9.4350	=P*N(d1)-X*exp(-r*T)*N(d2)			
30							
31		Put					
32		-d1	(0.2490)				
33		-d2	(0.1641)				
34		N(-d1)	0.4017	=Formula NormSDist(-d1)			
35		N(-d2)	0.4348	=Formula NormSDist(-d2)			
36		Put	5.6260	=P*N(-d1)-X*exp(-r*T)*N(-d2)			
37							

Figure 10.38 shows how the binomial option moves closer to the Black–Scholes result. With fewer steps the binomial model will converge more quickly on the Black–Scholes result.

Figure 10.39 plots the differences between the options and the Black–Scholes model, and in this example the difference reduces to 0.01 by the last period.

Comparison of Binomial and Black–Scholes call option

Figure 10.38

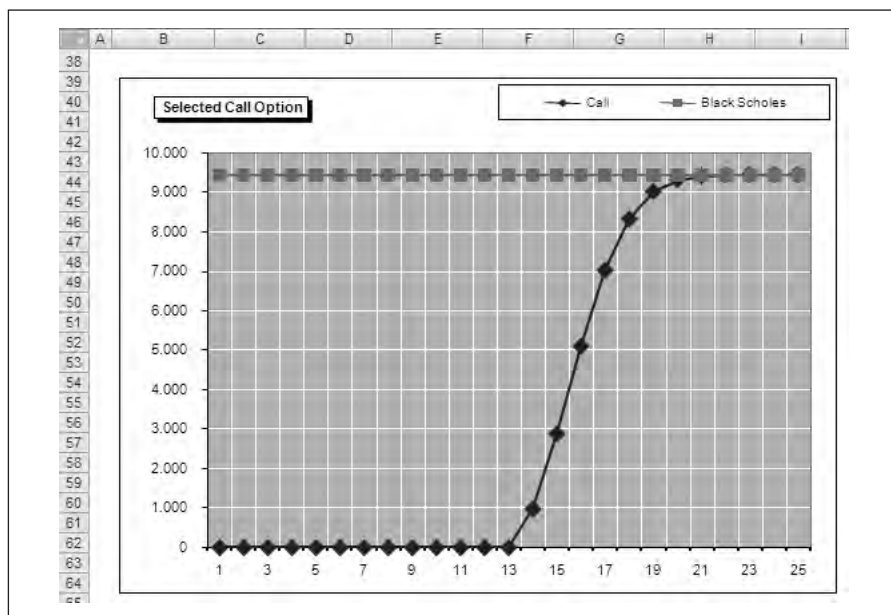
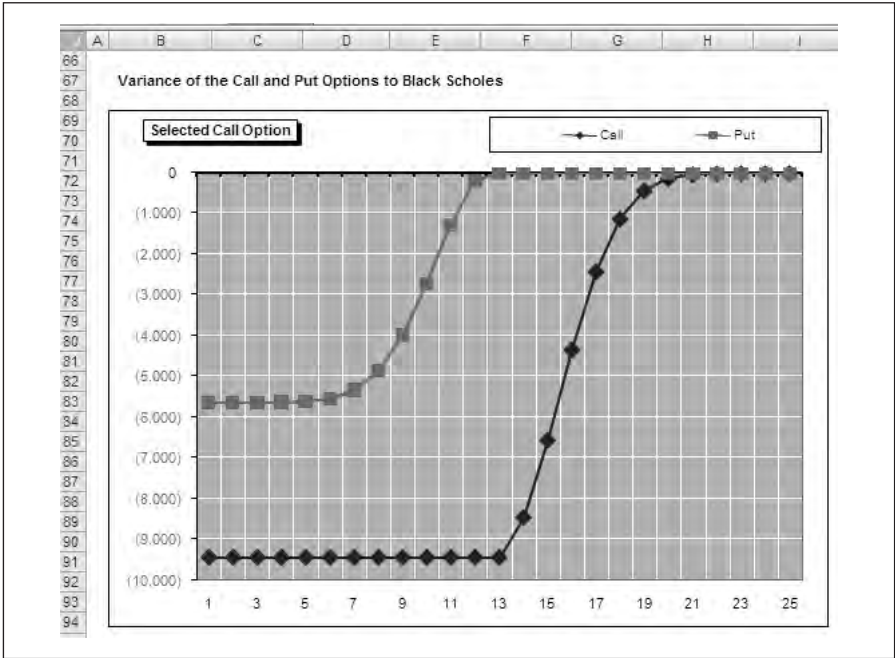


Figure 10.39

Variance chart



SUMMARY

Options products seek to manage the risk of price change in underlying assets and this chapter has presented some examples of options pay-offs, trading strategies and pricing using the Black–Scholes and binomial models. The trading strategies and pricing are based on the variables of the underlying and expiry prices, a risk-free rate, the length time and the volatility in the price of the underlying asset.

Real options

.....
Introduction

.....
Project

.....
Option to delay

.....
Option to abandon

.....
Option to expand

.....
Summary
.....

File: MRM2_11

INTRODUCTION

This chapter reviews further methods of adding risk to project appraisal and by extension to company valuation. The traditional view of investment analysis is that payback and accounting return are deficient when compared to time value of money methods such as net present value (NPV). You produce a set of pre- and post-tax free cash flows for a project and then discount them to a present value at a rate which reflects the cost of capital and any implied project risk. If a project yields a positive NPV then you may decide to proceed; otherwise the project fails on value grounds. A positive result adds value to the company whereas a negative result destroys value. This approach may assist with cash-saving projects but may be inflexible when applied to technology or other industries where operational flexibility is required. The traditional NPV method is thought to be deficient since the cash flows appear fixed from inception without any possibility of variance. In reality, management has the ability to terminate a failing project by incurring extra costs or salvaging work to date. Alternatively, the market prospects may rise allowing the choice of continuation or expansion to capitalize on new market opportunities. As a third alternative, a delay could be useful to gather more information or wait for competitive response.

When a company undertakes a capital project, it possesses a series of options to grow or contract. The flexibility has a value and the model in this chapter uses options theory to calculate a variance and a value for the option. Uncertainty and volatility are generally accepted to have increased in the past decade and this methodology enhances the NPV rule by incorporating the risk and uncertainty. A company with an opportunity to invest holds a financial call option since it has the right, but not the obligation, to make the investment in return for an uncertain stream of cash flows. The 'now or never' NPV rule is therefore replaced by a series of options which may or may not be exercised. By committing to an investment a company effectively destroys the option and dispenses with the possibility of waiting. The lost option value represents an opportunity cost which should be included as part of the investment. Instead of an NPV greater than or equal to zero, the present value of the expected cash flows should exceed the initial cost of the investment by an amount equal to the value of retaining the open option. (See Figure 11.1.)

The opportunity cost is highly sensitive to change in economic conditions and options theory uses a Black–Scholes model for pricing in volatility or uncertainty. Risk is present in the receipt of future cash flows and changes could have an impact on the decision to invest. A delay could allow more information or market knowledge to become available. Only when the option has been exercised does it become irreversible. If the option value

increases, so does the benefit of investing, while a decline means that the project can be abandoned with the cost capped at the value of the preliminary or sunk work. This chapter introduces a project model and then calculates the value of options to undertake alternative actions comprising delay, abandonment and expansion.

Figure 11.1

Call option pay-off diagram

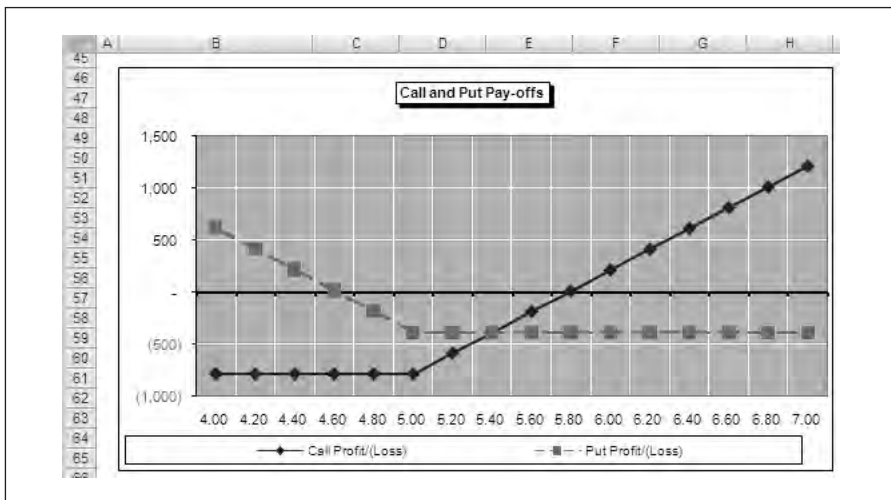


Figure 11.2

Project inputs

	A	B	C	D	E
5					
6					
7		Scenario Name:		Case 1	
8		Prepared by:		Product Management	
9		Product Code:		MJD-123	
10		Manager:		Matthew Miles	
11		Start Date:		01-Jan-10	
12		Initial Investment:		2,000,000.00	
13		Initial Sales Price per Unit:		50.00	
14		Annual Price Change:		(10.00%)	
15		Initial Cost per Unit:		40.00	
16		Annual Cost Improvement:		20%	
17		Project Life:		10.00 yrs	
18		Residual Value:		0.00	
19		Working Capital as % of Sales:		10.0000%	
20		Selling and Administration Costs		300,000.00	
21		Cost of Funds:		12.0000%	

PROJECT

The basic model uses a non-tax project based on the inputs shown in Figure 11.2. The project lasts 10 years and there are sales and costs per unit of

output with annual price and cost variances. The volume is set at 50,000 per annum for 10 years in the Case 1 scenario.

Financial statements

Figure 11.3

	Year 0 Jan-10	1 Dec-10	2 Dec-11	3 Dec-12
Sales Volume		50,000	50,000	50,000
Price per Unit		50.00	45.00	40.50
Sales Revenue		2,500,000	2,250,000	2,025,000
Annual Cost per Unit		40.00	32.00	25.60
Manufacturing Cost		(2,000,000)	(1,600,000)	(1,280,000)
Profit and Loss Account				
Sales Revenue		2,500,000	2,250,000	2,025,000
Cost of Sales		(2,000,000)	(1,600,000)	(1,280,000)
Contribution		500,000	650,000	745,000
Selling and Administration Costs		(300,000)	(300,000)	(300,000)
Recovery of Development Costs		(200,000)	(200,000)	(200,000)
Profit/(Loss)		-	150,000	245,000
Balance Sheet				
Fixed Asset	2,000,000	2,000,000	2,000,000	2,000,000
Depreciation		(200,000)	(400,000)	(600,000)
Net Fixed Assets	2,000,000	1,800,000	1,600,000	1,400,000
Cash	(2,000,000)	(2,050,000)	(1,675,000)	(1,207,500)
Total Assets	-	(250,000)	(75,000)	192,500
Working Capital - (Liability)/Asset		(250,000)	(225,000)	(202,500)
Shareholders Funds	-	-	150,000	395,000
Total Liabilities	-	(250,000)	(75,000)	192,500

The schedule builds up a manufacturing account, income statement, balance and cash flow, and calculates an NPV at the input cost of capital of 12 per cent. The cash flow is dependent on the volume and sale price per unit against the declining cost price. The model displays the present value and addresses other management tests in a summary box at the top of the schedule (see Figure 11.3). Following the Systematic Design Method, you can see changes in the answers immediately you amend the inputs.

The management tests show that this project passes all the tests (see Figure 11.4). The workings at the side use MATCH and IF statements to work out if the periodic cash flows or profits are below the input minimums. The first statement checks if the value is below the minimum; the second row puts in a '1' if it is below the required level; and the third uses a MATCH function to look for '1' along the line so it can report the period number in which the rule failed.


```
=IF (G41<=$I$11, G41, 0)
=IF (S41=0, 0, IF (S41<=$I$11, 1, 0))
=IF (SUM (R42:AA42)=0, 0, MATCH (1, R42:AA42, 0))
```

Office 2007 – Functions, Function Library, Lookup & Reference (Excel 2003 – Insert, Function)

Figure 11.4

Management summary

Management Tests of Project Acceptability:			
Payback < 7 years	7 yrs	6.00 yrs	Yes
Minimum IRR 12.00%	12%	14.50%	Yes
Positive Operating Profit > 0	0		Yes
Operating Cash Flow 120%	120%		Yes
Net Present Value > 0	0	254,159	Yes

There are two further scenarios in the model and these provide changed inputs and results. One is more pessimistic and the other more optimistic. A further sheet called Scenarios contains the scenarios report with probabilities as an expected net present value (ENPV) – see Figure 11.5. The user assigns a probability to each of the scenarios and then the model multiplies out the answer. Thus, 50,831.72 is 254,158 * 0.20.

Figure 11.5

Expected net present value

Scenario	NPV	Probability	Result
Case 1	254,158.59	0.20	50,831.72
Case 2	(976,206.27)	0.40	(390,482.51)
Case 3	2,570,613.63	0.40	1,028,245.45
Expected Net Present Value (ENPV)		1.00	688,594.66

Sensitivity Table to Case 1 Across and Case 2 Down	
Interval Across	0.05
Interval Down	0.05

	0.05	0.10	0.15	0.20
688,594.66				
0.25	-	-	-	-
0.30	-	-	-	-
0.35	-	-	-	-
0.40	-	-	-	688,594.7
0.45	-	-	627,076.4	-
0.50	-	565,558.2	-	-
0.55	504,039.9	-	-	-

The data table suppresses impossible values by ensuring that all values add up to one. Case 3 is not used and the sensitivity uses Case 1 as the x -axis and Case 2 as the y -axis. The formula at the top-left of the data table is:

```
=IF (AND (D7>=0, D6>=0, D6+D7+D8=1), E10, 0)
```

The formulas ensure that all the inputs add up to one and that the X and Y inputs are positive or equal to zero. The answer is in the middle of the table using 0.20 of Case 1, 0.40 of Case 2 and 0.40 of Case 3. The three scenarios are the best estimates of the future, and further risk techniques such as data tables, standard deviation and simulation could be applied. However, the emphasis here is on extending the model to find a value for possibilities other than committing the 2,000,000 in its entirety on inception.

OPTION TO DELAY

The first section introduced flexibility into the investment process by introducing the possibility of delay, expansion or abandonment. The sheet called 'Delay' uses a Black–Scholes model with inputs from the Project sheet. The extra inputs are the risk-free rate and the volatility. The latter could be gained from a Monte Carlo simulation or previous projects, but for simplicity these are inputs to this model (see Figure 11.6).

Delay inputs

Figure 11.6

	A	B	C	D	E
4					
5		Years	T		10.0 yrs
6		Risk Free Interest Rate	Int		5.00%
7		Volatility	S		20.00%
8		PV of Future Cash Flows	P		2,254,168.58
9		Initial Investment	X		2,000,000.00
10					
11					

The number of years, present value (PV) of future cash flows and the initial investment are looked up from Case 1 on the Project sheet. The inputs are:

- years – life of the project;
- risk-free rate – rate such as a 10-year government bond currently at around 5 per cent;
- volatility – forecast future variance in cash flows;
- present value of future cash flows before subtracting initial investment;
- initial investment as the cost of the project on inception.

This project achieves a positive NPV but there may still be advantages in delaying the investment. The rule in the first section was that the NPV should be greater than the option value of the delay. A delay could allow more market research, better use of technology or gaining more information on competitive response.

The workings at the bottom of the schedule (see Figure 11.7) calculate the terms d_1 and d_2 and use the function NORMSDIST to return the standard normal cumulative distribution function. This distribution has a mean of 0 (zero) and a standard deviation of one, as shown in Figure 11.8 generated by the function.

Office 2007 – Formulas, Function Library, More, Statistical (Excel 2003 – Insert, Function)

Figure 11.7

Option calculation

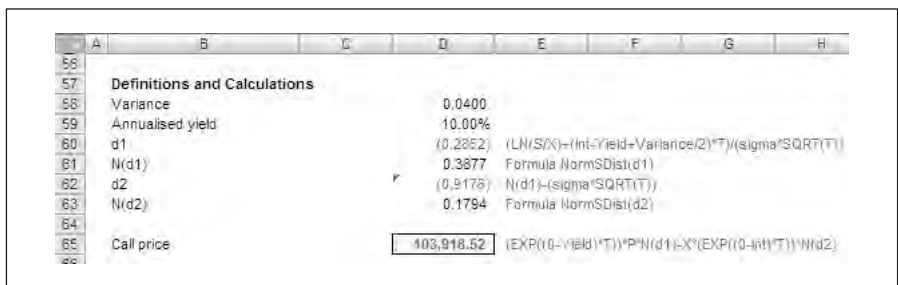
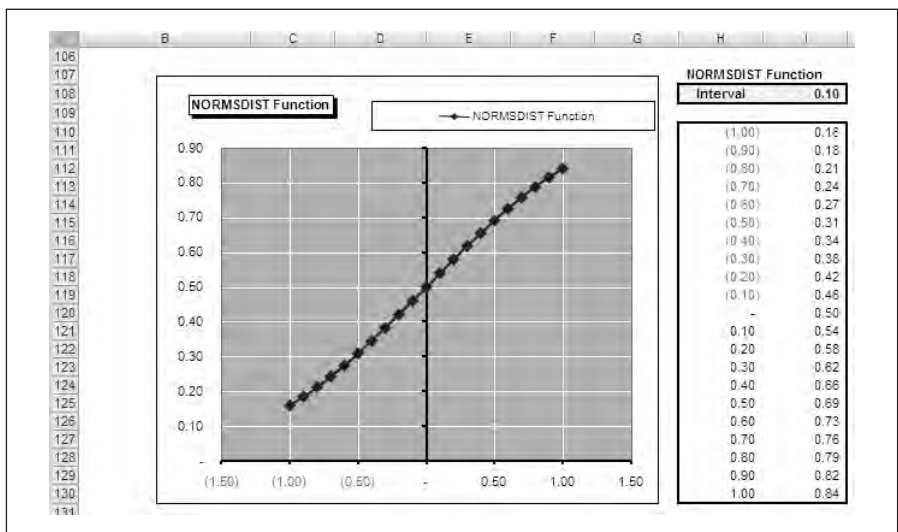


Figure 11.8

NORMSDIST function



The value of the option is 103,918 and this can be compared against the NPV – the variance is positive. There is also a data table showing the sensitivity to the present value of cash flows and the volatility displaying the change in the option price (see Figure 11.9). A dynamic chart also provides the possibility of reviewing individual lines in the table.

Sensitivity to cash flows and volatility

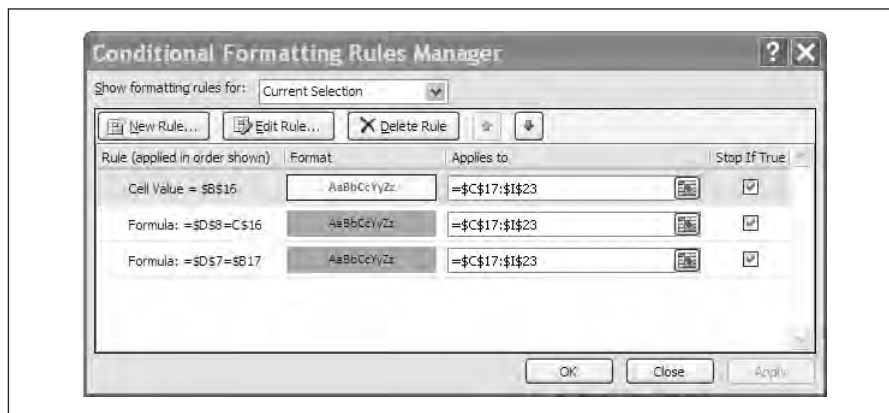
Figure 11.9

	Sensitivity: Call Option						Units: 30	
	PV of Future Cash Flows Across		100,000					
	Volatility Down		5.00%				Slope 0.1424	
	103,918.5217	1,954,158.6	2,054,158.6	2,154,158.6	2,254,158.6	2,354,158.6	2,454,158.6	2,554,158.6
	5.00%	18.1	59.1	167.9	423.0	959.1	1,981.9	3,774.0
	10.00%	5,972.5	8,860.9	12,870.2	17,842.1	23,805.6	30,973.5	39,739.1
	15.00%	29,665.9	37,326.3	46,117.5	56,069.7	67,173.2	79,460.1	92,916.7
	20.00%	86,668.7	77,395.1	90,152.1	103,918.5	118,673.1	134,390.3	151,042.2
	25.00%	107,728.0	122,707.8	138,574.7	155,294.6	172,835.0	191,183.7	210,248.6
	30.00%	152,969.1	170,020.5	188,424.9	207,547.4	227,354.4	247,814.0	268,895.8
	36.00%	197,668.5	217,577.6	238,127.3	259,264.1	281,016.4	303,295.0	326,092.4

The table uses two types of conditional formatting to form an XY cross at the answer together with particular formatting for the answer (see Figure 11.10). \$D\$8 is the input for the present value of the cash flows and \$D\$7 is the input for volatility used by the data table.

Conditional formatting

Figure 11.10



It is also interesting to know how the value of the option changes over time and to understand at what point in the 10-year cycle the option ceases to have value. The present value calculation on the Project sheet uses a lookup for period zero against a table of NPVs for year zero, one, two, etc. This means that a data table can be constructed using the offset value as the input. Line

124 contains the delay option which rises in value and then declines towards the expiry date (see Figure 11.11). Calculating a price in this manner assumes that the behaviour of the cash flows does not change over time. This may be ultimately unrealistic but it at least creates a benchmark.

Figure 11.11

Change in option prices

	A	B	C	D	E	F	G	
118								
119		Sensitivity of Option Value to Delay						
120		Period No	0					
121								
122		PV	2,254,158.6	2,574,657.6	2,508,616.5	2,342,150.5	2,104,458.6	
123		Year	0	1	2	3	4	
124			103,918.5	103,918.5	154,568.5	143,344.6	116,650.0	83,684.8
125			157,366.6	157,366.6	194,533.0	186,815.4	167,492.1	140,313.8
126			87,239.2	87,239.2	87,239.2	87,239.2	87,239.2	87,239.2
127								
128		Delay Option						
129		NPV	254,158.6	574,857.6	508,616.5	342,150.5	104,458.6	
130		Variance	150,240.1	420,089.1	365,272.0	225,300.6	20,773.7	
131								
132		Expansion Option						
133		NPV	254,158.6	574,857.6	508,616.5	342,150.5	104,458.6	
134		Variance	96,792.0	380,124.7	321,801.2	174,656.4	(35,865.1)	
135								
136		Abandonment Option						
137		NPV	254,158.6	574,857.6	508,616.5	342,150.5	104,458.6	
138		Variance	166,919.4	487,418.4	421,377.3	254,911.3	17,219.4	
139								

OPTION TO ABANDON

Investment means that an option has been exercised but there are still possibilities to abandon or expand. If the value of the project is greater than abandonment then you continue; otherwise you consider exercising the option. This takes the form of a put option (see Figure 11.12).

The Abandon sheet calculated the value of this option in the first year. The inputs here change since the liquidation or salvage value is needed as opposed to an initial investment (see Figure 11.13).

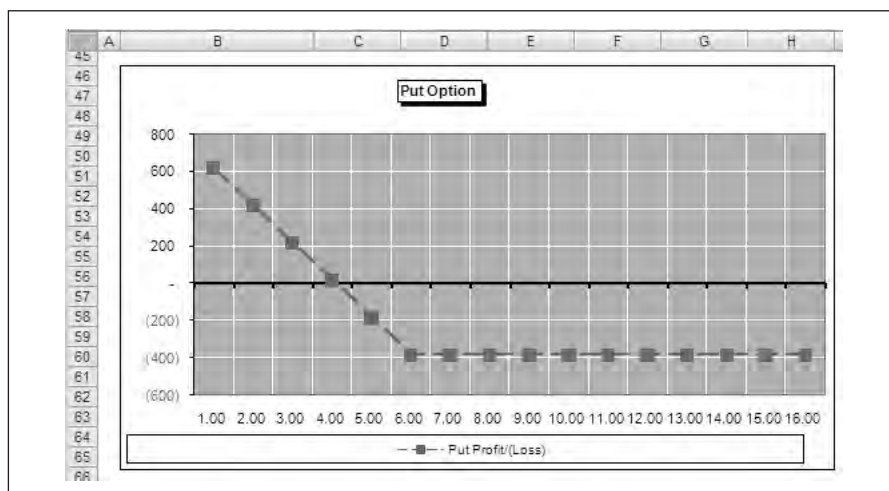
The number of years and the present value are brought forward from the Project sheet. The extra inputs are the number of years remaining and the percentage salvage value of the original investment. The calculation therefore provides a value immediately after inception and assumes a constant salvage value of 50 per cent. See Figures 11.14 and 11.15.

There are workings to calculate the option value against falling salvage values in future years. The PV in cell D8 depends on the number of years remaining and uses this offset to look along the row of present values on the Project sheet. This is illustrated in Figure 11.11.

=OFFSET(Project!C122,0,10-Abandon!D10)

Put option

Figure 11.12



Abandon sheet inputs

Figure 11.13

	A	B	C	D	E
Years	T			10.0 yrs	
Risk-Free Interest Rate	Int			5.00%	
Volatility	S			20.00%	
PV of Future Cash Flows	P			2,254,158.59	
Salvage % of Capital Value	X			50.00%	
Years Remaining				10.0 yrs	

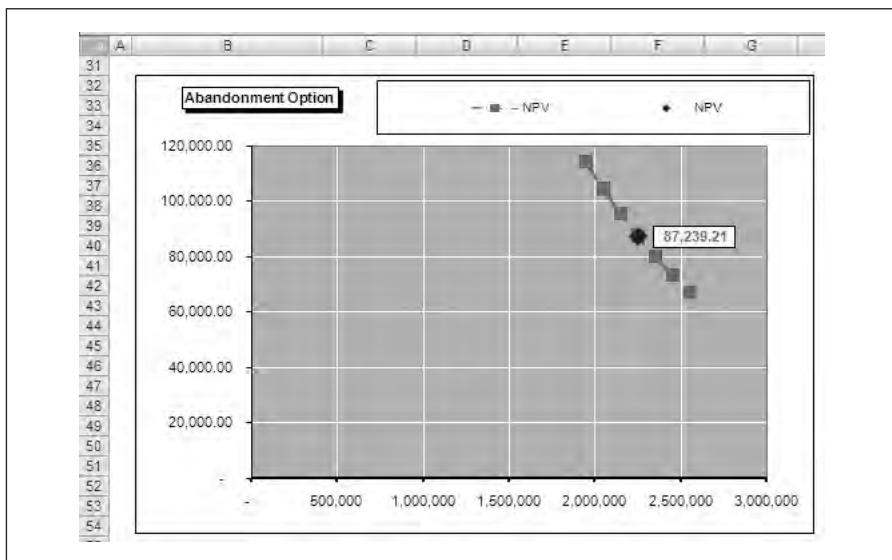
Abandonment sensitivity

Figure 11.14

	A	B	C	D	E	F	G	H	I	
12	Sensitivity: Put Option									
13	PV of Future Cash Flows Across		100,000							
14	Volatility Down		5.00%							
15									Slope	(0.0177)
16	57,239.2058	1,954,158.6	2,054,158.6	2,154,158.6	2,254,158.6	2,354,158.6	2,454,158.6	2,554,158.6		
17	5.00%	7,511.5	3,998.7	2,043.4	1,006.8	480.3	222.7	100.7		
18	10.00%	38,888.0	30,817.9	24,119.3	18,926.6	14,802.2	11,544.6	8,983.3		
19	15.00%	75,781.5	66,274.8	57,947.3	50,883.2	44,298.3	38,741.1	33,891.7		
20	20.00%	113,675.4	104,185.2	95,302.0	87,239.2	79,518.1	73,287.2	67,221.7		
21	25.00%	151,950.8	142,369.7	133,508.6	125,308.4	117,710.0	110,863.5	104,122.5		
22	30.00%	189,114.7	179,981.3	171,435.3	163,429.2	155,920.1	148,869.4	142,241.8		
23	35.00%	225,109.2	216,544.6	208,467.0	200,836.4	193,624.8	186,795.6	180,322.8		

Figure 11.15

Sensitivity chart



The workings table at the bottom of the schedule uses a salvage value from input percentages and the number of years remaining to generate a grid of values (see Figure 11.16). The values in bold are possible values and other values should be ignored. The value 87,239 represents 10 years outstanding and the initial salvage value.

Figure 11.16

Workings

Workings - Flexible Period							
			87,239	10	9	8	7
10	50.0%	1,000,000	87,239	54,766	46,547	43,161	
9	45.0%	500,000	63,130	37,526	30,874	27,797	
8	40.0%	800,000	43,019	23,957	18,935	16,420	
7	35.0%	700,000	27,049	13,915	10,456	8,638	
6	30.0%	600,000	15,209	7,090	4,991	3,866	
5	25.0%	500,000	7,266	2,985	1,927	1,367	
4	20.0%	400,000	2,693	935	535	334	
3	15.0%	300,000	645	176	84	43	
2	10.0%	200,000	64	12	4	2	
1	5.0%	100,000	1	0	0	0	
-	-	-	-	-	-	-	-

The net result is a table of present values remaining in each year and the put option associated with it (see Figure 11.17). The salvage values can be adjusted and this will work through the tables and update the option values. The value declines as the present value and salvage values decrease in the latter stages of the project.

Abandonment summary

Figure 11.17

	A	B	C	D	E	F	G
69		Change in Value of Abandonment Option based on Period Number					
70							
71		Year	NPV	Salvage	Value	Option	Variance
72		0	254,158.6	50.00%	1,000,000.0	87,239.2	186,919.4
73		1	574,657.6	45.00%	900,000.0	37,526.1	537,131.5
74		2	508,618.5	40.00%	800,000.0	18,934.7	489,683.8
75		3	342,150.5	35.00%	700,000.0	8,637.8	333,512.9
76		4	104,458.8	30.00%	600,000.0	3,332.8	101,125.8
77		5	(182,221.4)	25.00%	500,000.0	970.6	(183,252.0)
78		6	(501,422.7)	20.00%	400,000.0	170.5	(501,593.2)
79		7	(840,670.1)	15.00%	300,000.0	10.6	(840,680.8)
80		8	(1,191,148.4)	10.00%	200,000.0	0.0	(1,191,148.5)
81		9	(1,546,667.3)	5.00%	100,000.0	0.0	(1,546,667.3)

OPTION TO EXPAND

Expansion is the last of the possibilities since management may have the flexibility to increase the investment and thereby improve the overall NPV (see Figure 11.18). This is dependent on an initial investment in the project and therefore there is a cut-off at the expiry of the project life. Also, it depends on the competitive position and the ability to retain control over future cash flows. The pay-off diagram is similar to the option to delay with characteristics of a call option.

The inputs are:

- years – this is looked up from the Project sheet;
- interest rate – the risk-free rate;
- volatility – volatility of future cash flows which could be different to the other options;
- expansion potential – this is expressed as a percentage of the present value of cash flows;
- investment required – this is a percentage of the initial investment, here 2,000,000;
- cost of delay – this is the cost of waiting until the new investment starts to provide positive benefits.

The Sensitivity table (see Figure 11.19) shows the variance of the percentage expansion against the volatility using the inputs of cells D8 (expansion) and D7 (volatility). As the expansion percentage rises, with the investment remaining static, the value of the option increases. With greater volatility, the value also rises.

Figure 11.18

Expansion option

	A	B	C	D	E
4					
5		Years	T	10.0 yrs	
6		Interest Rate	Int	5.00%	
7		Volatility	S	20.00%	
8		Expansion Potential	P	20.00%	
9		Investment Required	X	10.00%	
10		Cost of Delay %		5.00%	
11					

Figure 11.19

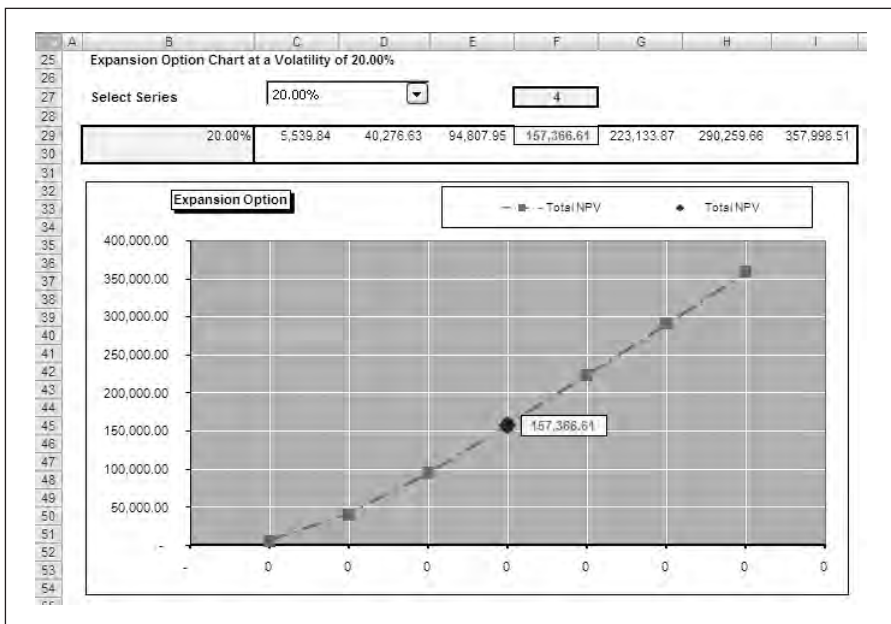
Expansion sensitivity

	A	B	C	D	E	F	G	H	I	
12		Sensitivity: Call Option					Investment Amount	200,000.0		
13		Expansion Potential Across	5.00%						Units \$0	
14		Volatility Down:	5.00%							
15							Slope	1,204,048.6		
16		157,366.6117	5.00%	10.00%	15.00%	20.00%	25.00%	30.00%	35.00%	
17		5.00%	0.5	18,051.3	83,779.2	152,137.1	220,497.9	288,858.8	357,219.6	
18		10.00%	393.4	25,051.1	84,770.7	152,228.8	220,506.8	288,859.7	357,219.7	
19		15.00%	2,333.9	32,644.5	88,747.1	153,633.8	220,961.0	289,026.0	357,281.4	
20		20.00%	5,539.6	40,276.6	94,807.9	157,366.6	223,133.9	290,259.7	357,998.5	
21		25.00%	9,421.7	47,791.8	101,897.3	162,951.9	227,290.2	293,303.0	360,226.5	
22		30.00%	13,617.9	55,110.7	109,427.5	169,693.4	233,015.1	298,082.2	364,194.0	
23		35.00%	17,920.7	62,179.6	117,071.4	177,032.6	239,769.3	304,170.4	369,636.7	
24										

Figure 11.20 shows the single series of 20 per cent volatility rising from 5 to 35 per cent expansion in the initial present value.

Figure 11.20

Sensitivity chart



The workings at the base of the schedule repeat the methodology of the abandonment schedule (see Figure 11.21). The x -axis of the table represents the number of years outstanding and the y -axis the expansion amounts assigned to each of the years. Again, the possible combinations are represented in bold type.

Expansion table

Figure 11.21

Workings - Flexible Period							
			157,367	10	9	8	7
10	20.0%	450,832	157,367	164,445	171,877	179,703	
9	18.0%	405,749	131,787	137,384	143,229	149,350	
8	16.0%	360,665	106,900	111,044	115,321	119,747	
7	14.0%	315,582	83,015	85,767	88,538	91,321	
6	12.0%	270,499	60,585	62,067	63,461	64,739	
5	10.0%	225,416	40,277	40,701	40,960	41,009	
4	8.0%	180,333	23,030	22,738	22,258	21,553	
3	6.0%	135,250	10,049	9,505	8,838	8,031	
2	4.0%	90,166	2,466	2,136	1,782	1,413	
1	2.0%	45,083	109	74	46	25	
			-	-	-	-	

Expansion summary

Figure 11.22

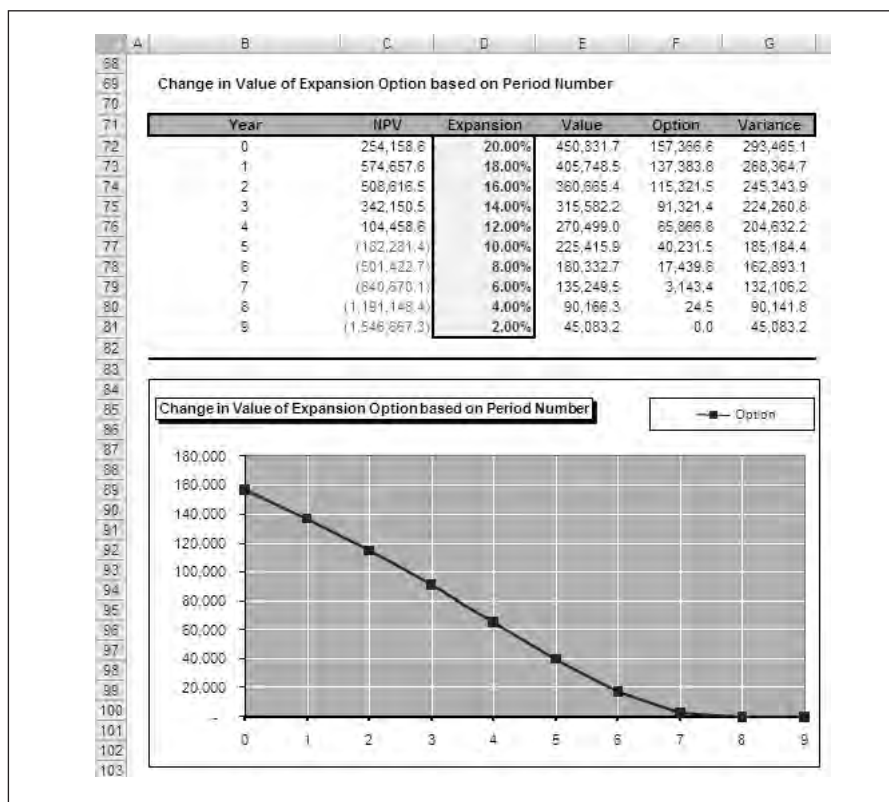


Figure 11.22 shows the present values for expansion against the option value with a chart of the option. The option loses value during the life of the project as the benefits from expansion decline.

SUMMARY

This chapter uses a 10-year project model with three initial scenarios based on the expected Case 1 and two alternative pessimistic and optimistic views. Given that management has operational flexibility, the chapter develops an options model for reviewing other choices such as expansion, delay or abandonment. The basic methodology follows the Black–Scholes model. Delay and expansion possess characteristics similar to call options, while abandonment is similar to a put option. The chapter also provides some Sensitivity tables to show how the values flex with changing present value and volatility. Gaining further information on the value of different options can provide more insight and alleviate some of the deficiencies of the rigid NPV rule. As part of a decision process, the method provides more risk information for management.

INTRODUCTION

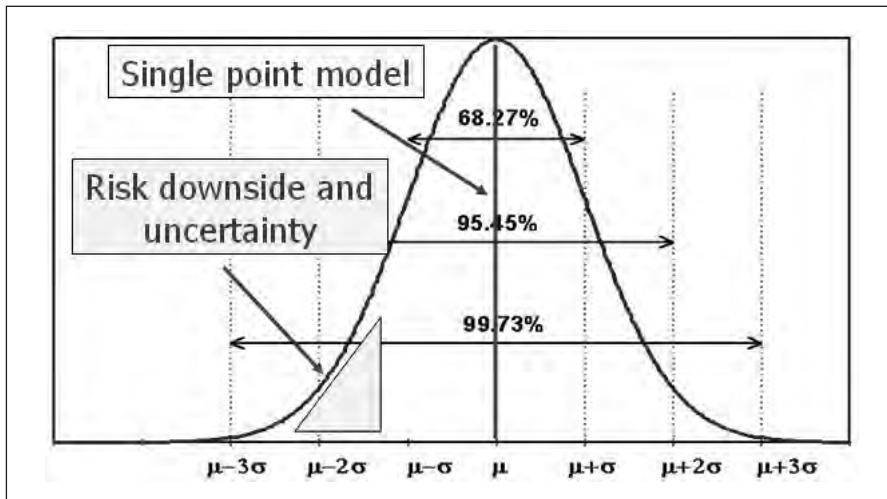
Portfolios of stocks possess varying levels of risk and return, and this chapter models the possible future returns over the next 12 months based on historic data. Different stocks possess different characteristics of risk and return, and portfolio risk can easily be modelled. Excel is used to generate 1000 future scenarios and these are incorporated into the monthly returns over the next year.

Modern portfolio theory is based on the 1952 work of Harry Markowitz, whose doctoral thesis suggested a new method of assessing stock performance. He looked at the performance of a portfolio of assets based on the combination of its components' risk and return rather than fundamental analysis of stocks. Whilst it was assumed that diversification was better than investing in single stocks, previously there was no underlying theory to back this up. Portfolio theory provides the mathematical basis and shows how you can combine risky assets into portfolios, which then contain less overall risk because of the effect of diversification.

With any stock, you can calculate the expected return at the end of a time period. Since the assets are risky, you cannot be sure about the return on these assets. By using the past to project into the future, investors can determine the likelihood of a certain return. The expected return on a risky asset is based on the probabilities attached to all possible rates of return for the asset. With a 50–50 chance of a favourable outcome, the expected return on a portfolio with one asset returning 30 per cent and the other 10 per cent is its weighted average of 20 per cent. Figure 12.1 shows a normal distribution with the percentage results contained by one, two and three standard deviations.

Normal distribution of outcomes

Figure 12.1



In many problems involving probabilities, the probabilities of all possible outcomes are assumed to have a bell-shaped normal distribution as in Figure 12.1. The mean is the top of the distribution and the area under the normal curve is the probability of realizing a return between the extreme points on the curve. This probability is equal to one.

The historical annual volatility or the degree of variation from the expected return is measured by the standard deviation. Assuming a normal distribution, we can say with a 68.26 per cent certainty that the actual one-year return will be somewhere between a low of the expected return less one standard deviation and a high of the expected return plus one standard deviation. You can calculate similar results for two and three standard deviations. The actual return of a less volatile stock, say, one with a standard deviation of 10 per cent, will move within a narrower range of possible returns than a stock with a standard deviation of 15 per cent.

Diversification involves a trade-off between risk and return. If you were certain of a stock's future value, then you would buy only that asset yielding the maximum return under those conditions, and no trade-off would be necessary. The theory makes some assumptions about the way investors behave regarding risk. Although some investors can take more risk than others, investors are assumed to be risk averse rather than risk seeking. Risk averse means that where assets promise the same return, you would choose the assets with the least downside risk. In order for you to accept higher risk, you would want to be compensated with the potential for earning a higher return and vice versa. Table 12.1 and Figure 12.2 show the US experience from 1926 to 1994 where stocks, bonds and bills show different rates of risk defined by standard deviation and average return.

Table 12.1

US experience

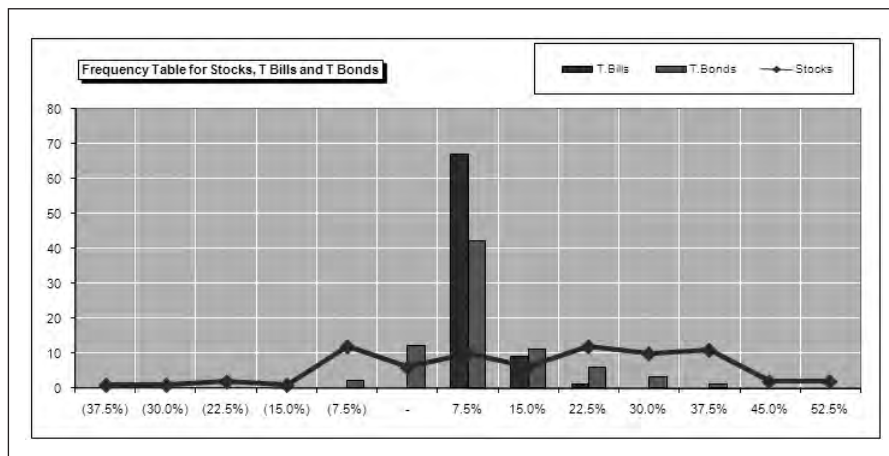
Measure	Small companies	Large companies	Government bonds	Treasury bills
Return	12%	10%	5%	4%
Standard deviation	35%	20%	9%	3%

The general assumptions for the portfolio model are:

- each possible investment has a probability distribution of expected returns over time;
- investors are risk averse and require increased returns for increased risk;
- risk is measured by the variability of expected returns (standard deviation);
- only risk and expected return are used in making investment decisions;
- investors will choose the highest return for a given risk level.

US stock returns

Figure 12.2



If the correlation between assets is one, then there would be no point in diversifying as all stocks would move in the same direction and would provide no benefit for diversification. However, this is unlikely to be the case across a basket of stocks. By combining assets in different weights, the theory shows that it is possible to produce portfolios with different characteristics of risk and return. Efficient portfolios are efficient if there is no other portfolio (or asset) offering a higher level of return for the same or lower risk. It therefore follows that there is a limit or frontier where a portfolio ceases to be efficient. It is an intensive modelling exercise to find the 'best' portfolio, and the model in this chapter uses random number generation and Solver within Excel to find the optimum weights in a five-stock portfolio.

Office 2007 – Data, Analysis, Solver (Excel 2003 – Tools, Solver)

HISTORIC DATA

The Data sheet in the model contains returns for five stocks over a five-year period. These are expressed as decimal percentages and show the gain or loss in each month (see Figure 12.3). There are 60 data points in all.

In the previous section, it stated that diversification would not yield benefits with perfectly correlated assets. A correlation matrix (see Figure 12.4) shows the relationship between the stocks using the function CORREL.

```
= CORREL ($D$9 : $D$68, E$9 : E$68)
```


Figure 12.3

Stock returns

Period	Date	Stock 1	Stock 2	Stock 3	Stock 4	Stock 5
1	30-Jan-10	0.02889	0.00732	(0.03863)	(0.03993)	0.05202
2	28-Feb-10	(0.05080)	0.11197	(0.00401)	(0.06690)	0.03297
3	30-Mar-10	0.05070	0.09415	0.04840	0.09302	(0.02660)
4	30-Apr-10	(0.30295)	(0.37391)	(0.14231)	(0.16666)	(0.24590)
5	30-May-10	(0.06538)	0.04254	(0.03586)	(0.10639)	(0.13768)
6	30-Jun-10	0.19342	-	(0.04189)	0.03809	0.06723
7	30-Jul-10	-	(0.02250)	0.06798	0.05275	0.07087
8	30-Aug-10	0.04034	0.02301	0.11362	(0.05011)	0.00735
9	30-Sep-10	-	(0.04081)	0.07347	0.05961	(0.09489)
10	30-Oct-10	0.06826	0.49768	0.06084	0.00867	0.02419
11	30-Nov-10	0.01917	(0.00947)	0.14895	(0.07297)	0.00787
12	30-Dec-10	0.03135	0.08143	0.02969	0.04167	0.09375
13	30-Jan-11	(0.01216)	(0.02210)	(0.02580)	(0.04446)	0.01429
14	28-Feb-11	(0.05846)	(0.08170)	0.05139	(0.03255)	(0.04049)
15	30-Mar-11	0.05556	(0.00322)	(0.00147)	(0.06730)	0.07523
16	30-Apr-11	0.05882	(0.04785)	0.19287	0.08247	0.01365
17	30-May-11	(0.03801)	(0.08835)	(0.00746)	(0.03809)	0.04882
18	30-Jun-11	0.01520	0.06454	(0.02508)	(0.01487)	(0.00642)
19	30-Jul-11	0.17665	0.18229	0.08741	0.19099	0.14376
20	30-Aug-11	0.02799	0.03616	0.05437	(0.08227)	(0.01412)

Figure 12.4

Correlation matrix

	1	2	3	4	5
1	1.00000	0.49444	0.23646	0.57353	0.71299
2	0.49444	1.00000	0.18573	0.31712	0.53987
3	0.23646	0.18573	1.00000	0.37459	0.30987
4	0.57353	0.31712	0.37459	1.00000	0.50848
5	0.71299	0.53987	0.30987	0.50848	1.00000

RETURNS SUMMARY

The Returns sheet summarizes the data and includes a table for generating future scenarios. The scenario number uses the RANDBETWEEN function to generate a number between 1 and 60. This is a uniform distribution since the possibility of any of the outcomes is equal. The random number is used as a row number in the table on the Data sheet to look up a return and then multiplies the result to the cumulative amount in the previous row. The starting point is one so the gains and losses are percentages.

C7 formula: RANDBETWEEN(Data!\$B\$9,Data!\$B\$68)

D7 formula: D6*(1!OFFSET(Data!\$B\$8,\$C7,2))

The formula uses a two-dimensional OFFSET formula to start at the top left-hand corner of the table and go down by the number of rows generated by the RANDBETWEEN function and across to the column containing Stock 1

(see Figure 12.5). By pressing F9 and recalculating, further scenarios can be generated based on the historic data. Each month adds a new gain or loss to the previous cumulative amount. This is the uniform distribution where any result is equally likely.

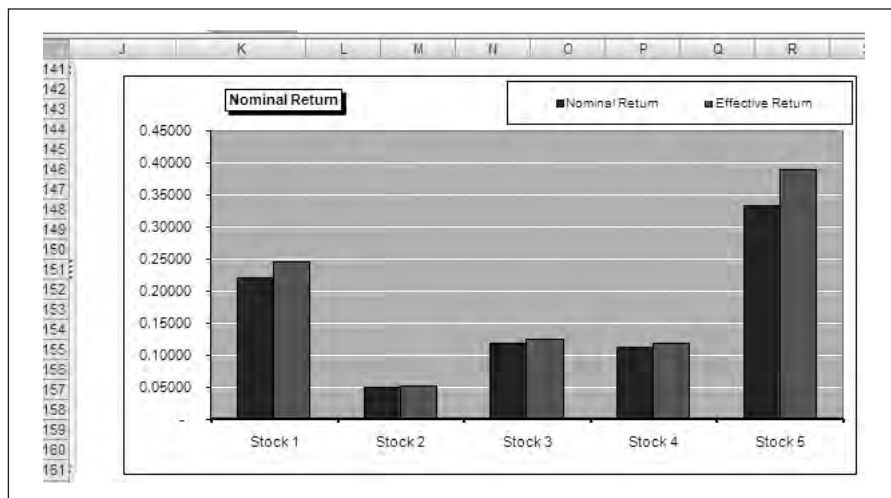
Scenario table

Figure 12.5

Month	Scenario	Stock 1	Stock 2	Stock 3	Stock 4	Stock 5
0		1.00000	1.00000	1.00000	1.00000	1.00000
1	50	1.01729	1.03738	0.99515	0.97067	1.03555
2	15	1.07381	1.03404	0.99369	0.90535	1.11345
3	14	1.01103	0.94956	1.04476	0.87587	1.06836
4	57	0.98134	0.94536	1.05167	0.87587	1.05369
5	33	0.99479	0.84646	0.96122	0.84812	1.07732
6	23	1.04813	0.95992	0.94201	0.83566	1.11360
7	17	1.00637	0.87511	0.93496	0.80383	1.16797
8	35	1.16375	1.00572	1.03919	0.92408	1.32573
9	22	1.21062	1.12323	1.01551	1.00247	1.37377
10	9	1.21062	1.07740	1.09013	1.06224	1.24342
11	17	1.16480	0.98221	1.08200	1.02177	1.30412
12	58	1.24556	1.05207	1.12471	1.11821	1.39036
Periodic		0.01847	0.00424	0.00984	0.00935	0.02784
Nominal Return		0.22161	0.06087	0.11810	0.11225	0.33413
Effective Return		0.24556	0.05207	0.12471	0.11621	0.39036

Effective interest rates

Figure 12.6



At the bottom, the inherent interest rates are calculated using the RATE and EFFECT functions. Note that the latter function is only available if you have selected Analysis Toolpack as one of the Excel add-in options in the Home tab (Excel 2003 – Tools, Add-ins). The periodic rate is calculated by the number of periods per annum (12) to form the nominal rate.

D20 formula: `RATE($B18,0,D6,-D18,0)`

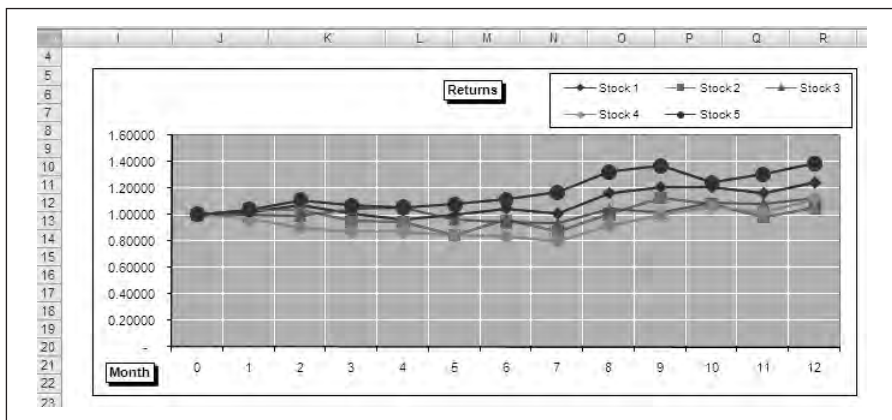
D22 formula: `= IF (ISERROR (EFFECT (D21,$B18)),0,EFFECT (D21,$B18))`

The RATE function is equivalent to this calculation: $\{1.0793/1.000\}^{[1/12]}$. The EFFECT function provides the effective (annual equivalent) based on the number of compounding periods in the year (see Figure 12.6). The formula to convert nominal to effective rates is $\{(1 + \text{Nominal}/C)^C\} - 1$, where C is the number of compounding periods per annum.

You can see the range of outcomes in Figure 12.7, where two of the stocks have virtually doubled over the 12-month period. This of course will change every time you press F9. However, the range of outcomes will be based on the average and standard deviation of the historic returns.

Figure 12.7

Scenario chart



The second part of the schedule summarizes the historic data. This uses a FREQUENCY array function to count the number of results in the bins between -20 per cent and +20 per cent. To further describe the distributions, the minimum, maximum, median, skew, kurtosis, mean standard deviations and range are shown (see Figure 12.8). The distributions offer different characteristics of mean and standard deviation with Stocks 1 and 2 with the highest mean, and Stock 2 with the highest standard deviation. Stock 2 seems to offer a higher return than the other stocks but only with higher risk expressed by standard deviation.

The formulas are:

Maximum = `MAX (Data!D$9 :D$68)`

Minimum = `MIN (Data!D$9 :D$68)`

Median = `MEDIAN (Data!D$9 :D$68)`

Skew = `SKEW (Data!D$9 :D$68)`

Kurtosis = KURT (Data!D\$9:D\$68)
 Mean = AVERAGE (Data!D\$9:D\$68)
 Standard deviation = STDEVP (Data!D\$9:D\$68)

Frequency table

Figure 12.8

	A	B	C	D	E	F	G	H
28								
29								
30								
31		(20.00%)		1	2	1	0	1
32		(18.00%)		0	0	0	0	0
33		(16.00%)		0	0	0	1	0
34		(14.00%)		0	1	1	0	0
35		(12.00%)		0	1	0	0	3
36		(10.00%)		1	4	0	1	0
37		(8.00%)		1	3	2	2	3
38		(6.00%)		1	1	2	4	3
39		(4.00%)		5	4	8	5	5
40		(2.00%)		4	7	7	7	2
41		-		5	5	6	6	8
42		2.00%		9	5	6	6	7
43		4.00%		12	6	8	6	9
44		6.00%		8	3	6	8	7
45		8.00%		5	3	4	2	7
46		10.00%		2	2	3	6	1
47		12.00%		2	2	4	1	1
48		14.00%		1	2	1	1	1
49		16.00%		1	4	1	1	2
50		18.00%		1	0	0	0	0
51		20.00%		1	1	1	1	0
52								
53		Sum		60	56	60	60	60
54								
55		Maximum		0.19342	0.49766	0.19237	0.19099	0.15578
56		Minimum		(0.30295)	(0.37391)	(0.31168)	(0.18666)	(0.24590)
57		Median		0.02563	0.01096	0.00917	0.00900	0.01397
58		Skew		(1.17252)	0.81352	(1.00200)	0.13572	(0.74248)
59		Kurtosis		5.90705	4.00196	4.49051	0.41327	-1.67588
60		Mean		0.02129	0.02341	0.01232	0.01063	0.00540
61		Standard deviation		0.07266	0.13010	0.07618	0.06524	0.07116
62		Range		0.49638	0.87159	0.50453	0.35765	0.40168

Another method of describing the distributions is to draw out the quartiles using the same data. This is a convenient way of calculating the minimum, maximum and median together (see Table 12.2 and Figure 12.9).

The chart of the table also illustrates the spread of results effectively: the range on Stock 2 shows up clearly with the lowest minimum and the highest maximum (see Figure 12.10). By contrast, Stock 4 has the lowest range.

Figure 12.10 is a non-standard chart called a box plot and was created with the data in the specific order in Table 12.3.

The instructions are:

- highlight the whole table, including figures and series labels and then click on *Insert, Charts, Line Chart (Excel 2003 - Chart Wizard)*;

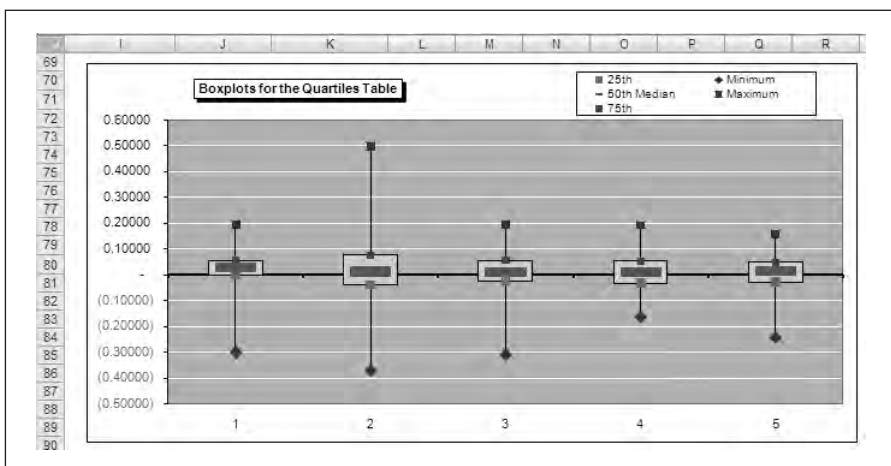
Figure 12.9

Quartiles

	A	B	C	D	E	F	G	H
69		Quartiles Table						
70								
71		Intervals	Percentile	Stock 1	Stock 2	Stock 3	Stock 4	Stock 5
72								
73		0	Minimum	(0.30295)	(0.37391)	(0.31186)	(0.16866)	(0.24590)
74		1	25th	(0.00386)	(0.04138)	(0.02669)	(0.03500)	(0.03005)
75		2	50th Median	0.02563	0.01096	0.00917	0.00900	0.01397
76		3	75th	0.05423	0.07371	0.05372	0.05122	0.04630
77		4	Maximum	0.19342	0.49768	0.19287	0.19099	0.15578
78								
79		Mean		0.06735	0.13524	0.05722	0.05405	0.04650
80	RM							

Figure 12.10

Quartiles chart



- select a Line Chart;
- at Step 2 plot by Rows (the default is Columns), then Finish;
- select each data series in turn and use Format Data Series to remove the connecting lines;
- select any of the data series and Format Data Series; select the Options tab and switch on the checkboxes for High–Low lines and Up–Down bars.

Table 12.2

Quartile number	Answer
0	Minimum value
1	First quartile (25th percentile)
2	Median value (50th percentile)
3	Third quartile (75th percentile)
4	Maximum value

Table 12.3

	Stock 1	Stock 2	Stock 3	Stock 4	Stock 5
25th	(0.00388)	(0.04138)	(0.02689)	(0.03500)	(0.03005)
Minimum	(0.30295)	(0.37391)	(0.31166)	(0.16666)	(0.24590)
50th (median)	0.02563	0.01096	0.00917	0.00900	0.01397
Maximum	0.19342	0.49768	0.19287	0.19099	0.15578
75th	0.05423	0.07371	0.05372	0.05122	0.04630

A further chart on the schedule allows you to compare two distributions (see Figures 12.11 and 12.12). This allows you to test the shape of Stocks 2 and 4 with the individual frequencies and the variance between them.

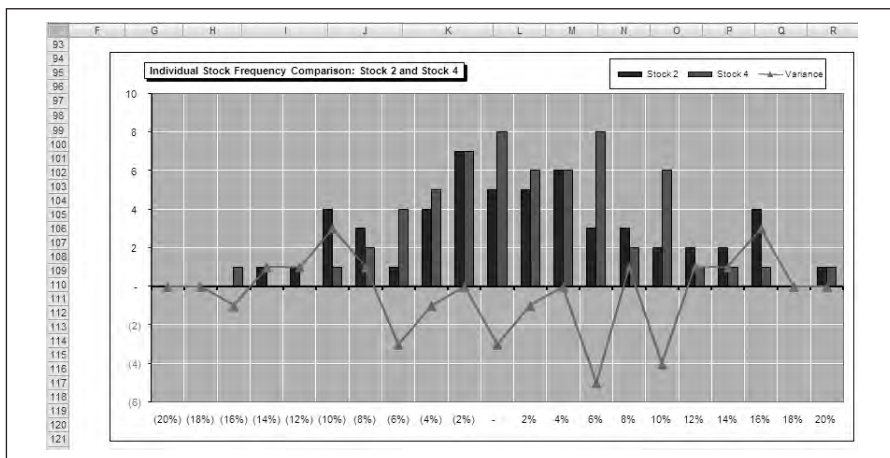
Comparison of two stocks

Figure 12.11

Intervals	Stock 2	Stock 4	Variance
(0.20)	-	-	-
(0.18)	-	-	-
(0.16)	-	1	(1)
(0.14)	1	-	1
(0.12)	1	-	1
(0.10)	4	1	3
(0.08)	3	2	1
(0.06)	1	4	(3)
(0.04)	4	5	(1)
(0.02)	7	7	-
-	5	8	(3)
0.02	5	6	(1)
0.04	6	6	-
0.06	3	8	(5)
0.08	3	2	1
0.10	2	6	(4)
0.12	2	1	1
0.14	2	1	1
0.16	4	1	3
0.18	-	-	-
0.20	1	1	-
Sum	54	60	(6)

Figure 12.12

Comparison chart



SIMULATION

The Simulation sheet contains 1000 lines of data generated by the Simulation macro. The macro recalculates and, based on the random numbers generated by the RANDBETWEEN function, builds up to a value at the end of 12 months. This value is pasted into the stock returns row and the process repeats 1000 times through a FOR NEXT loop. This assumes that the possibility of any of the previous months happening again is random. The process is repeated 1000 times so that there is sufficient data to provide a theoretical distribution.

The portfolio return (see Figure 12.13) is composed of the values for that row multiplied by the weightings in row nine on the Portfolio sheet. The SUMPRODUCT function is a convenient method for multiplying out the two arrays.

$$= \text{SUMPRODUCT}(\text{Portfolio!}\$C\$9:\$G\$9, \text{Simulation!}C6:G6) - 1$$

Where the portfolio return falls below the minimum (in this case 10 per cent), this is recorded using an IF function. This is used later to calculate the probability of a loss.

$$= \text{IF}(H6 < \text{Portfolio!}\$C\$7, \text{Portfolio!}\$C\$7 - H6, 0)$$

Below is the text of the macro, which recalculates and pastes the data into the sheet. Each time you run the macro a fresh set of data is created in the Simulation sheet:

```

Sub Simulation()
Dim Original_Answer
Original_Answer = Range("Returns!d18:h18")
Range("Simulation_Results") = "" 'Zero previous results

Randomize
Application.Calculation = xlSemiautomatic
Application.ScreenUpdating = False

For r = 1 To 1000 'START OF LOOP
RandomFactor = Rnd
Calculate
Sheets("Returns").Select
Range("d18:h18").Select
Selection.Copy

Sheets("Simulation").Select
Range("C5").Select
ActiveCell.Offset(r, 0).Select

Selection.PasteSpecial Paste:= xlPasteValues, Operation:= xlNone,
SkipBlanks:= False, Transpose:= False

Application.CutCopyMode False
Range("a2").Select

Sheets("Data").Select
Range("A2").Select
Application.ScreenUpdating = True
Range("data!h5") = r
Application.ScreenUpdating = False
Next r          'END OF LOOP

Sheets("Returns").Select
Application.CutCopyMode = False
Range("a2").Select
Application.ScreenUpdating = True
Application.Calculation = xlAutomatic
End Sub

```


Figure 12.13

Portfolio returns

	A	B	C	D	E	F	G	H	I
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									

Simulation Number	Stock 1	Stock 2	Stock 3	Stock 4	Stock 5	Portfolio Return	Shortfall to Simulation Target Return
0001	1.56947	1.06573	1.23475	0.92709	0.88365	0.44284	-
0002	1.58196	2.08344	0.78052	1.32517	1.25780	-0.37888	-
0003	0.75801	0.51282	0.82261	0.99317	0.76079	(0.23407)	(0.33407)
0004	1.04803	0.75922	1.18697	0.68118	0.86953	0.06888	(0.03114)
0005	1.60341	1.27073	1.14528	1.17541	0.96830	0.45281	-
0006	1.33897	0.75410	1.24898	0.99370	1.22282	-0.28015	-
0007	1.36089	1.18384	1.03389	0.96722	1.16094	0.25588	-
0008	1.54141	1.12101	1.04027	1.10478	1.23224	0.37407	-
0009	1.67916	1.10139	0.86575	1.32606	1.13873	-0.41637	-
0010	1.60480	2.40755	1.37063	1.20390	1.62253	-0.57608	-
0011	1.72714	1.09307	1.23935	1.26885	1.52425	-0.55228	-
0012	1.00597	1.09384	1.31794	0.88826	0.93192	0.09753	(0.00247)
0013	1.23765	0.87952	1.34802	1.27053	1.34264	0.25072	-
0014	1.20472	1.03470	1.79369	1.23291	1.00823	-0.38255	-
0015	1.12267	1.12102	1.75588	1.30630	1.00828	0.30315	-
0016	1.04186	0.78914	1.08809	1.00917	1.06968	0.04160	(0.05840)
0017	1.06978	1.31670	1.63325	1.09978	0.96750	0.24186	-
0018	1.09115	1.56827	1.14356	1.46552	0.96109	-0.13415	-
0019	1.51073	1.79629	1.24874	1.16306	1.24266	0.44808	-
0020	1.25430	1.68200	1.19879	0.93844	0.94659	0.25755	-

PORTFOLIO

The Portfolio sheet uses the Simulation sheet data to construct optimum portfolios with the Solver add-in. This allows you to maximize, minimize or target a particular cell value by changing multiple cells subject to a number of rules or constraints. On the schedule, there are inputs for the required return, risk-free rate, a minimum return (for working out the possibility of loss) and weighting for each of the five stocks (see Figure 12.14). The sum of the weightings must be equal to one.

The statistics are calculated as follows:

- Mean =AVERAGE (Simulation!H\$6:H\$1005)
- Standard deviation =STDEVP (Simulation!H\$6:H\$1005)
- Possibility of loss =PERCENTRANK (Simulation! I\$6:I\$1005, 0)
- Downside risk =-AVERAGE (Simulation!I6:I1005)
- Sharpe ratio = (H13-C6) /H14

Portfolio sheet

Figure 12.14

	A	B	C	D	E	F	G	H
4								
5		Required Return	25.00%					
6		Risk-Free Rate (Rf)	5.00%					
7		Market Rate (Rm)	12.00%					
8		Market Standard Deviation	10.00%					
9		Simulation Target Return	10.00%					
10			Stock 1	Stock 2	Stock 3	Stock 4	Stock 5	Portfolio
11		Weights	0.65655	0.05140	0.28235	0.00969	-	1.00000
12								
13		Mean	1.28464	1.32736	1.15959	1.12716	1.06086	
14		Standard Deviation	0.30584	0.58834	0.31627	0.24166	0.26028	
15		Portfolio Return						0.25000
16		Standard Deviation						0.25289
17		Probability of Loss						0.27600
18		Downside Risk						0.04287
19		Sharpe Ratio						0.79987

The mean is the weighted average return on the portfolio. The standard deviation uses the function for a population with the following formula:

$$\sqrt{\frac{n \cdot x^2 - (\cdot x^2)}{n^2}}$$

The possibility of loss uses the function PERCENTRANK to derive the percentage of results below zero and therefore constituting a loss. Similarly, the downside risk is the percentage of observations which fall below the minimum input of 10 per cent.

The Sharpe ratio of the portfolio is a composite measure for evaluating performance. It seeks to measure total risk by including the standard deviation of returns. The measure provides the risk premium earned per unit of total risk. It follows therefore that a high score indicates a more efficient portfolio in terms of risk and reward:

$$\frac{\mu - r}{\sigma}$$

where

μ = mean return on the portfolio

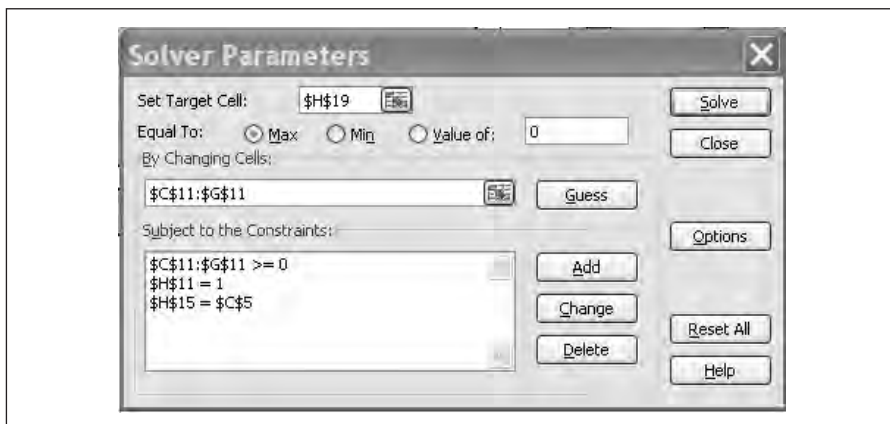
ρ = risk-free rate

σ = standard deviation of the portfolio.

The standard deviation, possibility of loss, downside risk and Sharpe ratio are all portfolio measures that could be used to define a portfolio with certain characteristics. You could minimize the first three or maximize the Sharpe ratio. The model attempts to maximize the Sharpe ratio by changing the weights afforded to each stock with the provisos that the minimum return has to be met and that the weights cannot be less than zero or add up to more than 100 per cent. This is the manual Solver dialog box (see Figure 12.15).

Figure 12.15

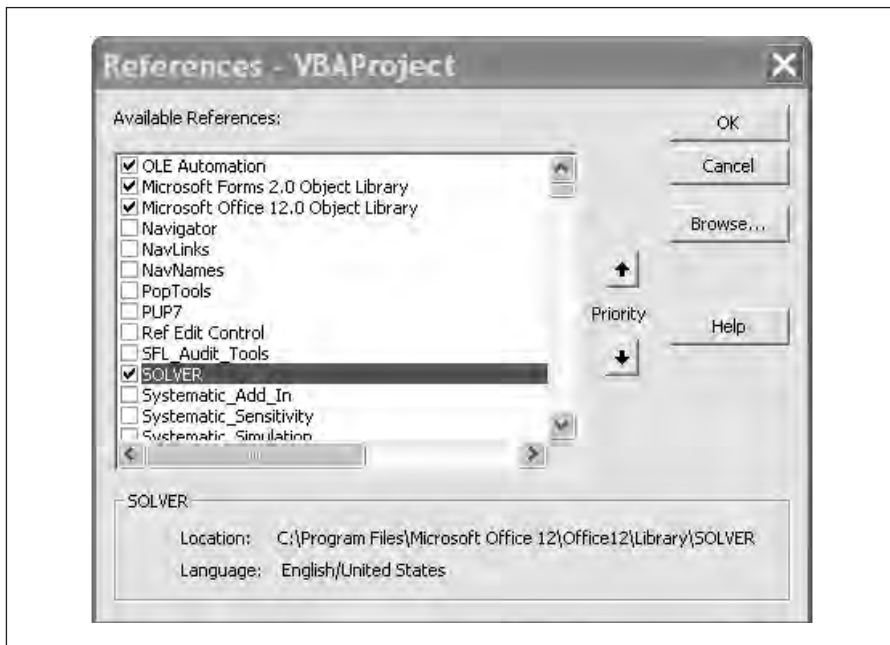
Solver dialog box



Note that there are sometimes problems with different language versions of Solver used in code. The fact that Solver will be required has to be noted as a reference in the Visual Basic Window (see Figure 12.16). If you get an error while running the macro, then check that Excel can find the Solver add-in. Browse and re-click the add-in and the macro should run.

Figure 12.16

Solver reference



The Solver Parameters box shown in Figure 12.15 produces a single portfolio at a given rate but a chart of several portfolios is required to

understand how it 'behaves'. The sheet contains a macro to take required returns in order, perform a Solver analysis, paste the weightings and the answers into a table and then go on to the next expected return. The full text of the SolverTable macro is as follows:

```

Sub SolverTable()
'
Dim Original_Answer, Required_Return
Application.Calculation = xlSemiautomatic

SolverOk SetCell:=" $H$19", MaxMinVal:= 1,
Valueof:=0, ByChange: = "$C$11:$G$11"
SolverSolve userfinish: = True

Original_Answer = Range("portfolio!c11:g11")
Required_Return = Range("c5")
Range("SolverTable") = ""
For r = 1 To 7

Range("c11:g11") 0
Range("B21").Select
ActiveCell.Offset(r, 0).Select
Selection.Copy
Range("c5").Select
Selection.PasteSpecial Paste:=xlPasteValues,
Operation:=xlNone, SkipBlanks :=False,
Transpose:=False

SolverOk SetCell:="$H$19", MaxMinVal:=1, Valueof:=0,
ByChange:="$C$11:$g$11"

'SolverOk SetCell:="$H$14", MaxMinVal:=2, ValueOf:="0",
ByChange:="$C$9:$g$9"
SolverSolve userfinish:=True
Range("C11:G11").Select
Selection.Copy
Range("C21").Select
ActiveCell.Offset(r, 0).Select
Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone,
SkipBlanks :=False, Transpose:=False

Range("H15:H19").Select
Application.CutCopyMode False
Selection.Copy
Range("H21").Select

```

```

ActiveCell.Offset(r, 0).Select
Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone,
SkipBlanks :=False, Transpose:=True

Application.CutCopyMode False
Range("B21").Select
Next r

Range("portfolio!c11:g11") Original_Answer
Range("c5") Required_Return
Range("a2").Select
Application.Calculation xlAutomatic

End Sub

```

The result is a table of returns stepping up in predetermined intervals showing the weighting of stock and the results in terms of standard deviation and the Sharpe ratio. As the required return increases, Stocks 4 and 5 are removed since they do not offer a sufficient return (see Figure 12.17).

Figure 12.17

Portfolio workings

	Solver TableTarget	Stock 1	Stock 2	Stock 3	Stock 4	Stock 5
21	Portfolio Return					
22	19.00%	0.32455	0.01667	0.28293	0.36405	0.01180
23	21.00%	0.43160	0.02830	0.28391	0.25819	-
24	23.00%	0.54408	0.03985	0.28313	0.13294	-
25	25.00%	0.65855	0.05140	0.28235	0.00989	-
26	27.00%	0.78155	0.09048	0.14797	-	-
27	29.00%	0.86590	0.12190	0.00220	-	-
28	31.00%	0.40643	0.59357	-	-	-

Standard deviation increases with return whereas the probability of loss and the downside risk reduce and then start to increase. The Sharpe ratio increases until the required return of 27 per cent and then starts to decline (see Figure 12.18).

The chart is an XY scatter chart with standard deviation as the *x*-axis and the required return as the *y*-axis. This shows the efficient frontier where it leads to diminishing returns after 27 per cent to demand a greater return (see Figure 12.19). Each extra unit of return costs more in risk. As a check the market line has been calculated using a market rate of 12 per cent and a risk free rate of 5 per cent. Based on a standard deviation of 10 per cent, the Sharpe ratio is 0.70. The market line is drawn on the chart and a forecast linear trend line directed through it. Portfolios at expected returns of 19 per cent and 31 per cent lie below the market line. The optimum portfolio lies between 25 per cent and 27 per cent.

Portfolio results

Figure 12.18

Solver Table Target	Portfolio Return	Standard Deviation	Probability of Loss	Downside Risk	Sharpe Ratio	
Portfolio Return	19.00%	0.19000	0.21844	0.34600	0.04682	0.84682
	21.00%	0.21000	0.22451	0.31000	0.04399	0.71268
	23.00%	0.23000	0.23685	0.29400	0.04290	0.75997
	25.00%	0.25000	0.25289	0.27800	0.04287	0.79087
	27.00%	0.27000	0.27550	0.27800	0.04548	0.79855
	29.00%	0.29000	0.30751	0.28100	0.05044	0.78047
	31.00%	0.31000	0.41981	0.32400	0.06974	0.61982
Risk Free Rate (Rf)	0.05000	-	-	-	-	-
Actual Market Rate (Rm)	0.12000	0.10000	-	-	-	0.70000

Efficient frontier

Figure 12.19

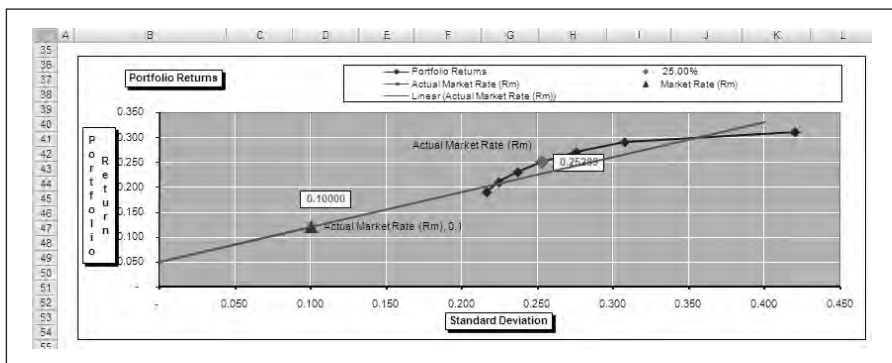
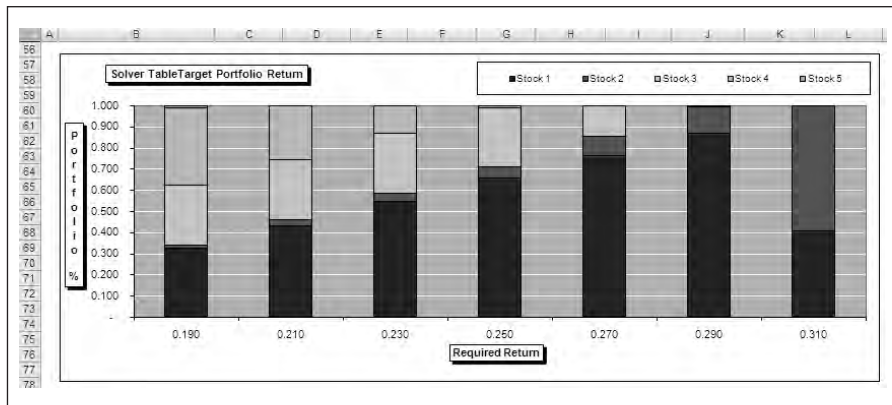


Figure 12.20 shows the composition of each of the portfolios. Stock 1 increases as a percentage of the portfolio until the required return is 29 per cent and is then overtaken by Stock 2 when the higher yield is specified. Stock 5 hardly features since the return is low compared with the other stocks.

Portfolio comparison

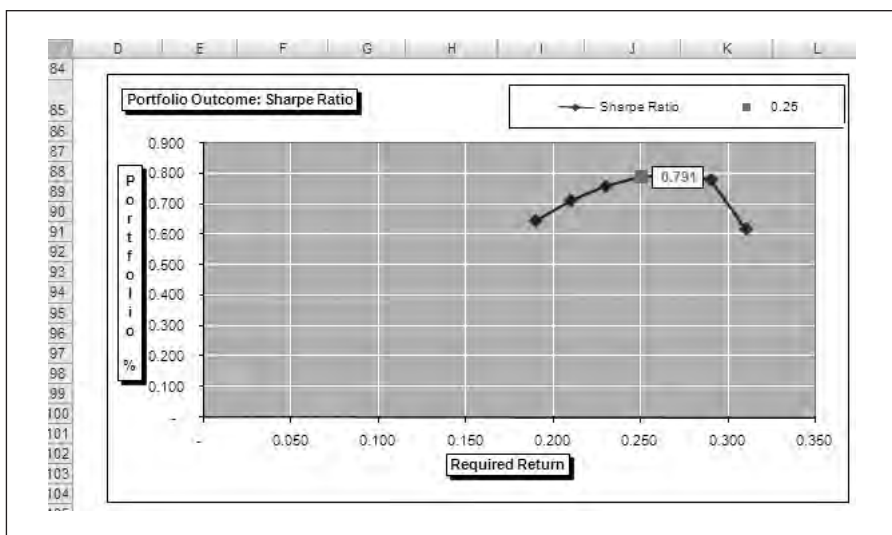
Figure 12.20



A third chart allows you to select one of the measures and check the answer along the line. Figure 12.21 illustrates how the Sharpe ratio starts to decline with the increasing risk inherent in the higher yielding portfolios. This type of chart allows you to test the portfolios graphically, and here it emphasizes the viable portfolios up to about 30 per cent after which each unit of return brings decreased portfolio benefits.

Figure 12.21

Sharpe ratio



SUMMARY

Portfolio theory shows how you can combine risky assets and use diversification to reduce overall portfolio risk. This model uses simulation to generate a data set of possible portfolios and then analyses the findings using Solver to build portfolios with the optimum balance of risk and return at required portfolio rates of return. The model goes one stage further using macros to build up a table of solved portfolios and draws charts of the portfolios. The Portfolio sheet provides a graphical and tabular answer to finding the optimum portfolios for this set of data. Using these tools, portfolios can be constructed with predetermined rates of risk and return.

REFERENCES

- Markowitz, Harry M., 1952, 'Portfolio Selection', *Journal of Finance*, March, 77–91.
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- Sharpe, William F., 1966, 'Mutual Fund Performance', *Journal of Business*, 39, no.1, part 2 (January), 119–38.
- Sharpe, William F., 1994, 'The Sharpe Ratio', *Journal of Portfolio Management*, 21, no.1 (Autumn), 49–59.

Risk adjusted returns

.....
Introduction

.....
Economic capital

.....
Risk-adjusted return on capital (RAROC)

.....
Summary
.....

File: MRM2_13

INTRODUCTION

The measurement of economic capital provides a common framework for quantifying risk arising from varied sources and also allows the calculation of equity that a bank should hold to support the various levels of risk taking. Banks need a certain level of capital to support their liabilities and this framework is contained in the Basel II documentation. ‘Capital’ is defined here as the difference between the value of assets and the value of liabilities. The value of both sides of the equation can change daily and this can impact on the bank’s ability to pay its debts. This means that there is a direct relationship between the amount of capital held, the amount of risk capacity generated and the probability of default.

ECONOMIC CAPITAL

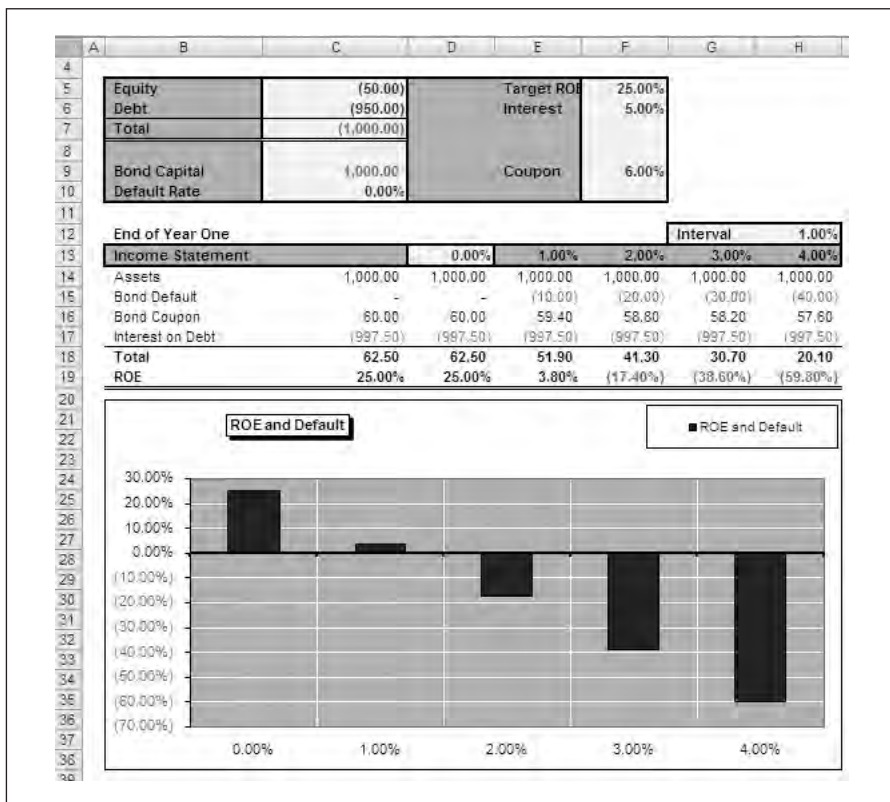
Economic capital is said to represent the emerging best practice for measuring and reporting all kinds of risk across a financial organization. It is called ‘economic’ capital because it measures risk in terms of economic realities rather than potentially misleading regulatory, accounting or book values. The term ‘economic capital’ is also used since part of the measurement process involves analysing and converting a risk distribution to the amount of capital that is required to support the risk, in line with the institution’s target financial strength or credit rating.

While some risk distributions can be calculated with more certainty than others, market risks tend to be more accessible than operating risks. For example, the approach can be applied in principle to almost all bank risks, and to any business line within the institution. Economic capital therefore provides management with a standardized unit, for comparing and discussing potential profit opportunities and related threats and downsides. Economic capital numbers can also be multiplied by an institution’s equity hurdle rate (the minimum acceptable rate of return on equity) to offer a ‘cost of risk’ number that is comparable to other kinds of bank expense.

In the example shown in Figure 13.1, the bank is 95 per cent leveraged and invests in 1000 bonds paying 6 per cent and repayable in one period’s time. The model calculates the in and outflows. The assets in one year’s time should be 1000 plus 6 per cent, from which the debt and equity holders can be paid. Paying the debt holders for the 950 debt leaves 62.5 which equates to a 25 per cent return. If the default rate rise above zero, then the return to shareholders falls since the debt needs to be paid out of a declining income. At 2 per cent default, the return is already –17 per cent.

Figure 13.1

Return on equity

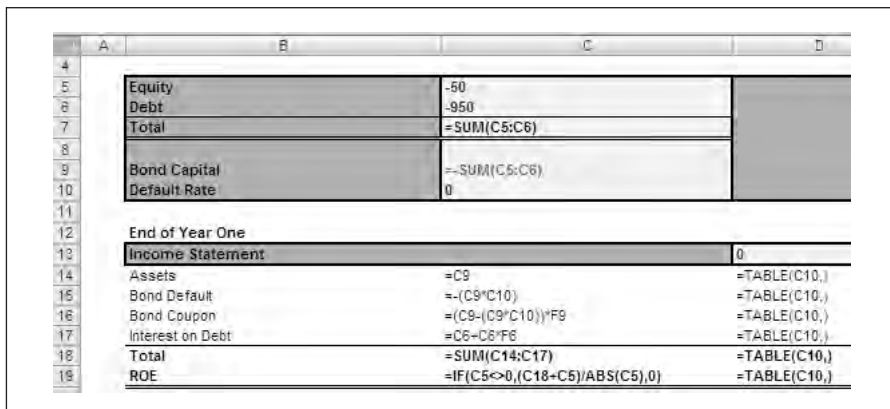


The model uses a table to generate the potential losses with increasing default percentages. The interest and capital repayment do not decrease; however, there is less income to repay the debt.

Figure 13.2 explains the cell formulas.

Figure 13.2

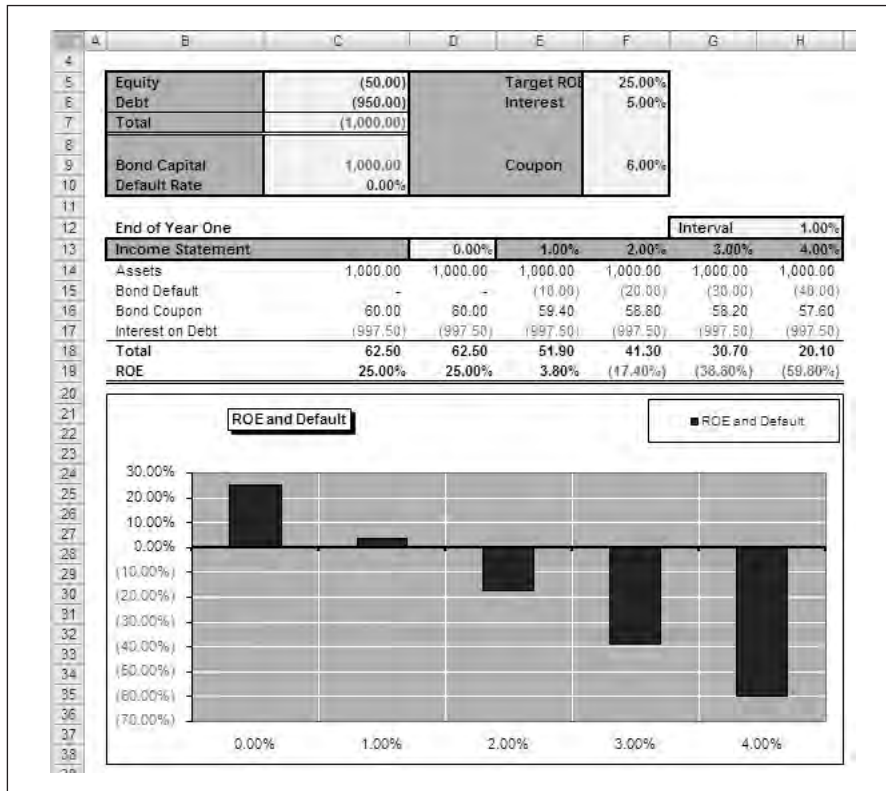
Explanation of the cell formulas



Reducing the leverage (see Figure 13.3) reduces the initial return to 10 per cent but the overall losses are also reduced as the default percentage increases. At 4 per cent, the negative return is 11 per cent against 59 per cent, demonstrating the trade-off between risk and return.

Reduced leverage

Figure 13.3



The next stage could be to generate a number of scenarios (see Figure 13.4) based on the probability of default and show how the future value of the portfolio could vary. The outcome is a continuous variable as there are an infinite number of outcomes. The representation is a probability density function, where the x -axis is the value of the assets and the y -axis is the probability. With increased capital, the probability of bank default is reduced because of the increased capital base. Economic capital represents this trade-off between initial capital, risks taken and the probability of the bank being forced to default. Economic capital is therefore a framework for translating risks into a single measure.

Figure 13.4

Table scenarios

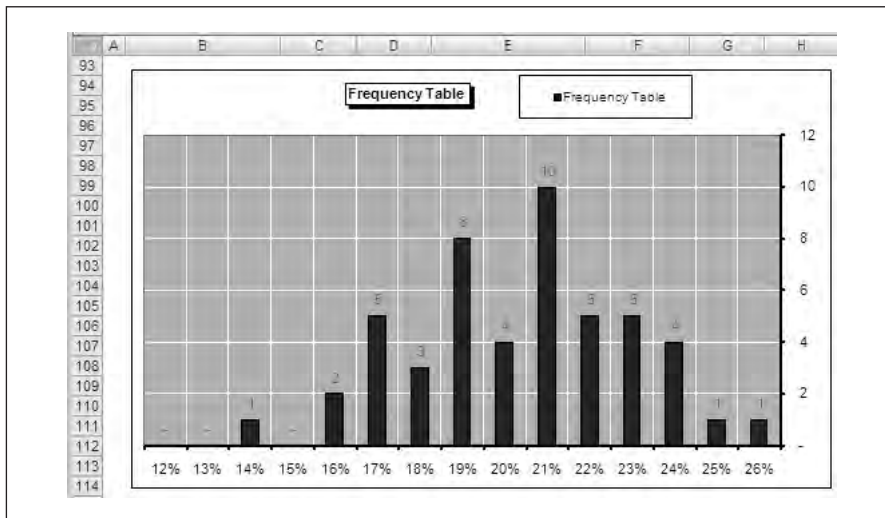
	A	B	C	D	E	F
11						
12		End of Year One				
13		Income Statement			Standard Deviation	0.50%
14		Assets	1,000.00		Default Rate	2.00%
15		Bond Default	-			
16		Bond Coupon	60.00			
17		Interest on Debt	(840.00)			
18		Total	220.00			
19		ROE	10.00%			
20						
21					ROE	Capital
22					10.00%	1,060.00
23		1	0.89	2.62%	17.71%	1,075.42
24		2	0.29	1.73%	18.21%	1,076.41
25		3	0.84	2.49%	20.77%	1,081.53
26		4	0.58	2.10%	20.37%	1,080.74
27		5	0.71	2.27%	18.60%	1,077.20
28		6	1.00	3.41%	22.14%	1,084.27
29		7	0.16	1.51%	18.10%	1,078.19
30		8	0.40	1.87%	22.66%	1,085.33
31		9	0.88	2.59%	23.46%	1,088.91
32		10	0.49	1.98%	24.49%	1,088.98
33		11	0.33	1.78%	15.59%	1,071.19
34		12	0.70	2.27%	18.93%	1,077.87
35		13	0.65	2.19%	20.46%	1,080.92
36		14	0.47	1.96%	21.54%	1,083.08
37		15	0.85	2.51%	18.85%	1,073.69
38		16	0.40	1.87%	19.18%	1,078.36
39		17	0.54	2.05%	21.50%	1,082.00
40		18	0.42	1.90%	17.75%	1,075.51
41		19	0.24	1.65%	18.85%	1,077.29
42		20	0.51	2.01%	16.50%	1,072.99

The table in Figure 13.4 is based on the RAND function to generate the probability and the NORMINV function to compute the overall default rate. The table returns the return on equity and the total capital after deduction of default. The frequency table and chart (see Figure 13.5) show the spread of results based on a 2 per cent default rate.

Economic capital is the net value that a financial institution must have at the beginning of a trading period to ensure that there is only a small probability of defaulting during the period and producing a loss. The net value is the assets less the liabilities. The small probability is based on the credit rating of the institution, for example an A rating normally equates to about 0.1 per cent over the coming year. Economic capital in this sense represents the buffer against default in that the shareholders and directors must ensure sufficient capital such that the bank can maintain the business profile and target credit rating.

Frequency table

Figure 13.5



RISK ADJUSTED RETURN ON CAPITAL (RAROC)

Banks are not only interested in the risk but also the profitability associated with the risk. Risk adjusted performance can be used to assist with business and credit decisions:

- deciding which products are profitable and how they should be priced to be profitable;
- deciding which client relationships yield the highest return;
- deciding whether or not to enter into a transaction and at what price;
- reviewing business units in their use and return on capital in return for the risks undertaken.

Table 13.1 shows the action that management could take to improve profitability or choose between operating units. If a bank loses heavily on its loan portfolio, it has to maintain minimum percentages of equity capital and therefore has to attract new capital or reduce its borrowings.

Overcapitalized	Undercapitalized
Reduce capital base	Increase capital base
Buy back shares	Issue shares (ordinary and preference)
Increase dividends	Reduce dividends to shareholders
Increase risks taken	Reduce risks taken
Grow existing units with RAROCs	Cut back on activities with low or negative RAROCs
Buy or build further business activities	Transfer out concentrated risks to others

Table 13.1

Common ratios such as return on assets (net operating profit/total assets) or return on equity (earnings after tax/shareholders' funds) do not provide an adequate metric for return since risk is not encapsulated in the measure. The earlier model can be extended to include a further measure called the risk adjusted return on capital (RAROC).

This is calculated as the net risk adjusted profit divided by the economic capital based on market values:

$$RAROC = ENP/EC$$

RAROC treats all transactions as additions to a portfolio, and the price is the amount of capital that must be set aside to make the transaction happen. The return equates to the net increase in value. A more complete formula is:

$$RAROC =$$

$$\frac{(Initial_Loan * Interest) + Fees - (Debt * Interest) - Operating_Cost - Losses}{EC}$$

$$RAROC =$$

$$\frac{(Loan * Interest) + Fees - (Loan - EC) * Interest - Operating_Cost - Losses}{EC}$$

For a trading position, the RAROC is the net change in the value of the position minus operating costs. The required profitability that must be reached is the hurdle rate multiplied by the economic capital. The equation is:

$$RAROC = \frac{\Delta Value - Operating_Cost}{Economic_Capital}$$

Shareholder value added gives an alternative measure of profitability as the amount of value added. This is the amount as per the economic capital equation minus a hurdle return multiplied by economic capital.

$$SVA = (Loan * Interest) + Fees - (Loan - EC) * Interest - Operating_Cost - Losses - Hurdle - EC$$

In this example, the inputs are as shown in Figure 13.6.

The loan is 100 sold to the client at a rate of 7 per cent against an inter-bank rate of 5.5 per cent. The average default correlation with the rest of the portfolio is 3 per cent and the capital multiplier is 6. The calculation for economic capital is:

RAROC calculation

Figure 13.6

	A	B	C	D	E	F	G	H	I
4									
5		Loan		100.00		Expected Loss			0.060
6		Interbank Rate		5.50%		Unexpected Loss (Credit Risk)			1.340
7		Customer Interest Rate		7.00%		Unexpected loss contribution (ULC)			0.232
8		Operating Costs		1.000		Economic Capital (EC)			1.393
9		Default Correlation		3.00%					
10		Loss in Event of Default		30.00%		RAROC			37.09%
11		Probability of Default		0.20%		Total Return			0.517
12		Capital Multiplier		6.000		Required Hurdle Return			0.348
13		Hurdle Rate		25.00%		Shareholder Value Added (SVA)			0.168
14						(Total Return - Required Hurdle Return)			
15									

*Expected loss = loan * loss in event of default*

** probability = 0.06*

*Unexpected loss = loan * loss in event of default*

** $\sqrt{\text{probability} - \text{probability}^2} = 1.34$*

Unexpected loss contribution (ULC) = $\sqrt{\text{default correlation}}$

** unexpected loss = 0.232*

*Economic capital = multiplier * ULC = 6 * 0.232 = 1.393*

The RAROC calculation of 37.09 per cent is:

*(Loan * customer interest rate - (loan - EC)*

** interbank rate - operating costs - expected loss) / EC*

The shareholder value added of 0.168 is:

*(Loan * customer interest rate - (loan - EC)*

** interbank rate - operating costs - expected loss) - (hurdle rate * EC)*

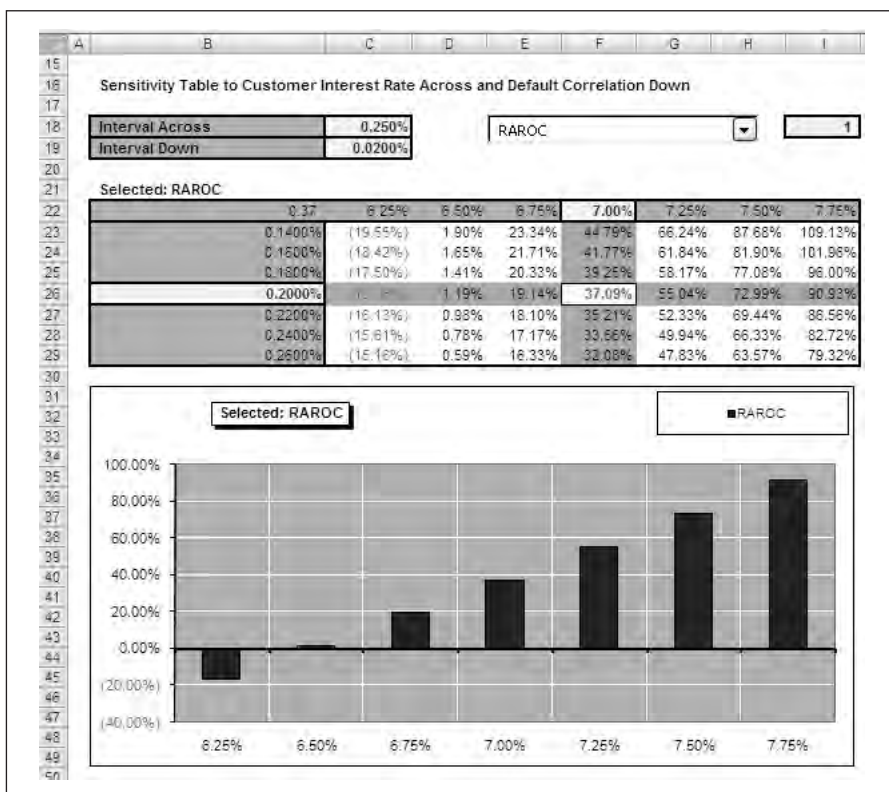
Figure 13.7 shows the sensitivity to the customer interest rate and the probability of default. The customer interest rate is plotted across and the probability down. As the customer rate and default correlation fall, the RAROC declines. The chart displays the middle 0.020 series computed above.

Over multiple periods, the RAROC is the expected net profit divided by the economic capital or the internal rate of return of the cash flows. This is more complex since:

- over longer periods, the probability of default increases and therefore increases the required economic capital and debt needed to support loans;
- if the default of debt increases, the likelihood of paying all the administration costs therefore declines;
- the outstanding loan can vary accordingly to the amortization profile;
- the security or collateral can change in value thereby increasing or decreasing the potential exposure.

Figure 13.7

RAROC sensitivity



The bank loans the funds at the beginning of the period and to fund this invests some economic capital and raises debt. The net cash flow is equal to the economic capital which has been paid to the customer. During the loan period, the client pays back interest and principal and the bank needs to pay operating costs. The expected receipt is dependent on the probability of default:

$$Cashflow_In = Loan * (1 + Interest) * (1 - Default_Probability) + Recovery * Default_Probability$$

$$Cashflow_Out = Debt * (1 + Interest) + Operating_Cost$$

Using these formulas, it is possible to construct cash flows for longer periods and find the internal rate of return or RAROC over longer periods. By understanding the capital at risk and the cash flows, it is possible to understand the return being made for the risk incurred.

The inputs in Figure 13.8 show a two-year loan using the same figures as the previous schedule. The loss in the event of default rises in the second year as does the probability of default. This implies that the RAROC in the second year will be lower because of the rise in these two factors.

Two-year loan

Figure 13.8

	A	B	C	D	E	F
4						
5		Year			1	2
6		Loan			100.00	
7		Interbank Rate			5.50%	
8		Customer Interest Rate			7.00%	
9		Operating Costs			1.000	1.000
10		Default Correlation			3.00%	
11		Loss in Event of Default			30.00%	40.00%
12		Probability of Default			0.20%	0.25%
13		Capital Multiplier			6.000	
14		Hurdle Rate			25.00%	
15						
16		Recovery in the Event of Default			70.000	60.000
17		Expected Loss			0.060	0.060
18		Unexpected Loss (Credit Risk)			1.340	1.997
19		Unexpected loss contribution (ULC)			0.232	0.346
20		Economic Capital (EC)			1.393	2.076
21						
22		RARDC			37.09%	26.70%
23						
24		Total Return			0.517	0.554
25		Required Hurdle Return			0.348	0.519
26		Shareholder Value Added (SVA)			0.168	0.035
27		(Total Return - Required Hurdle Return)				
28						

The cash flows are as in Figure 13.9. The cash on inception is the loan less the economic capital.

The formulas are:

$$\text{Cash_In_1} = \text{Loan} * \text{Interest} * (1 - \text{Prob}) + \text{Recovery}$$

$$* \text{Prob} + \text{Loan_Year_2} * (1 - \text{Prob})$$

$$\text{Cash_Out_1} = \text{Debt} * (1 + \text{Debt_Interest}) + \text{Operating_Costs}$$

$$\text{Cash_In_2} = \text{Loan} * (1 + \text{Interest}) * (1 - \text{Prob}) * (1 - \text{Prob_2})$$

$$+ \text{Recovery} * (1 - \text{Prob}) * \text{Prob_2}$$

$$\text{Cash_Out_2} = \text{Debt_2} * (1 - \text{Prob}) * (1 + \text{Debt_Interest})$$

$$+ \text{Operating_Costs} * (1 - \text{Prob})$$

Cash flows

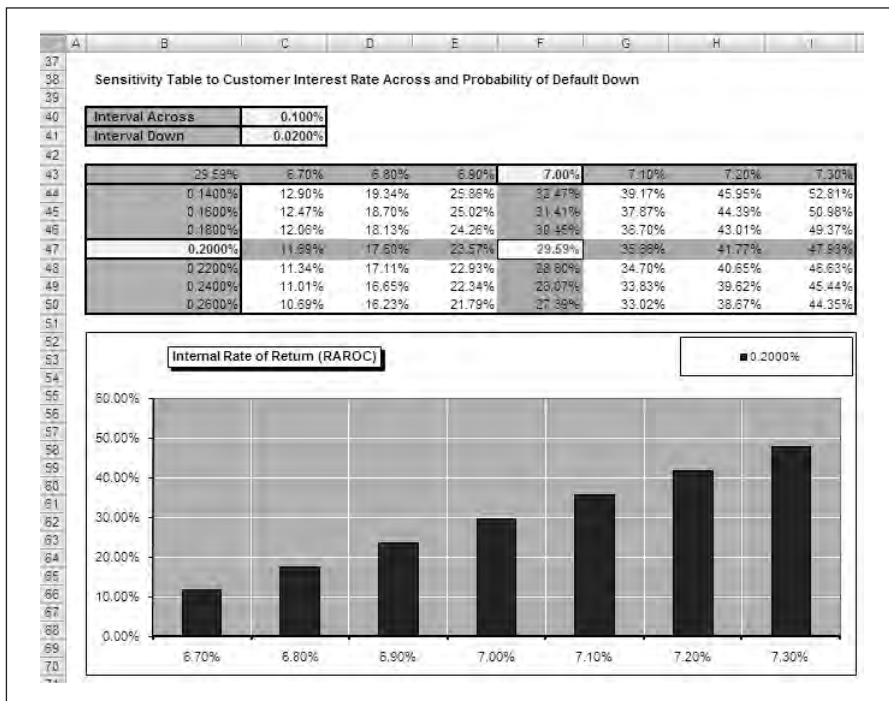
Figure 13.9

	A	B	C	D	E	F
28						
29		Cash Flows				
30			Debt	In	Out	Difference
31			0	98.61	(100.00)	(1.39)
32			1	98.61	104.85	(6.19)
33			2	97.92	106.67	2.57
34						
35		Internal Rate of Return (RAROC)		29.587%		
36						

The Sensitivity table is shown in Figure 13.10.

Figure 13.10

Sensitivity table



The RAROC for two years is below the initial answer of 37 per cent. One solution is to use Goal Seek (see Figure 13.11) to solve the customer rate needed to achieve a RAROC of 37 per cent. In this case this is 7.12 per cent using the macro code. Here the target cell is D35 and the changing cell is E8. Since Goal Seek does not allow you to set the target as a cell reference, you can record it easily as a macro and then change the hard-coded value to a cell reference:

```

Application.Calculation = xlCalculationSemiautomatic
Range("d35").Goalseek Goal:=Range("i13"), ChangingCell:=Range("e8")
Range("a2").Select
Application.Calculation = xlCalculationAutomatic
End Sub
    
```

Office 2007 – Data, Data Tools, What-if Analysis (Excel 2003 – Tools, Goal Seek)

Goalseek variables

Figure 13.11

Year	1	2
Loan	100.00	
Interbank Rate	5.50%	
Customer Interest Rate	7.00%	
Operating Costs	1.000	1.000
Default Correlation	3.00%	
Loss in Event of Default	30.00%	40.00%
Probability of Default	0.20%	0.25%
Capital Multiplier	6.000	
Hurdle Rate	25.00%	
Recovery in the Event of Default	70.000	60.000
Expected Loss	0.060	0.060
Unexpected Loss (Credit Risk)	1.340	1.997
Unexpected loss contribution (ULC)	0.232	0.346
Economic Capital (EC)	1.393	2.076
RAROC	37.09%	26.70%
Total Return	0.517	0.554
Required Hurdle Return	0.348	0.519
Shareholder Value Added (SVA)	0.168	0.035
(Total Return - Required Hurdle Return)		

Cash Flows	
	Debt In Out Difference
0	98.61 (100.00) (1.39)
1	98.61 104.85 (106.03) (0.60)
2	97.92 106.67 (108.10) 2.57

Internal Rate of Return (RAROC)	29.587%
---------------------------------	---------

Results	
IRR (RAROC)	29.587%
Goalseek	
Change Customer Rate Target	
RAROC	37.00%
Goal Seek	

SUMMARY

Risk adjusted return on capital is a measurement that includes volatility to the calculation of returns. It states the return on capital required to offset losses on the underlying asset should volatility cause its value to decline by two or three standard deviations. This chapter has used an example to show the basic calculations and the effect on returns of changing key variables such as the rate or default probability.

Value at risk

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Introduction

.....
Single asset model

.....
Two assets

.....
Three asset portfolio

.....
Summary
.....

File: MRM2_14

INTRODUCTION

Value at risk (VaR) was developed in the early 1990s in response to failures and problems in financial institutions. Initially, the purpose of VaR is to quantify financial risks facing institutions by using standard statistical techniques. It measures the worst expected loss over a given horizon under normal market conditions at a given confidence level. On a \$100 million facility, it is unlikely that a bank will lose all its capital, and this measure tries to denote the amount that could be lost at a particular confidence interval based on historic experience. Conditions are said to be normal and past volatility is assumed to continue into the future. In addition, quantitative techniques are used so that the models do not capture operational, political, liquidity or personnel risk. However, VaR is now being used to control and manage risk actively rather than just provide information. By making use of VaR tools, institutions obtain more information and can decide how to allocate economic capital and how to evaluate the trade-off of risk and return.

VaR is considered by risk managers and regulators because of the promise it holds for improving risk management. The Basel Accords I and II encourage banks to develop their own risk measurement systems to assist in calculating capital adequacy. Rather than impose a set of rigid regulations, VaR may be seen as a system of self-regulation. The proposals create incentives since the required amount of risk capital can be reduced compared with banks that follow a standard approach. Similarly, the globalization of capital markets emphasizes the links between institutions and their role in the entire system. In 1994, J. P. Morgan made its RiskMetrics system and data sets available on the Internet and this allowed institutions to develop their own systems or use the growing number of proprietary models. This chapter first outlines the basic concepts and then works through a simple VaR model in stages.

Definitions

Two more precise definitions of VaR are as follows:

- a forecast of a given percentile, usually in the lower tail, of the distribution of returns on a portfolio over some period; similar in principle to an estimate of the expected return on a portfolio, which is a forecast of the 50th percentile;
- an estimate of the level of loss on a portfolio which is expected to be equalled or exceeded with a given, small probability.

You need to understand both the return and the risk on a portfolio since a higher spread or risk usually means a higher loss at the given probability. If you are told, for example, that there is a 1 in 100 chance of losing x dollars over the forecast holding period, then following portfolio theory, this is easy to understand and provides an estimate of the capital at risk. Portfolio theory provides the basic equations and these are modelled in the following sections.

SINGLE ASSET MODEL

This model is on the Single_Asset sheet. In order to measure the VaR for a single asset, the inputs are as shown in Figure 14.1.

The standard deviation is the daily volatility or fluctuation from the mean. If an asset is volatile, there is the opportunity to make large profits or large losses against an index. An institution needs to know both its return and also its risk position. The confidence level is 95 per cent and the VaR amount 1,000,000. The model assumes that returns on an asset are normally distributed and follow a classic bell curve (see Figure 14.2). The advantage is that much is known about the attributes of normal distributions.

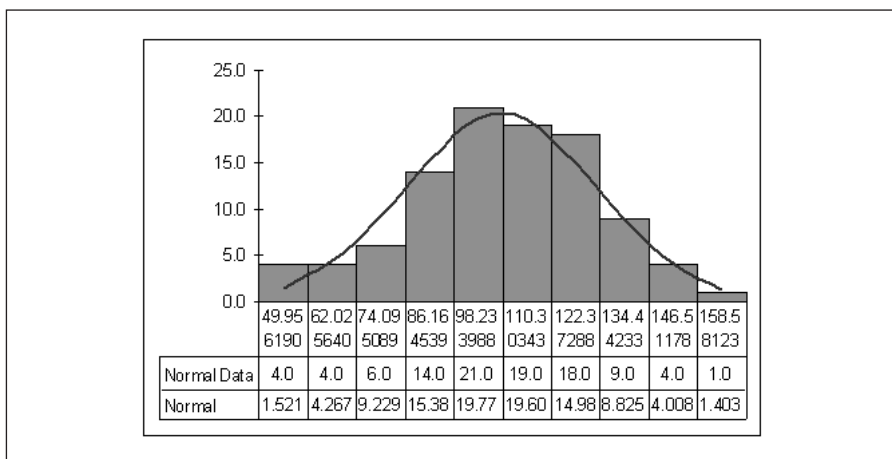
Figure 14.1

Inputs

	A	B	C	D
4				
5		Standard Deviation		0.10000
6		Horizon Days		5.0 days
7		Total Period Days		20.0 days
8		Confidence Level		0.95
9		VaR Amount		1,000,000.0
10				

Figure 14.2

Normal distribution



With a normal distribution, most of the results are clustered around the mean and the standard deviation. Table 14.1 uses the `NORMSDIST` function to return the probability for a given standard deviation. Thus 0.5 deviations in either direction from the mean encompass 69 per cent of the observations.

Office 2007 – Formulas, Function Library, Other, Statistical (Excel 2003 – Insert, Function)

Table 14.2 uses a `NORMSINV` function to return the number of standard deviations for a given probability. This provides a table of the probability or degree of confidence required against the number of standard deviations. Therefore 99 per cent confidence is equivalent to 2.33 standard deviations from the mean.

Standard deviation	Percentage
0.2500	0.5987
0.5000	0.6915
1.0000	0.8413
1.5000	0.9332
1.6449	0.9500
2.0000	0.9772
2.5000	0.9938
3.0000	0.9987

Table 14.1

Standard deviation	Percentage
0.950	1.6449
0.955	1.6954
0.960	1.7507
0.965	1.8119
0.970	1.8808
0.975	1.9600
0.980	2.0537
0.985	2.1701
0.990	2.3263
0.995	2.5758
0.999	3.0903

Table 14.2

Single asset VaR

The screenshot shows an Excel spreadsheet with columns F through J and rows 4 through 10. A table is displayed with the following data:

Horizon Standard Deviation	0,05000
No of Standard Deviations	1,64485
Unit VaR	0,08224
Position Limit	12,159,506,3

Figure 14.3

The horizon standard deviation is derived from the formula:

$$\text{Daily standard deviation} * \text{Square root (Days/Period days)}$$

$$0.05 * \text{SQRT}(5/20) = 0.05$$

VaR increases with the time horizon and this is logical since the level of risk usually increases with time. The assumption is that the standard deviation increases with the square root of time, which is based on the random movement of financial asset prices.

The number of standard deviations is derived by the NORMSINV function. The unit VaR is the horizon multiplied by the number of standard deviations (see Figure 14.3).

$$0.05 * 1.64485 = 0.08224$$

$$\text{Position limit} = \text{VaR amount}/\text{Unit VaR} = 1,000,000/0.08224$$

Figure 14.4 shows the VaR percentage, position limit and the variance to the 95 per cent position. The percentage increases at higher confidence levels and therefore the position limit declines.

The chart and combo box allow the VaR percentage, position limit and variance to be plotted (see Figure 14.5). The workings at the bottom transpose the labels from the table to form the text for the combo box. The chart workings use an OFFSET based on the cell link for the column offset to look up the data.

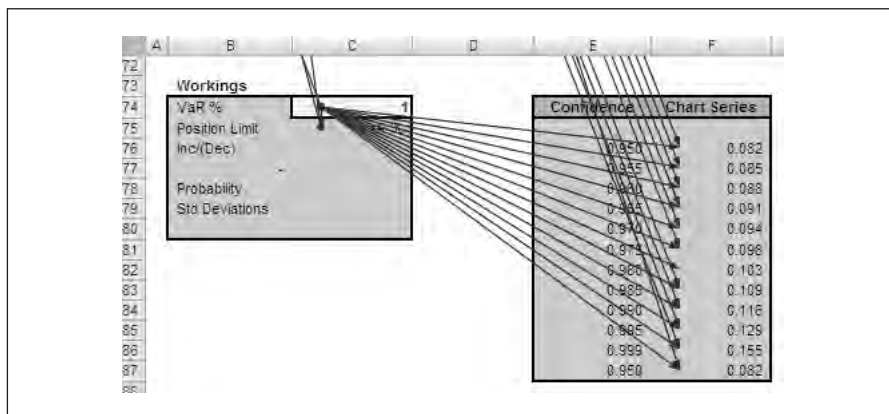
Figure 14.4

Data table

	A	B	C	D	E
11					
12		Interval		0.005	
13					
14		Confidence	VaR %	Position Limit	Inc/(Dec)
15			0.0822	12,159,506.3	
16		0.950	0.0822	12,159,506.3	-
17		0.955	0.0848	11,797,000.7	(362,505.6)
18		0.960	0.0875	11,424,440.0	(735,066.3)
19		0.965	0.0906	11,038,407.3	(1,121,099.0)
20		0.970	0.0940	10,634,132.3	(1,525,374.0)
21		0.975	0.0980	10,204,579.4	(1,954,928.9)
22		0.980	0.1027	9,738,584.8	(2,420,921.4)
23		0.985	0.1085	9,218,486.2	(2,943,020.1)
24		0.990	0.1163	8,597,427.9	(3,582,078.4)
25		0.995	0.1268	7,764,725.7	(4,394,780.8)
26		0.999	0.1545	6,472,202.1	(5,687,204.2)

Audit trail for chart workings

Figure 14.5

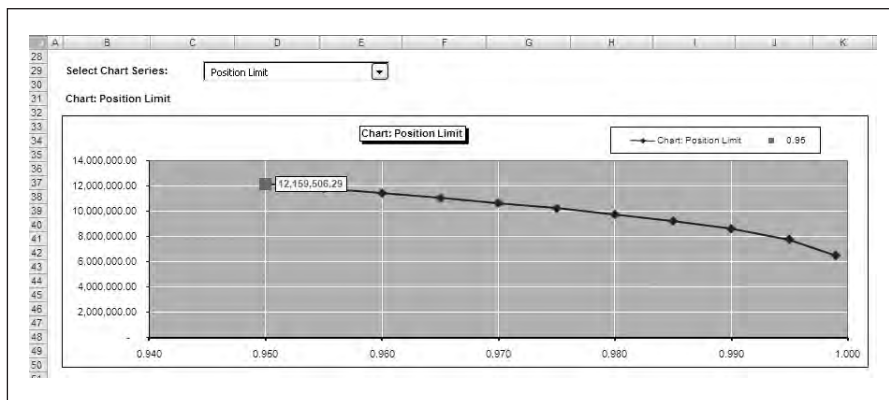


Office 2007 – Formulas, Formula Auditing, Show Precedents (Excel 2003 – Tools, Formula Auditing)

The chart demonstrates that the position limit declines from 13 million to 6.5 million based on a VaR amount of 1 million (see Figure 14.6). Similarly, the VaR percentages rise on the second chart with increasing confidence levels (see Figure 14.7).

Chart of position limit

Figure 14.6



The sensitivity chart shows the relationship between the number of days and the confidence level where the VaR increases with the number of days and a higher confidence level (see Figure 14.8).

Figure 14.7

Chart of VaR percentages

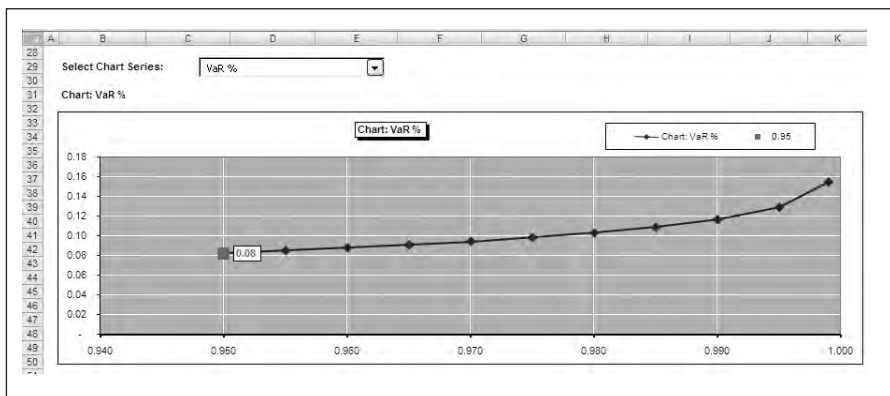


Figure 14.8

Table of confidence level against horizon days

VaR % Sensitivity Table to Confidence Level Across and Horizon Days Down

Interval Across	0.01							
Interval Down	1.00							
	0.95	0.92	0.93	0.94	0.95	0.96	0.97	0.98
1.00	-	0.031	0.033	0.035	0.037	0.038	0.042	0.046
2.00	-	0.044	0.047	0.049	0.052	0.055	0.059	0.065
3.00	-	0.054	0.057	0.060	0.064	0.068	0.073	0.080
4.00	-	0.063	0.066	0.070	0.074	0.078	0.084	0.092
5.00	-	0.070	0.074	0.078	0.082	0.088	0.094	0.103
6.00	-	0.077	0.081	0.085	0.090	0.096	0.103	0.112
7.00	-	0.083	0.087	0.092	0.097	0.104	0.111	0.121
8.00	-	0.089	0.093	0.098	0.104	0.111	0.119	0.130
9.00	-	0.094	0.098	0.104	0.110	0.117	0.126	0.138
10.00	-	0.099	0.104	0.110	0.116	0.124	0.133	0.145

TWO ASSETS

The Two_Assets sheet shows a series of sections leading to a portfolio risk measure. The calculations are:

- mean and standard deviation
- correlation
- VaR.

Mean and standard deviation

Figures 14.9 and 14.10 show two portfolios both with a mean of 8 per cent. Portfolio A is close to the means on all observations and therefore the standard deviation is also low. If past volatility holds, then the future returns are likely to be close to the mean. Portfolio B has the same mean, but there is a greater variety in the observations and therefore the standard deviation is

higher. It follows that a risk adverse investor would chose Portfolio A since the return overall is the same as Portfolio B and the volatility is lower. Thus they could be more sure of returning 8 per cent. Since the risk is higher on Portfolio B it follows that the VaR figure would be higher, in this case at 1.5 per cent.

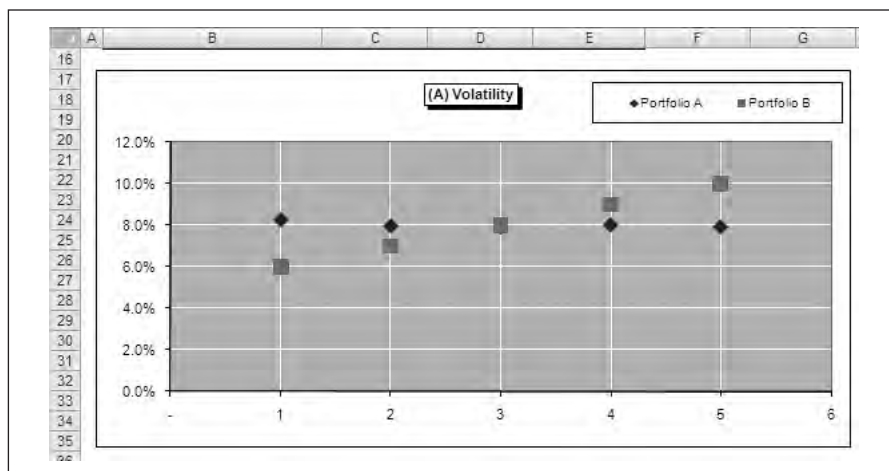
Two assets

Figure 14.9

(A) Volatility				
Observation	Portfolio A	Portfolio B	Difference	
1	8.25%	6.00%	0.02	
2	7.95%	7.00%	0.01	
3	7.90%	8.00%	(0.00)	
4	8.00%	9.00%	(0.01)	
5	7.90%	10.00%	(0.02)	
Mean	8.00%	8.00%	0.00%	
Standard deviation	0.146%	1.581%	(1.435%)	

Two assets chart

Figure 14.10



Figures 14.11 and 14.12 show a mean observation of 5 per cent and then target returns starting below the target and rising above it. Using the standard deviation of 2 per cent, minus two standard deviations means that only 2.28 per cent of future observation will be below 1 per cent. On the other hand, at the mean 50 per cent of observations are likely to be below and 50 per cent above. At the confidence level of 95 per cent, 1.64 standard deviations are needed while 2.32 are required for 99 per cent confidence.

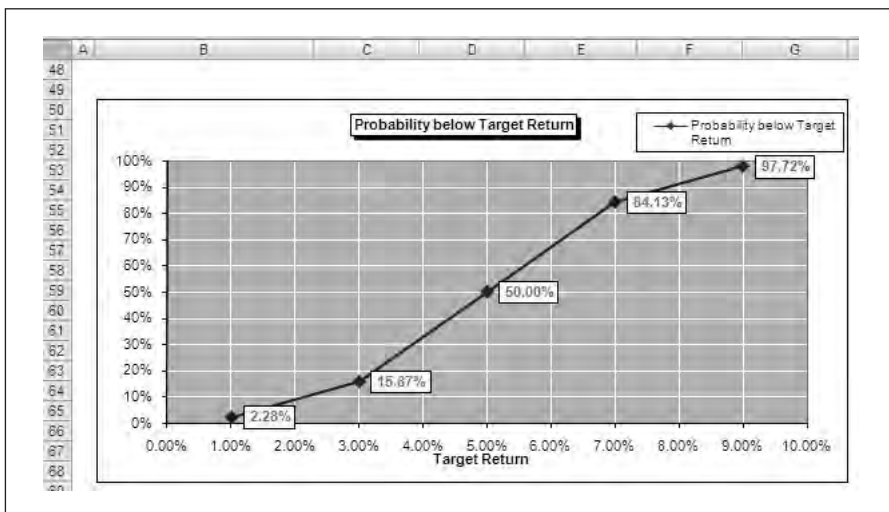
Figure 14.11

Normal distribution

	A	B	C	D	E	F	G
37							
38		(B) Normal Distribution					
39		Number of Standard Deviations	1.645	(1.000)	-	1.000	1.645
40		Probability	-95.00%	15.87%	50.00%	84.13%	95.00%
41							
42		Observation	1	2	3	4	5
43		Mean Return	5.00%				
44		Target Return	1.00%	3.00%	5.00%	7.00%	9.00%
45		Standard Deviation	2.00%				
46		Number of Standard Deviations	(2.00)	(1.00)	-	1.00	2.00
47		Probability below Target Return	2.28%	15.87%	50.00%	84.13%	97.72%

Figure 14.12

Cumulative distribution



The table uses the formula $(\text{Target return} - \text{Mean return}) / \text{Standard deviation}$ to work out the number of standard deviations. The function NORMSDIST from the statistical function library is used to compute the probabilities.

Correlation

Portfolio theory suggests that risk can be reduced through diversification. Lower risk means a lower VaR figure and encourages holding a variety of assets, taking risk and minimizing the downside through spreading risk. The diversification assists since all assets in a portfolio are unlikely to rise or fall to extreme values. Traders can reduce their own positions through hedging while contributing to the overall risk of the institution, and correlation shows the effect this has on the overall result.

Figure 14.13 shows a number of assets together with returns. The average returns are the same but correlation plots the degree to which they move together. Correlation values and what they signify are as follows:

- 1 = both sets of values move perfectly together in a positive manner;
- 0 = no relationship between the data sets;
- -1 = both sets of values move perfectly in a negative linear manner.

Four assets

Figure 14.13

Observation	Asset 1	Asset 2	Asset 3	Asset 4
1	8.00%	26.00%	6.00%	20.00%
2	9.00%	21.00%	9.00%	6.00%
3	10.00%	10.00%	10.00%	8.00%
4	11.00%	12.00%	12.00%	20.00%
5	12.00%	9.00%	13.00%	6.00%
6	13.00%	6.00%	13.00%	6.00%
7	14.00%	5.00%	14.00%	20.00%
8	15.00%	3.00%	15.00%	8.00%
Average return	11.50%	11.50%	11.50%	11.50%
Correlation with Company 1		(0.9270)	0.9802	(0.1155)
Standard deviation	2.45%	8.05%	2.98%	7.07%
Required VaR	95.00%			
Number of standard deviations	1.5448			
Volatility or VaR at 5.00%	4.03%	13.25%	4.90%	11.63%

In the example shown in Figure 14.13, Asset 2 moves negatively to Asset 1 which implies that when the former is doing well, the latter will perform badly and vice versa. In terms of value, change would have a neutral effect on a portfolio and VaR would be low. This conclusion ignores other factors such as overall market sentiment since steep falls in certain shares or sectors have a consequent effect on the whole market.

Asset 3 is positively correlated and therefore there will be little positive gain from diversification. Both stocks appear to move together and so a change in price for one will be matched by a similar change in the other stock. Asset 4 shows no strong relationship with correlation around zero. There will be some benefit from diversification but this will not be as great as if the correlation were more strongly negative.

The formula for cell D84 uses the statistical function CORREL for correlation:

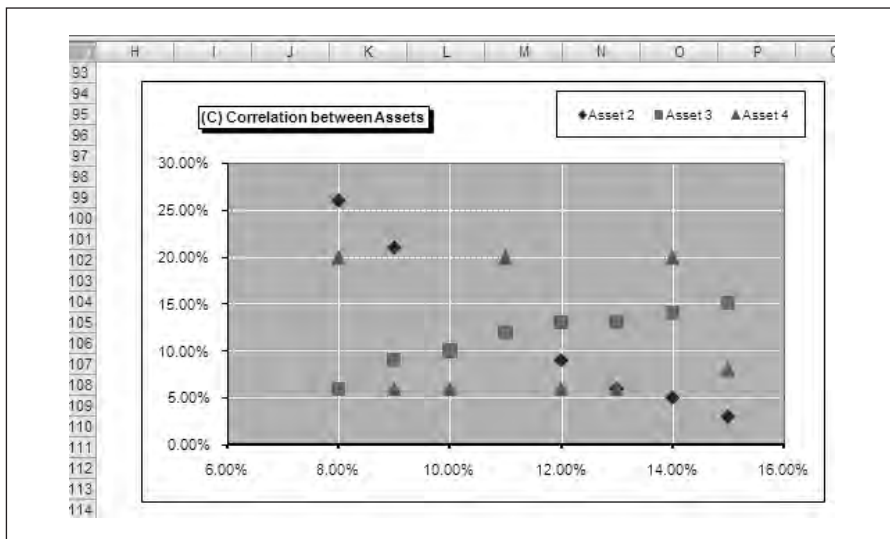
$$= \text{CORREL}(D74:D81, \$C\$74:\$C\$81)$$

The formulas for covariance and correlation are:

$$\begin{aligned} \text{Covariance} &= \{1/\text{No of observations}\} \\ &\quad * \text{Sum}\{(A - \text{Mean } A) * (B - \text{Mean } B)\} \\ \text{Correlation} &= \text{Covariance} / (\text{Std Dev } A * \text{Std Dev } B) \end{aligned}$$

Figure 14.14

Correlation



The VaR calculation is the standard deviation multiplied by the number of standard deviations for the confidence level of 95 per cent. Figure 14.14 shows the strong negative correlation on Asset 2 as a declining linear series while the positive correlation for Asset 3 is plotted as rising linear trend.

Portfolio VaR

The VaR for the whole portfolio required the standard deviation for the whole portfolio. Figure 14.15 brings forward the data from the last section for the volatility and correlation coefficients. The weightings for Asset 1 are inputs to show portfolios composed of 50 per cent of Asset 1 and a balance of Assets 2, 3 and 4. The first step is to compute the portfolio standard deviation. The formula is:

$$\begin{aligned} \text{Variance} &= (((W_A)^2) * (SDev_A)^2 + ((W_B)^2) * (SDev_B)^2 \\ &\quad + 2 * W_A * SDev_A * W_B * SDev * \text{Correlation}) \end{aligned}$$

where:

- W_A = weighting A
- $SDev_A$ = standard deviation A
- W_B = weighting B
- $SDev_B$ = standard deviation B
- $Correlation$ = correlation between the two assets.

Portfolio VaR

Figure 14.15

	A	B	C	D	E	F
115						
116	(D) Portfolio VaR					
117		Asset 1	Asset 2	Asset 3	Asset 4	
118						
119	Total Amount	1,000,000.00				
120	Asset 1 Weighting	50.00%	50.00%	50.00%	50.00%	
121	Standard Deviation	2.45%				
122						
123	Second security					
124	Standard Deviation	2.45%	8.05%	2.90%	7.07%	
125	Individual VaR	4.03%	13.25%	4.90%	11.63%	
126	Weighting	50.00%	50.00%	50.00%	50.00%	
127	Correlation coefficient	1.0000	(0.9270)	0.9602	(0.1165)	
128	Portfolio variance	0.06%	0.09%	0.07%	0.13%	
129						
130	Standard Deviation	2.45%	2.93%	2.69%	3.61%	
131	Number of Standard Deviations	1.6449				
132	Diversified VaR	4.03%	4.82%	4.42%	5.93%	
133	Amount	40,290.52	48,156.38	44,179.82	59,306.04	
134						
135	Undiversified VaR	4.03%	8.64%	4.46%	7.83%	
136	Amount	40,290.52	86,378.53	44,621.47	78,299.62	
137						
138	Variance	-	(38,222.14)	(441.65)	(18,993.58)	
139						

Portfolio mix with Assets 1 and 2

Figure 14.16

	A	B	C	D	E	F	G
138							
140	(E) Data Table: Diversified VaR against Undiversified VaR using Asset 2						
141							
142	Interval Across	10.0%					
143							
144		Diversified VaR	Amount	Undiversified VaR	Amount	Variance	
145		4.82%	48,156.38	8.64%	86,378.53	(38,222.14)	
146	0.0%	13.25%	132,466.53	13.25%	132,466.53	-	
147	10.0%	11.55%	115,495.03	12.32%	123,248.93	(7,753.90)	
148	20.0%	9.86%	98,550.13	11.40%	114,031.33	(16,481.20)	
149	30.0%	8.16%	81,648.39	10.48%	104,813.73	(23,165.34)	
150	40.0%	6.48%	64,823.57	9.56%	95,596.13	(30,772.56)	
151	50.0%	4.82%	48,156.38	8.64%	86,378.53	(38,222.14)	
152	60.0%	3.19%	31,894.90	7.72%	77,180.92	(45,286.03)	
153	70.0%	1.72%	17,228.95	6.79%	67,943.32	(50,714.37)	
154	80.0%	1.26%	12,557.65	5.87%	58,725.72	(46,168.07)	
155	90.0%	2.45%	24,491.89	4.95%	49,508.12	(25,016.13)	
156	100.0%	4.03%	40,290.52	4.03%	40,290.52	-	
157							

The portfolio standard deviation is multiplied by the number of standard deviations required and then by the total amount to derive the portfolio VaR. The undiversified VaR is simply the individual VaR multiplied by their weights, for example in cell D135:

$$\begin{aligned}
 &= \$C\$125 * D120!D125 * D126 \\
 &= [4.03\% * 50\%] + [13.25\% * 50\%] = 8.64\%
 \end{aligned}$$

The first column of Figure 14.15 had the same figure of 4.03 per cent since this assumes only Asset 1. The benefits from diversification appear in the next three columns where Asset 2 with the negative correlation obtains a reduced figure, whereas Asset 3 with positive correlation yields little benefit between the diversified and undiversified figures.

Figure 14.16 demonstrates how the risk increases as the more risky Asset 2 appears in the portfolio. The amounts on the left are the percentages of Asset 1. At a split of 20:80, diversified VaR increases to 9.86 per cent from 4.82 per cent.

THREE ASSET PORTFOLIO

The formula for standard deviation becomes more complex with more than two assets, and it is easier to use matrix methods to multiply out the correlations using the variance–covariance approach. This uses the function `MMULT` to multiply matrices as an array as shown in Figure 14.17. To calculate the product using the `MMULT` function (see Figure 14.18), enter both arrays and lock them with `$` symbols. Copy across and down to form the four squares for the result (see Figure 14.19) and then Control, Shift and Enter at the same time to enter the function. Array functions have to be entered in this manner or they will not work correctly.

The Three Asset sheet starts with an example of three assets together with their weightings and standard deviations. The correlation is shown as a matrix such that A:B is 0.6, A:C is 0.5 and B:C is 0.3 (see Figure 14.20). The number of standard deviations relates to the confidence level of 99 per cent.

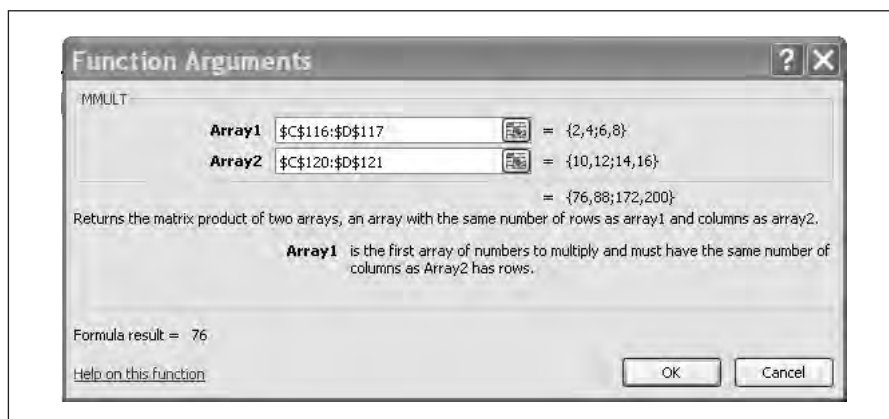
Figure 14.17

Matrices A and B

	A	B	C	D
113				
114	MMULT Example			
115				
116	A		2	4
117			6	8
118				
119				
120	B		10	12
121			14	16

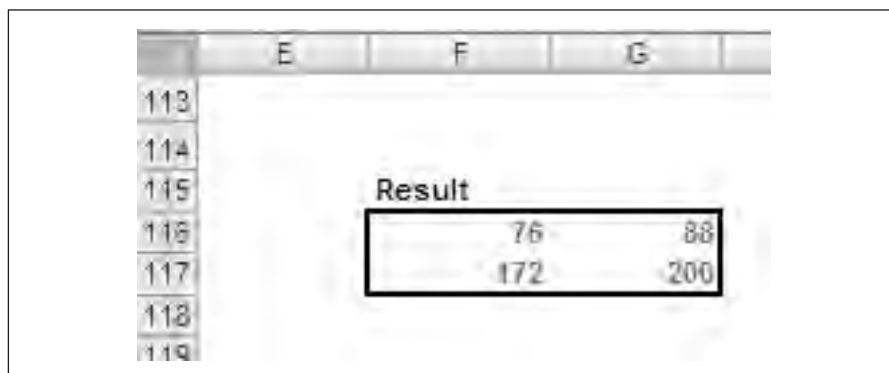
MMULT function

Figure 14.18



MMULT result

Figure 14.19



The first stage is to multiply the matrices for standard deviation and correlation using `MMULT` in the cells VC below. The formula is as below with the outer brackets denoting the array function:

```
{ =MMULT ($D$21:$F$23, $G$21:$I$23) }
```

Three asset input

Figure 14.20

	A	B	C	D	E	F
6	Value of portfolio			5,000,000		
7	Confidence level			99.00%		
8	Asset			A	B	C
9	Standard deviation			5.00%	2.00%	3.00%
10	Weighting			45.00%	25.00%	30.00%
11						
12	No of standard deviations			2.3263		
13						
14	Correlation matrix					
15		A	B	C		
16		1	0.6	0.5		
17		0.6	1	0.3		
18		0.5	0.3	1		

The VC matrix is then multiplied by the standard deviation matrix to form the VCV or Variance–Covariance matrix (see Figure 14.21). The covariance determines the relationship between two data sets.

Figure 14.21

VCV matrix

Portfolio VaR using Matrices			S Deviation (V)			Correlation		
			A	B	C	A	B	C
Variance * correlation	A		5.00%	-	-	1.00	0.60	0.50
	B		-	2.00%	-	0.60	1.00	0.30
	C		-	-	3.00%	0.50	0.30	1.00
VC * V			VC			VCV		
			A	B	C	A	B	C
	A		5.00%	3.00%	2.50%	0.25%	0.06%	0.08%
	B		1.20%	2.00%	0.60%	0.06%	0.04%	0.02%
	C		1.50%	0.90%	3.00%	0.08%	0.02%	0.09%

The third step is to multiply the VCV matrix by the weightings matrix and the answer in this example is 0.1 per cent (see Figure 14.22). Standard deviation is the square root and the VaR the product multiplied by the number of standard deviations, 2.32.

An alternative approach would be to calculate the undiversified VaR and then to include the correlation to calculate the diversified VaR. The undiversified VaR assumes the correlation is equal to one. The first stage is to multiply the matrices for the weightings and the standard deviation as per WV in Figure 14.23. The standard deviation is the sum of the elements and the VaR is the standard deviation multiplied by 2.32. The VaR is simply the amount multiplied by 7.27 per cent.

Figure 14.22

Portfolio VaR

Weighting * VCV			A B C			Weightings		
			0.15%	0.04%	0.07%			
WVCVW			0.10%			A	0.45	
Standard deviation			3.13%			B	0.25	
VaR			7.27%			C	0.30	
Value at risk			363,526.75					

To derive the diversified VaR, you multiply the WV matrix by the correlation matrix and this results in the UC matrix. You multiply out the UC matrix by the WV matrix using the function SUMPRODUCT as each matrix

has only one axis and the square root of this is the standard deviation. The standard deviation is then multiplied by the confidence and the amount to produce the VaR amount. The figure is the same as that produced by the first method. Again, this shows the benefits of diversification since the VaR reduces from 8.49 per cent to 7.27 per cent (see Figure 14.24).

Undiversified VaR

Figure 14.23

	A	B	C	D	E	F	G	H	I
86									
87		Undiversified VaR							
88		Weightings			Standard Deviation				
89		A	B	C	A	B	C		
90	Weightings	0.45	0.25	0.30	5.00%	-	-		
91					-	2.00%	-		
92					-	-	3.00%		
93	WV	2.25%	0.50%	0.90%					
94									
95	Standard Deviation	3.65%	=SUM(C93:E93)						
96	VaR	8.49%	=C95*D12						
97	VaR Amount	424,558.49	=C96*D6						

Diversified VaR

Figure 14.24

	A	B	C	D	E	F																	
98																							
99		Diversified VaR																					
100																							
101	Correlation matrix	<table border="1"> <thead> <tr> <th></th> <th>A</th> <th>B</th> <th>C</th> </tr> </thead> <tbody> <tr> <th>A</th> <td>1.00</td> <td>0.60</td> <td>0.50</td> </tr> <tr> <th>B</th> <td>0.60</td> <td>1.00</td> <td>0.30</td> </tr> <tr> <th>C</th> <td>0.50</td> <td>0.30</td> <td>1.00</td> </tr> </tbody> </table>					A	B	C	A	1.00	0.60	0.50	B	0.60	1.00	0.30	C	0.50	0.30	1.00		
	A	B	C																				
A	1.00	0.60	0.50																				
B	0.60	1.00	0.30																				
C	0.50	0.30	1.00																				
102																							
103																							
104																							
105	Undiversified * Corr			3.00%	2.12%	2.18%																	
106																							
107	SumProduct	0.10%	=SUMPRODUCT(C93:E93,D105:F105)																				
108	Standard deviation	3.13%	=SQRT(D107)																				
109	Diversified VaR	7.27%	=C108*D12																				
110	VaR Amount	363,526.75	=C109*D6																				
111																							

Problems

The normal distribution does not provide all the answers, and basic VaR models cannot capture all the facets of market risk. Some of the problems are as follows.

- Markets do not always behave normally. Empirical data suggests that markets deviate consistently from normal distributions. There are more observations clustered around the mean and there are more extreme

values possible. This is 'excess kurtosis' and causes problems with predicting values especially over short time horizons.

- Normal distributions assume randomness and do not take account of the 'herd' mentality. When markets are falling, there is often extra pressure to sell and this pushes the market more quickly to extremes.
- Liquidity and operational risks are not included in the calculation.
- Volatility is not constant since the future does not exactly equal the past. Whilst the models suggest that the future will follow average volatility, empirical evidence appears to show periods where volatility changes. This again has an effect on VaR, especially in the area of options pricing where the Black–Scholes formula prices options accordingly to past volatility.

SUMMARY

This chapter summarizes the main elements of value at risk (VaR) as a statistical measure of risk exposure. The measure attempts to provide a figure of potential losses over a time period at a given confidence level using as its basis normal distribution curves. The tool has assumed greater importance as banks try to allocate capital more efficiently and regulators seek to understand the individual and collective risk positions built up by institutions. The model builds up positions with one, two and three assets and shows the use of different methods and more advanced array functions in calculating each of the parameters of standard deviation and VaR.

Credit value at risk

.....
Introduction

.....
Portfolio approach

.....
Overview of components

.....
Single asset

.....
Two-bond portfolio

.....
Simulation

.....
Summary
.....

File: MRM2_15_01 and MRM2_15_02

INTRODUCTION

Credit value at risk (VaR) is the application of value at risk methodology to credit portfolios. Institutions traditionally have placed limits on individual clients in an effort to manage overall exposure. Portfolio managers similarly need to know just how much risk is contained in a portfolio of deals. In this context it is assumed:

- risk can be measured and analysed through probabilities and distributions;
- uncertainty consists of random events, which cannot easily be measured.

The advances in VaR methodology have shown that it is possible to produce models to quantify risk based on historic experience and assist managers in identifying potential areas of future risk. While credit modelling does not replace the intuitive judgement of experienced credit managers, a VaR approach may improve the understanding of marginal credit risk. The caveat is always that the future may not equal the past because of extreme or unexpected events. Credit VaR may allow an organization to consolidate credit risk across a company, industry or sector, and provides an amended VaR statement based on probabilities owing to:

- upgrades in value – improvement in the credit status of the underlying credit;
- downgrades in value – deterioration in the credit rating of the underlying credit;
- default – ultimate failure of the underlying credit.

The above takes into account that credit may deteriorate before ultimate failure. Loans generally exhibit signs of delinquency such as slow or missed payment before ultimate default. The aims of the method are:

- defining benchmarks for credit risk measurement as a common point of measurement for comparing different sources and measures of risk;
- promoting credit risk transparency and improved risk management tools for improving understanding and market liquidity;
- encouraging a regulatory capital framework that more closely reflects the economic risk associated with credit instruments;
- complementing other elements of credit risk management decisions, for example 'soft' factors.

With more in-depth understanding of a sector and its clients, an institution may be in a better position to predict economic downturns and the subsequent non-performing loans. This concentrates risk and leaves an institution open to cyclical downturns and therefore the ideal situation is to

build up specialist knowledge and then diversify risk using financial instruments. VaR methods identify:

- loans that produce the most risk;
- areas where credit derivatives can reduce the overall risk.

Institutions are now faced with taking more complex lending decisions. For example:

- credit spreads have narrowed in the last decade and banks now retain a greater percentage of their liabilities on their own books without syndication;
- the increase in the number and complexity of financial instruments has created uncertain and market sensitive exposures, which require more 'management' than traditional bonds;
- the increase in 'off balance sheet' special purpose vehicles;
- the increase in high yield 'junk' bonds and emerging markets with globalization is a significant factor;
- the deregulation and proliferation of institutions such as insurance companies offering credit.

Using VaR methodology is therefore a framework for evaluating credit derivatives and other credit transactions on a portfolio basis to provide a monetary value for risk.

PORTFOLIO APPROACH

Credit VaR is a framework for evaluating credit derivatives and other credit transactions on a portfolio basis. This is important for two reasons:

- credit risks for each client across a whole portfolio are included;
- correlations of credit quality are taken into account.

The benefits of diversification can be taken into account and quantified. This allows managers to quantify concentrations of risk to individual clients or groups of correlated clients, which can be mitigated through diversification or hedging. Furthermore, portfolios can be viewed along different dimensions such as industry, rating, country, type of instrument, etc.

The measures include both expected losses and VaR. This is uncertainty or volatility of value owing to changes in client quality across an entire portfolio and for marginal transactions, which occurs because of changes in credit events or 'migrations'.

Market risk and VaR are significantly different to credit risk. Market distributions are usually reasonably symmetrical and exhibit bell-shaped or

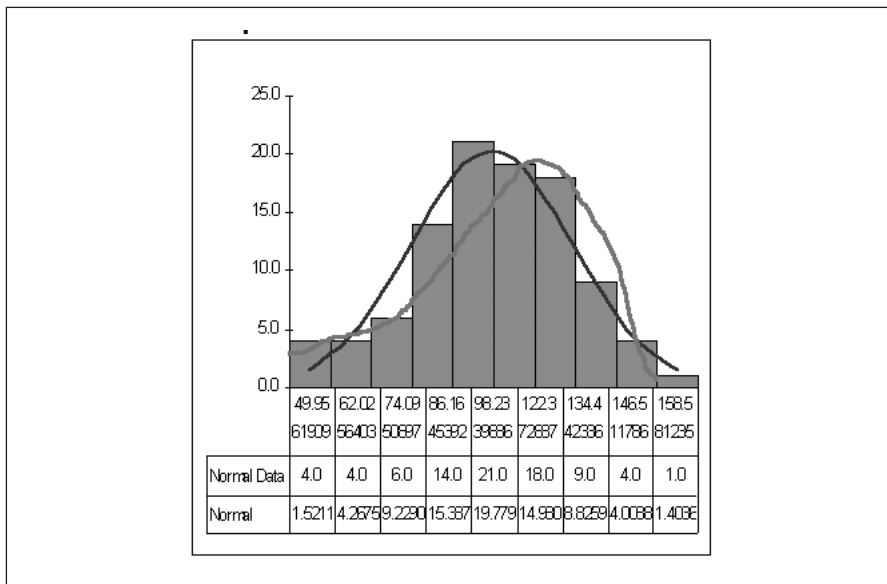
normal distributions. Credit portfolio values change little on upgrades and downgrades, but can be substantial on default. This remote possibility gives rise to skewed returns with long downside tails rather than standard normal distributions as shown in Figure 15.1.

Market VaR and other risk models look to a specific horizon and estimate risk across a distribution of estimated market outcomes. Credit VaR constructs a distribution of value given different credit outcomes. The challenge of modelling is not easy in practice since there are two distinct differences:

- Long tails, as in Figure 15.1, where there is a remote possibility of a big loss. More information is needed in addition to the mean (expected value) and standard deviation (volatility).
- Correlations in credit portfolios cannot be directly observed and must be derived indirectly from other sources.

Credit distribution

Figure 15.1



OVERVIEW OF COMPONENTS

As stated, Credit Metrics estimates portfolio VaR due to credit events that include upgrades, downgrades and default. The information comes from long-term estimates of migration in order to avoid bias and it is based on probability. This section provides an overview of the components:

- exposures and their distribution;
- VaR framework;
- correlations between individual exposures.

Components

The components are:

- Calculation of different exposure profiles and changes for each exposure type on a comparable basis.
- Derivation of the volatility of value due to credit quality migrations for each individual obligor (VaR framework). This is derived from a transition matrix where each migration results in a change in value. Each value outcome is weighted by its likelihood to create a distribution of value across each credit state from which the asset's expected value and volatility are calculated.
- Calculation of volatility of value due to credit quality migrations across a portfolio and estimation of correlation between the obligors. Individual value distributions are combined to yield a portfolio value, which requires the estimated correlation between the assets.

The sections below explain the principles using a portfolio model with one and then two bonds.

Outputs

The outputs of the model are:

- Standard deviation – this is the standard measure of symmetrical dispersion around the mean. As discussed earlier, standard deviation may not capture the full range of possibilities. The upside may be one standard deviation above the average, while the downside could be many standard deviations below the average.
- Percentile levels – these demonstrate the possibility that the portfolio value will fall below a specified level. In order to calculate percentiles, a full range of values must be computed, usually through a simulation technique such as Monte Carlo simulation. This allows a model to run through many scenarios and produce either a histogram or cumulative probability graph of possible outcomes.

SINGLE ASSET

This section follows the main calculations with a single asset in the Excel file called MRM2_15_01.xls.

Estimating credit exposure amounts

Many different types of instruments encompass credit risk where exposures vary. Variable exposures can change in a way that is related to upgrades and downgrades or because of non-credit-related market moves. These include receivables, bonds and loans. Therefore the features of the model are:

- likelihood (possibility) of credit quality changes;
- changes in value assessed against an exposure amount in the event of each credit quality change.

Receivables are non-interest-bearing debt or trade credit where the exposure is typically less than one year. The exposure on a floating rate note or loan will always be close to face value (par) but the value of fixed-rate bonds and loans moves with market interest rates. The risk horizon is the present value of the remaining coupons and principal and here one can use the yield curve for the category. Figure 15.2 shows yield curves for different credit categories denoted by credit ratings.

Estimating credit quality migrations

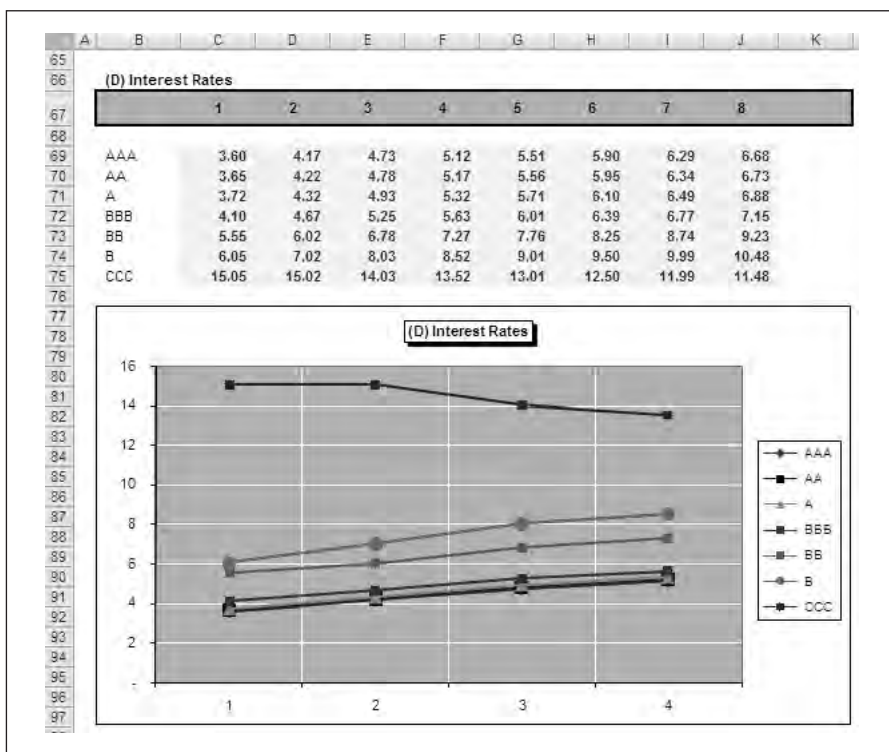
There are three key steps to calculating the volatility of value in a stand-alone credit exposure:

- estimating credit quality migrations from one grade to another using a transition matrix;
- estimating changes of value upon credit quality migration across grades;
- computing the distribution of resultant bond values.

Estimating credit quality migrations is based on upgrades, downgrades and defaults, which is represented by a transition matrix (see Figure 15.3). This shows the possibility of moving from one ratings band to another: for example, there is a 7.70 per cent chance that a BB will upgrade to BBB within a year. These matrices are published by the ratings agencies as a result of observing historical patterns and then applying smoothing techniques. These tables are on the Data sheet.

Figure 15.2

Interest rates



Estimating changes in value at the end of a forecast period involves revaluation, it follows, for each credit state that the possibilities are:

- upgrade
- downgrade
- default.

In default, the recovery rate depends on the seniority class, but there is great variation (volatility) within a class, as Figure 15.4 suggests. For upgrades and downgrades, the new value is simply the present value of the cash flows at the revised interest rates or yield. Thus, as interest rates go down the value of a bond rises.

Cumulative values show the varying experience of default between the different credit categories. The possibility of a CCC rating defaulting rises from 20 per cent to 45 per cent over a 10-year period (see Figure 15.5).

Computing the distribution of values consists of a probability-weighted value and standard deviation. Figure 15.6 shows a BBB bond together with its transition matrix and the bond values.

Transition matrix

Figure 15.3

	A	B	C	D	E	F	G	H	I	J	K
5											
6	(A) Transition Matrix										
7		AAA	AA	A	BBB	BB	B	CCC	Default	Check	
8											
9	AAA	90.80	8.30	0.70	0.10	0.10	-	-	-	-	100.00
10	AA	0.70	90.70	7.80	0.60	0.10	0.10	-	-	-	100.00
11	A	0.10	2.30	91.10	5.50	0.70	0.30	-	-	-	100.00
12	BBB	-	0.30	6.00	86.90	5.30	1.20	0.10	0.20	-	100.00
13	BB	-	0.10	0.70	7.70	80.50	8.80	1.00	1.20	-	100.00
14	B	-	0.10	0.20	0.40	6.50	83.50	4.10	5.20	-	100.00
15	CCC	0.20	-	0.20	1.30	2.40	11.20	64.90	19.80	-	100.00
16	Default										-
17											
18	Yield	4.00	4.50	4.70	4.90	5.00	12.00	14.00	-	-	
19	Recovery	53.00	53.00	51.00	51.00	38.00	32.00	17.00	-	-	
20	Uncertainty	26.00	26.00	25.00	25.00	24.00	20.00	11.00	-	-	

Default

Figure 15.4

	A	B	C	D	E	F	G	H	I	J	K
22											
23	(B) Seniority Class										
24		Mean %		Standard deviation %							
25											
26	Senior secured		53.00		26.00						
27	Senior unsecured		51.00		25.00						
28	Senior subordinated		38.00		24.00						
29	Subordinated		32.00		20.00						
30	Junior subordinated		17.00		11.00						

Cumulative default

Figure 15.5

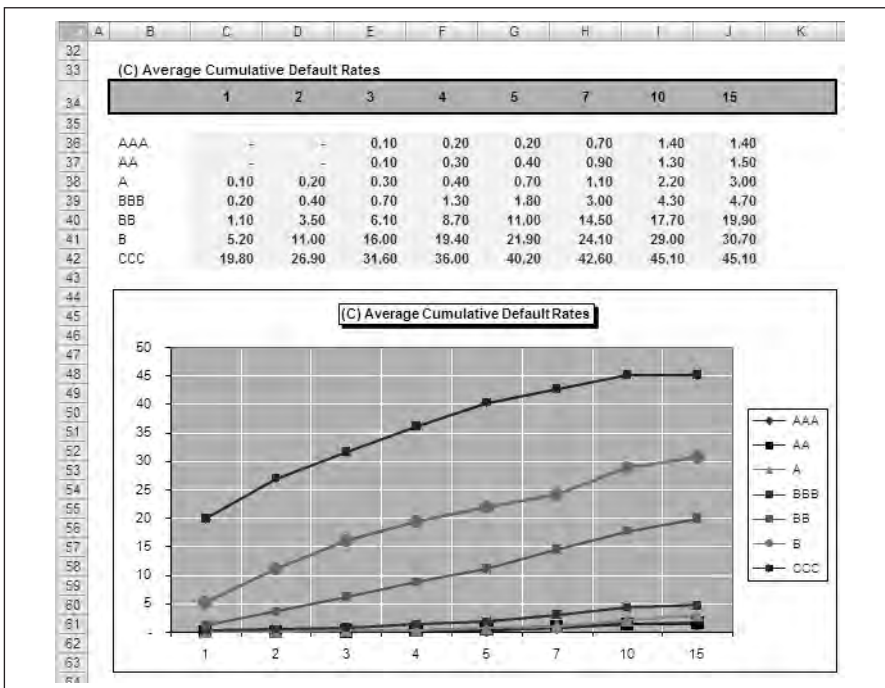


Figure 15.6

Distribution of value

	N	O	P	Q	R	S	T	U	V
39									
40					BBB				
41									
42		AAA	AA	A	BBB	BB	B	CCC	Default
43									
44		-	0.30	6.00	86.90	5.30	1.20	0.10	0.20
45									
46		109.35	109.17	108.64	107.53	102.01	98.09	83.63	51.00
47									

Single model

The sheet called 'Single' models the values starting with these inputs. The rating uses a combo box to highlight the available grades (see Figure 15.7). The redemption is 100 and the bond has four years to run, and on expiry the final coupon and principal is payable. The assumed coupon rate is 6 per cent.

Figure 15.7

Inputs

	A	B	C	D
4				
5		Rating:	BBB	
6		Required Confidence %:	95,000	
7		Issue Date:	1-Jan-10	
8		Settlement:	1-Jan-15	
9		Maturity 4 Years:	1-Jan-19	
10		Redemption Value:	100,000	
11		Coupon %:	6,000	
12		Yield to Maturity:	4,900	
13		Price:	0,000	
14		Bond Seniority:	Senior unsecured	
15		Coupons per Annum:	Annual	
16		Basis:	US (NASD) 30/360	
17				

The value of the bond is calculated using an interest rate table on the Data sheet (see Figure 15.8) and the values are looked up using an OFFSET function:

$$=OFFSET(Data!C68,Base!C115,0)$$

The individual values are present valued and added to complete the value of the bond.

$$=PV(G22/100,B22,0,-F22,0)$$

Interest rates

Figure 15.8

	A	B	C	D	E	F	G	H	I	J	K
65											
66											
67				(D) Interest Rates							
68				1	2	3	4	5	6	7	8
69	AAA		3.60	4.17	4.73	5.12	5.51	5.90	6.29	6.68	
70	AA		3.65	4.22	4.78	5.17	5.56	5.95	6.34	6.73	
71	A		3.72	4.32	4.93	5.32	5.71	6.10	6.49	6.88	
72	BBB		4.10	4.67	5.25	5.63	6.01	6.39	6.77	7.15	
73	BB		5.55	6.02	6.78	7.27	7.76	8.25	8.74	9.23	
74	B		6.05	7.02	8.03	8.52	9.01	9.50	9.99	10.48	
75	CCC		15.05	15.02	14.03	13.52	13.01	12.50	11.99	11.48	

The probabilities and yields are derived from the transition matrix on the Data sheet using `OFFSET` functions. The easiest way of calculating the bond values for each credit state is to use a data table based on the number of the rating. The inputs area uses a combo box to generate an index number for the bond. The workings area contains the data table which uses cell C115 as the column input and this approach saves the individual calculation of each of the values (see Figure 15.9).

```
{=TABLE(,C115)}
```

The calculation of standard deviation is thus shown in Figure 15.10.

Projected values

Figure 15.9

	A	B	C	D	E
113					
114					Bond Value 107.53
115		AAA		4	1 109.35
116		AA	BBB		2 109.17
117		A			3 108.64
118		BBB			4 107.53
119		BB			5 102.01
120		B			6 98.09
121		CCC			7 83.63
122		Default			
123					

The distribution of values shows the distinctive 'fat tail' represented by the 51 per cent recovery on default and the relatively small upside to the right of the BBB rating (see Figure 15.11).

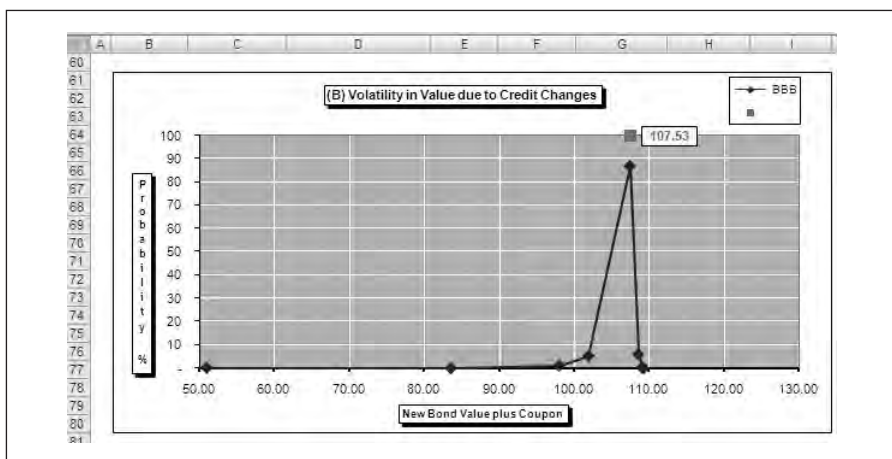
Figure 15.10

Calculation of standard deviation for a single bond

Number	Year End Rating	Probability %	Yield / Default Recovery	New Bond Value plus Coupon	Probability Weighted Value	Difference of Value from Mean	Probability Weighted Diff. ^2
1	AAA	-	4.00	109.3529	-	2.2934	-
2	AA	0.30	4.50	109.1724	0.3275	2.1129	0.0134
3	A	6.00	4.70	108.6430	6.5188	1.5835	0.1505
4	BBB	88.90	4.90	107.5309	93.4444	0.4715	0.1932
5	BB	5.30	5.00	102.0064	5.4063	(5.0531)	1.3533
6	B	1.20	12.00	98.0859	1.1770	(8.9726)	0.9883
7	CCC	0.10	14.00	93.8258	0.0836	(28.4337)	0.5491
8	Default	0.20	51.00	51.0000	0.1020	(58.0595)	8.2853
			100.00	107.5309	107.0595		9.5111

Figure 15.11

Distribution of values



Output

The probability-weighted value is the value at the interest rate for the grade multiplied by the probability of moving to the relevant credit state. The variance is a probability-weighted difference squared, which is 9.51 (see Figure 15.12). The standard deviation is the square root of the variance at 3.08.

The input confidence level was 95 per cent and therefore the number of standard deviations is 1.6449. This uses the NORMSINV function:

$$=NORMSINV(1 - (D53/100))$$

Standard deviation

Figure 15.12

	A	B	C	D
50				
51		Variance		9.5111
52		Standard Deviation		3.0840
53		Required Confidence		95.0000
54		No of Standard Deviations		(1.6449)
55		1.64 * Standard Deviation		(5.0777)
56		Price of 107.53 + Variance		102.46
57		5.00% Percentile		102.01

The standard deviation is multiplied by 1.6449 and subtracted from the current bond value of 107.53. This means that using standard deviation as the measure, there is a 5 per cent risk that the value of the bond will fall to 102.46.

It has already been stated that the distribution is not a normal bell curve. The 5 per cent percentile is found by looking up the rows of probabilities from the bottom of the table until 5 per cent is reached. In this case, the probabilities cross 5 per cent at BB, which gives a value of 102.01. This is lower than the standard deviation derived figure confirming the long down-side credit tails.

Column M adds the probabilities in column D starting with the 0.20 default (see Figure 15.13). The formula matches the required confidence of 5 per cent to the list in the range M40:M47. This is declining so the flag is set to -1 in the function.

```
=MATCH(100 - $D$53, $M$40:$M$47, -1)
```

The MATCH function finds the answer five and this is used as the row offset in the OFFSET function starting at cell F39. The answer returns as 102.01. Standard deviation overstates the value since it ignores the tail of default and there is a variance of 0.45 between the two results.

Office 2007 – Formulas, Function Library, Lookup & Reference (Excel 2003 – Insert, Function)

Estimating credit quality correlations and calculating portfolio risk

With one bond, there are only eight observable states or outcomes. With two bonds, the number rises to 64 (8^2) and with N bonds the number is 8^N . To derive the portfolio values, you have to estimate the probabilities of observing the combinations of values. This would be simple if all the values

were independent but, in the real world, the outcomes are not completely independent of each other. The correlations have to be estimated from empirical data such as actual rating and default correlations. The next section shows the modelling of a two-bond portfolio.

Figure 15.13

Cumulative probabilities

(B) Volatility in Value due to Credit Changes

Number	Year End Rating	Probability %	Yield / Default Recovery	New Bond Value plus Coupon	Percentiles
1	AAA	-	4.00	109.3529	100.00
2	AA	0.30	4.50	109.1724	100.00
3	A	8.00	4.70	108.8430	99.70
4	BBB	88.90	4.90	107.5309	93.70
5	BB	5.30	5.00	102.0064	6.80
6	B	1.20	12.00	98.0859	1.50
7	CCC	0.10	14.00	83.6258	0.30
8	Default	0.20	51.00	51.0000	0.20
			100.00	107.5309	102.01

TWO-BOND PORTFOLIO

The simple analysis above needs to be extended to portfolios containing many individual exposures. This worked example uses two bonds with these characteristics in the file MRM2_15_02.xls:

Figure 15.14

Inputs for two bonds

Reference	BBB	A
Amount:	1,000.0	1,000.0
Issue Date:	1-Jan-10	1-Jan-10
Settlement:	1-Jan-10	1-Jan-10
Maturity 5 Years:	1-Jan-15	1-Jan-13
Redemption Value:	100.000	100.000
Coupon %:	6.000	5.000
Yield to Maturity:	4.900	4.760
Price:	0.000	0.000
Required Confidence:	95.000	
Correlation:	0.000	
Bond Rating:	BBB	A
Coupons per Annum:	Annual	Annual
Basis:	US (NASD)	US (NASD)

- Bond #1: BBB rated, senior unsecured, 6% annual coupon, five-year maturity;
- Bond #2: A rated, senior unsecured, 5% annual coupon, three-year maturity.

The inputs are shown in Figure 15.14.

The process initially follows the same pattern as the single bond and then combines the values using joint probabilities. The steps are:

- estimating credit quality migrations using transition matrices;
- estimating changes of value upon credit quality migration;
- computing distribution of bond values;
- calculation of all possible portfolio values;
- calculation of joint probabilities;
- summation of a portfolio value;
- outputs – standard deviation and 5 per cent threshold value.

Bond prices

The model calculates the prices of two bonds using the interest rates and transition matrix on the Data sheet (see Figure 15.15). Controls are used as on the single bond to ease the inputs, and the workings are at the bottom of the schedule. More output is available and the schedule makes use of more advanced functions such as DURATION, MDURATION, COUPONDAYSNCD, COUPONNCD and ACCRINT.

Bond price calculations

Figure 15.15

	A	B	C	D	E	F	G	H	I	J
20										
21	(A) Price									Units \$'000
22	Weighting		50.00		50.00					
23	Clean price		104.7758		100.6565					Present value of coupons and principal
24	Coupon days		0 days		0 days					Days in this coupon period
25	Accrued interest at 6%		0.0000		0.0000					Simple interest based on number of days in coupon period
26	Dirty price		104.7758		100.6565					Clean price plus accrued interest
27	Price amount		104.776		100.657					Nominal value multiplied by amount
28	(B) Yield									
29	Current yield		5.7265		4.9674					Coupon/Price
30	Adjusted coupon yield		4.8148		4.7500					(Coupon - (Redemption - Clean) / Years to Maturity) / (Clean)
31	Yield to maturity		4.9000		4.7600					Calculated yield
32	(C) Duration									
33	Duration		4.4790 yrs		2.8598 yrs					Maturity: 5.00 years
34	Modified duration		4.2698 yrs		2.7300 yrs					Duration / (1 + (Yield / No of Coupons)) = Slope of series
35	Change in price per 0.5%		(2.2368)		(1.3739)					Duration * Price * [1 / (1 + Yld)] * 1%
36	(D) Dates									
37	Days to next coupon		360 days		360 days					Days remaining in this coupon period
38	Interest remaining		(5.0000)		(5.0000)					Interest still to be accrued in period
39	Ex dividend price		98.7758		95.6565					Clean price minus interest remaining in period
40	Next coupon date		1-Jan-11		1-Jan-11					
41	No of remaining coupons		5		3					Number until maturity
42	Total coupon amount paid		0.0000		0.0000					Coupon amounts paid since issue date
43	(E) Portfolio									
44	Price amount		205.432							Weighted amounts
45	Duration		3.6857 yrs							
46	Modified duration		3.5153 yrs							

Estimating credit quality migrations and changes in value

Figure 15.16 picks out the probabilities for each rating and then derives a probability-weighted bond value. The standard deviation at the 95 per cent level and the 95 per cent percentile are then calculated. This repeats the calculations in the previous section.

Figure 15.16

Bond BBB

Number	Year End Rating	Probability %	Yield / Default Recovery	New Bond Value plus Coupon	Probability Weighted Value	Difference of Value from Mean	Probability Weighted Difference $\times 2$	Percentage Probability	Standard Deviation
Bond BBB									
	Price			104.7756					
1	AAA	0.00	4.00	108.8036	0.0001	4.5488	0.0000	100.00%	9.51
2	AA	0.30	4.50	108.8860	0.3198	2.2301	0.0149	100.00%	4.75
3	A	8.00	4.70	105.8753	8.3405	1.3205	0.1046	99.70%	2.75
4	BBB	86.90	4.90	104.7756	91.0500	0.4208	0.1539	93.70%	1.53
5	BB	5.30	5.00	104.3295	5.5295	(0.0254)	0.0000	6.80%	(1.49)
6	B	1.20	12.00	78.3713	0.9405	(25.9835)	8.1017	1.50%	(2.17)
7	CCC	0.10	14.00	72.5354	0.0725	(31.8195)	1.0125	0.30%	(2.75)
8	Default	0.20	51.00	51.0000	(0.1020)	(53.3548)	5.6935	0.20%	(2.88)
				100.00	104.7756	104.3548	15.0811		
Variance				15.0811	=I65				
Standard Deviation				3.8834	=SQRT(I65)				
Required Confidence				95.0000	=D8I14				
No of Standard Deviations				(1.6401)	=NORMSINV(1+(D8J100))				
1.64 * Standard Deviation				(6.3877)	=D68*I27G				
Price of 100.66 + Variance				98.39	=D71+D8J26				
5.00% Percentile				104.33	=R65				

Using the chart in the overview section, the joint likelihood in the credit quality co-movements must be calculated. The objective is to show the probability-weighted value of the portfolio based on the transition matrices and subsequent changes in value. For simplicity, correlation is not included and is assumed to be zero. This means that movement in the rating of one bond has no bearing on the movement in price of another bond. In reality, price movements may be correlated and combinations of bonds lead to a reduced risk (volatility or standard deviation) for an optimized return.

The standard deviation and 5 per cent level are calculated using the same method as in the first section (see Figures 15.16 and 15.17).

Calculation of all possible portfolio values

Following the calculations for individual bonds, the values can be added across and down as shown in Figure 15.18. The values for Bond A are across and the values for Bond BBB are down. The values are a simple summation.

Bond A

Figure 15.17

Number	Year End Rating	Probability %	Yield / Default Recovery	New Bond Value plus Coupon	Probability Weighted Value	Difference of Value from Mean	Probability Weighted Difference *2	Percentage Probability	Standard Deviation
1	AAA	0.10	4.00	102.7751	0.1028	2.0277	0.0041	100.00%	6.18
2	AA	2.30	4.50	101.3745	2.3316	0.6271	0.0090	99.90%	3.09
3	A	91.10	4.70	100.8216	91.8485	0.0742	0.0050	97.60%	1.98
4	BBB	5.50	4.90	100.2728	5.5150	(0.4745)	0.0124	6.50%	(1.51)
5	BB	0.70	5.00	100.0000	0.7000	(0.7474)	0.0039	1.00%	(2.33)
6	B	0.30	12.00	83.1872	0.2496	(17.5602)	0.9251	0.30%	(2.75)
7	CCC	-	14.00	79.1053	-	(21.6421)	-	-	-
8	Default	-	51.00	51.0000	-	(49.7474)	-	-	-
		100.00		100.6565	100.7474		0.9596		
Variance		0.9596	=B80						
Standard Deviation		0.9796	=SQRT(B80)						
Required Confidence		95.0000	=SD\$14						
No of Standard Deviations		1.64	=NORMSINV(1-(D92/100))						
1.64 * Standard Deviation		1.5877	=D91*D93						
Price of 100.65 + Variance		99.05	=D94+*SE\$26						
5.00% Percentile		100.27	=R68						

All possible portfolio values

Figure 15.18

	AAA	AA	A	BBB	BB	B	CCC	Default
AAA	108.8036	211.6787	101.3745	100.8216	100.2728	100.0000	83.1872	79.1053
AA	108.5850	208.3601	207.9594	207.4085	208.8578	208.5850	188.7721	188.6903
A	105.6753	208.4504	207.0498	206.4969	205.9481	205.6753	188.8625	184.7806
BBB	104.7756	207.5507	206.1501	205.5972	205.0485	204.7756	187.9628	183.8809
BB	104.3285	207.1046	205.7040	205.1511	204.6023	204.3285	187.5167	183.4348
B	78.3713	181.1484	179.7458	179.1929	178.6442	178.3713	161.5585	157.4787
CCC	72.5354	175.3104	173.9098	173.3569	172.8082	172.5354	155.7225	151.6407
Default	51.0000	153.7751	152.3745	151.8216	151.2728	151.0000	134.1872	130.1053

Calculation of joint probabilities

There are eight possible outcomes for each bond, from default to AAA. This multiplies with two bonds to 2⁸ or 64 possible states. Thus 79.1659 in the middle of the table is the product of 91.1 per cent for A and 86.9 per cent for BBB (see Figure 15.19).

Joint probabilities

Figure 15.19

	AAA	AA	A	BBB	BB	B	CCC	Default
AAA	0.0001	0.0000	0.0000	0.0001	0.0000	0.0000	-	-
AA	0.3000	0.0003	0.0069	0.2733	0.0165	0.0021	0.0005	-
A	8.0000	0.0060	0.1380	5.4890	0.2300	0.0420	0.0180	-
BBB	86.9000	0.0869	1.9987	79.1659	4.7795	0.6083	0.2607	-
BB	5.2000	0.0053	0.1219	4.8283	0.2915	0.0371	0.0159	-
B	1.2000	0.0012	0.0276	1.0932	0.0660	0.0054	0.0036	-
CCC	0.1000	0.0001	0.0023	0.0911	0.0055	0.0007	0.0003	-
Default	0.2000	0.0002	0.0046	0.1822	0.0110	0.0014	0.0006	-

Row 113 uses the TRANSPOSE function to get the horizontal data for the second bond (see Figure 15.20).

{=TRANSPOSE(\$F\$79:\$F\$86)}

Figure 15.20

Audit trail of calculations

	AAA	AA	A	BBB	BB	B	CCC	Default
113		0.1000	2.3000	91.1000	5.5000	0.7000	0.3000	-
114	0.0001	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	-
115	0.0000	0.0000	0.0009	0.2733	0.0155	0.0021	0.0009	-
116	0.0000	0.0000	0.1300	5.4680	0.3300	0.0420	0.0180	-
117	0.0000	0.0009	1.9907	79.1659	4.7795	0.6083	0.2607	-
118	5.3000	0.0053	0.1219	4.8283	0.2915	0.0371	0.0159	-
119	1.2000	0.0012	0.0275	1.0932	0.0660	0.0084	0.0036	-
120	0.1000	0.0001	0.0023	0.0911	0.0055	0.0007	0.0003	-
121	0.2000	0.0002	0.0045	0.1622	0.0110	0.0014	0.0006	-

Summation of a portfolio value

The summation of portfolio values is the value multiplied by the probability. The value 162.6322 in cell F129 in the middle of the table (see Figure 15.21) is the value 205.4321 in cell F104 multiplied by the probability of 86.90 in cell F117.

The portfolio value is derived from the sum of all the probability weighted values and a variance against the initial portfolio value is given. This is the range D126 to K133 and adds up to 204.936 (see Figure 15.21).

Figure 15.21

Portfolio value

	AAA	AA	A	BBB	BB	B	CCC	Default
126	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	-	-
127	0.0006	0.0143	0.5968	0.0341	0.0043	0.0017	-	-
128	0.0125	0.2857	11.2871	0.6796	0.0884	0.0340	-	-
129	0.1804	4.1203	162.7629	9.8003	1.2457	0.4900	-	-
130	0.0110	0.2508	9.9053	0.5964	0.0758	0.0298	-	-
131	0.0022	0.0496	1.9589	0.1179	0.0150	0.0059	-	-
132	0.0002	0.0040	0.1579	0.0095	0.0012	0.0005	-	-
133	0.0003	0.0070	0.2766	0.0166	0.0021	0.0008	-	-
135	Portfolio value							
136	205.1024	=SUM(D126:K133)						
137	205.102	=(D126/SUM(D8:10,\$E\$10))+(100*(SUM(D36:\$E\$6))						
138	205.432	=D44						
139	205.432	=D44						
140								
141	10.330	=D137-D139						
142	10.330%	=(F141/D139)*100						

Outputs: standard deviation and 5 per cent threshold

The outputs comprise the standard deviation and the percentiles value. In both cases, the 95 per cent confidence value is used. Owing to the skew of credit curves, the values are slightly different (see Figure 15.22).

Outputs

Figure 15.22

	A	B	C	D	E	F	G	H	I
143									
144		VAR based on Correlation							
145		Interval	0.20						
146			(-0.40)	(-0.20)	(0)	(0.20)	(0.40)		
147		Portfolio variance	4.0102	3.2493	3.6296	4.0102	4.3906	4.7710	
148		Standard Deviation	2.0025	1.8026	1.9052	2.0025	2.0954	2.1843	
149		Required Confidence	95.0000	95.0000	95.0000	95.0000	95.0000	95.0000	
150		No of Standard Deviations	(1.6449)	(1.6446)	(1.6445)	(1.6449)	(1.6449)	(1.6449)	
151		1.64 * Standard Deviations	(3.2939)	(3.2950)	(3.1338)	(3.2939)	(3.4466)	(3.5928)	
152		(A) SD Value	202.1383	202.4671	202.2984	202.1383	201.9856	201.8384	
153		Revised Portfolio Value	202.138	202.467	202.298	202.138	201.986	201.839	
154		(B) Percentiles Value	205.1511	(0.2811)					
155		Revised Portfolio Value	205.151	(281)					
156									

The table uses the correlation in cell D15 across the top. The value in cell D15 is zero and so the schedule provides all the values for positive and negative correlation. The variance in cell D147 uses the formula:

$$(((\text{Weighting}_A)^2) * (\text{SDev}_A)^2 + ((\text{Weighting}_B)^2) * (\text{SDev}_B)^2 + 2 * \text{Weighting}_A * \text{SDev}_A * \text{Weighting}_B * \text{SDev} * \text{Correlation})$$

$$= (D22/100)^2 * D68^2 + (E22/100)^2 * D91^2 + 2 * (D22/100) * D68 * (E22/100) * D91 * D15$$

The standard deviation is the square root of variance, and the schedule multiplies out the 95 per cent confidence. The percentile value uses the workings table to the right to match the value along the cumulative probability (see Figure 15.23).

Offset table for cumulative percentiles

Figure 15.23

	A	B	C	D
110				
111		Joint Probabilities		
112		Percentiles		
113				
114		AAA	0.0001	91.10009
115		AA	0.3000	91.10000
116		A	6.0000	90.82670
117		BBB	86.9000	85.36070
118		BB	5.3000	6.19480
119		B	1.2000	1.36650
120		CCC	0.1000	0.27330
121		Default	0.2000	0.18220
122				205.15
123				

The formula in cell O122 uses OFFSET and MATCH. The OFFSET starts in cell C100 and moves right by the number in cell D238. This is three and

therefore the starting point is cell F100. The cumulative probabilities are in the range O114 to O121 and the match reads off the value five cells down in F105.

=OFFSET(OFFSET(C100,0,D238),MATCH(100-\$D\$14,O114:O120,-1),0)

Figure 15.24 shows the cluster of results around the 200 value. This is also evident in the second area chart with the peak between BBB and A (see Figure 15.25).

Figure 15.24

Combined values

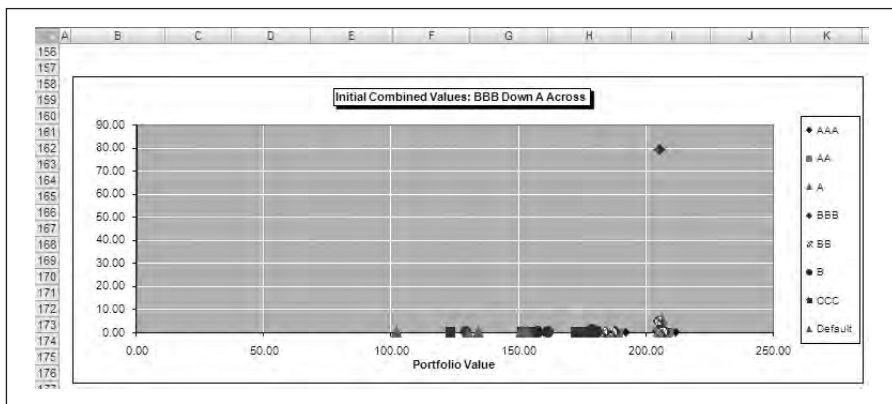
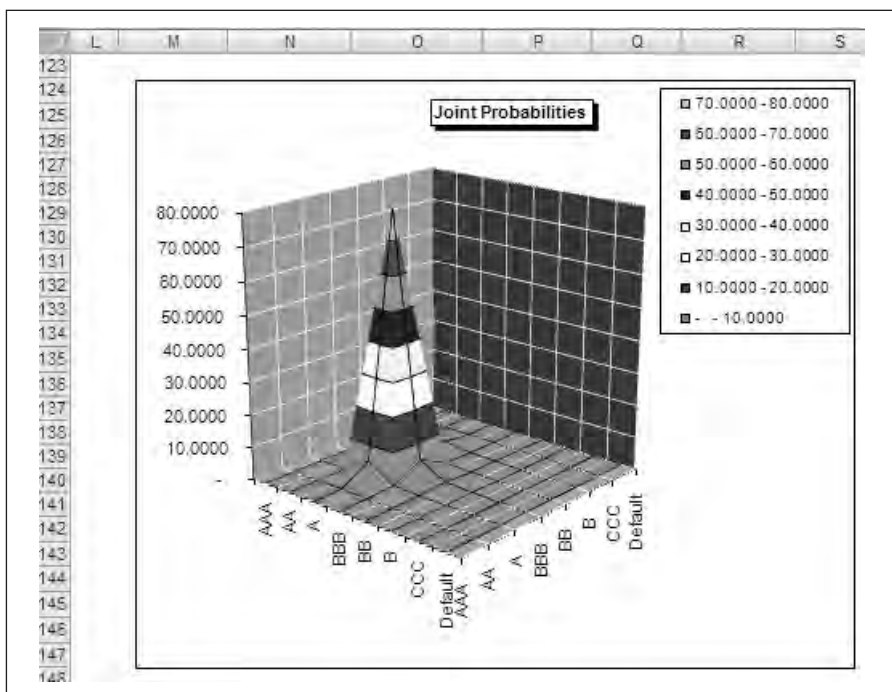


Figure 15.25

Portfolio chart



SIMULATION

The method outlined above works for one or two bonds, but large portfolios require a simulation approach and the use of specialized Excel add-ins such as @RISK or Crystal Ball. These generate random numbers with defined distributions and model large numbers of possible scenarios.

The Model_Simulation sheet calculates the values for each bond and then adds up the two values to form the portfolio value (see Figure 15.26).

Simulated bond value

Figure 15.26

	A	B	C	D	E	F	G
4							
5		Bond: BBB					
6		No	Random No	Standard Deviation	Grade	Rating	Value
7		1	0.3216	(0.4633)	4	BBB	104.7756
8		2	0.3504	(0.3843)	4	BBB	104.7756
9		3	0.2786	(0.5869)	4	BBB	104.7756
10		4	0.1558	(1.0120)	4	BBB	104.7756
11		5	0.2544	(0.6603)	4	BBB	104.7756
12		6	0.4809	(0.0980)	4	BBB	104.7756
13		7	0.0714	(1.4657)	4	BBB	104.7756
14		8	0.8538	1.0528	4	BBB	104.7756
15		9	0.6078	0.2737	4	BBB	104.7756
16		10	0.3037	(0.5139)	4	BBB	104.7756
17		11	0.2508	(0.8719)	4	BBB	104.7756
18		12	0.4367	(0.1943)	4	BBB	104.7756
19		13	0.5993	0.2514	4	BBB	104.7756
20		14	0.7743	0.7530	4	BBB	104.7756
21		15	0.4171	(0.2093)	4	BBB	104.7756
22		16	0.3113	(0.4922)	4	BBB	104.7756
23		17	0.8365	0.9803	4	BBB	104.7756
24		18	0.3639	(0.3479)	4	BBB	104.7756
25		19	0.8110	0.8815	4	BBB	104.7756
26		20	0.6381	0.3635	4	BBB	104.7756

The random numbers are generated by the macro:

```
=NORMSINV (C7)
```

A RAND function in the maths function library could have been used but this slows down the workbook. The standard deviation uses the NORMSINV function which returns the inverse of the standard normal cumulative distribution. The distribution has a mean of zero and a standard deviation of one and the input is the probability (see Table 15.1).

Table 15.1

Rating	Standard deviation
AAA	9.51
AA	4.75
A	2.75
BBB	1.53
BB	(1.49)
B	(2.17)
CCC	(2.75)
Default	(2.88)

The next row matches the standard deviation with the position on the list. For example, 0.8108 would read off as the fourth item in declining order. Column F provides the rating for the number using an `OFFSET` function. Therefore the further rating is a BBB.

```
=OFFSET(Data!$B$8,E10,0)
```

The value is also found by an `OFFSET` function using the values in range Model F56 to F63. This procedure is repeated for the second bond in columns H to N. Column O adds the two values and there are 1000 lines to provide a range of possible values.

The code for the random numbers is:

```
Sub Model_Simulation()

Dim RandomFactor, Count, StartA, StartB
Range("model_simulation!$C$6").Select

Application.ScreenUpdating = False
Application.Calculation = xlCalculationManual

For Count = 1 To 1000 'START OF LOOP
Application.StatusBar = "Generating random
numbers - " & Count
ActiveCell.Offset(1, 0).Select
ActiveCell.FormulaR1C1 = Rnd
ActiveCell.Offset(0, 5).Select
ActiveCell.FormulaR1C1 = Rnd
ActiveCell.Offset(0, -5).Select
Next Count 'END OF LOOP

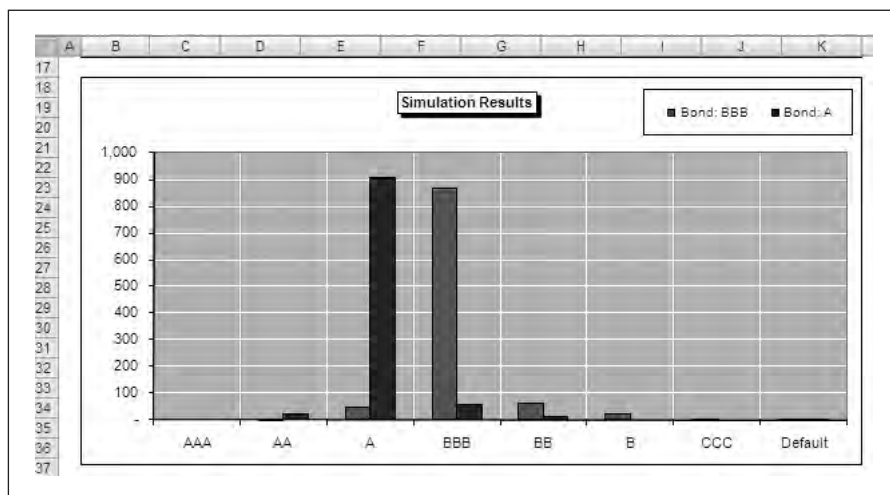
Application.StatusBar = False
Application.ScreenUpdating = True
Application.Calculation= xlCalculationSemiautomatic

End Sub
```

The Simulation_Results sheet illustrates the results of 1000 scenarios using random number generation (see Figure 15.27). Most of the results reflect the current rating of the bond as A or BBB. The histogram counts the number of results in each sector to show the peaks for each of the bonds. This is a FREQUENCY function entered as an array using Control and Enter together.

Simulation results

Figure 15.27



Bond BBB shows 866 results remaining at the same rating against the theoretical value of 869 for each 1000. Similarly Bond A shows 905 against 910. The results of course will vary with each run because of the random numbers. Therefore the results with 1000 scenarios are close to the transition matrix.

The next stage is to combine the results to show the portfolio results in values and percentiles. Figure 15.28 shows the values for each bond at a number of confidence levels and then the combined value. The statistics are:

- mean – simple arithmetic average;
- median – number in the middle of a set of numbers: that is, half the numbers have values that are greater than the median, and half have values that are less;
- mode – most frequently occurring value;
- skew – degree of asymmetry of a distribution around its mean (a positive skew indicates a distribution with an asymmetric tail extending towards positive values; a negative skew indicates a distribution with an asymmetric tail extending towards negative values);

- kurtosis – a relative peak or flatness of a distribution compared with the normal distribution (positive kurtosis indicates a relatively peaked distribution; negative kurtosis indicates a relatively flat distribution);
- percentiles to show the spread of values; again an array function.

{=PERCENTILE(Model_Simulation!\$N\$7:\$N\$1006,\$C\$50:\$C\$68)}

Figure 15.28

Bond statistics

	A	B	C	D	E	F	G	H	I	J
40	Bond Portfolio Percentiles									
41		Bond: BBB			Bond: A			Portfolio	Difference	% Diff
42		Initial Value		104.78		100.66		205.43		
43		Mean		104.13		100.69		204.82	(0.61)	(0.30%)
44		Median		104.78		100.82		205.60	0.17	0.08%
45		Mode		104.78		100.82		205.60	0.17	0.08%
46		Skew		(7.31)		(22.11)		(5.14)		
47		Kurtosis		59.14		491.13		78.72		
48		Interval	5.0%							
49		Percent	100.0%							
50		95.0%	104.78			100.82		206.15	0.72	0.35%
51		90.0%	104.78			100.82		205.60	0.17	0.08%
52		85.0%	104.78			100.82		205.60	0.17	0.08%
53		80.0%	104.78			100.82		205.60	0.17	0.08%
54		75.0%	104.78			100.82		205.60	0.17	0.08%
55		70.0%	104.78			100.82		205.60	0.17	0.08%
56		65.0%	104.78			100.82		205.60	0.17	0.08%
57		60.0%	104.78			100.82		205.60	0.17	0.08%
58		55.0%	104.78			100.82		205.60	0.17	0.08%
59		50.0%	104.78			100.82		205.60	0.17	0.08%
60		45.0%	104.78			100.82		205.60	0.17	0.08%
61		40.0%	104.78			100.82		205.60	0.17	0.08%
62		35.0%	104.78			100.82		205.60	0.17	0.08%
63		30.0%	104.78			100.82		205.60	0.17	0.08%
64		25.0%	104.78			100.82		205.60	0.17	0.08%
65		20.0%	104.78			100.82		205.60	0.17	0.08%
66		15.0%	104.78			100.82		205.60	0.17	0.08%
67		10.0%	104.78			100.82		205.15	(0.28)	(0.14%)
68		5.0%	104.33			100.27		205.05	(0.38)	(0.19%)
70		<hr/>								
71		Lower Percentiles								
72		5.0%	104.33			100.27		205.05	(0.38)	(0.19%)
73		4.0%	104.33			100.27		204.78	(0.66)	(0.32%)
74		3.0%	104.33			100.27		204.77	(0.66)	(0.32%)
75		2.0%	78.37			100.27		179.19	(26.24)	(12.77%)
76		1.0%	78.37			100.00		179.19	(26.24)	(12.77%)

Figure 15.29 shows the percentiles chart of bond values.

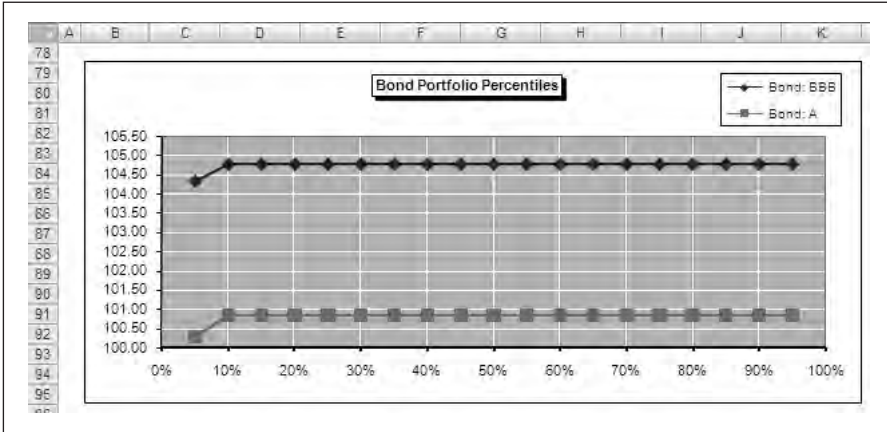
Figure 15.30 is the combined values and the count of occurrences with the histogram showing a peak at A and BBB with 786 of the possible results. The combined values table is brought forward from the Model sheet so that there is a portfolio value for each possible eventual value. In the bottom right-hand corner at cell K107 is the result if both bonds default and the recovery is around 50 per cent. Here the portfolio is worth 102.26. The next table uses a COUNTIF function to count the values if the values equal the combined amount in the table. In cell F115, the function counts

the number of results in column O that concur with the value 205.59 in cell F103. This is approximately 800.

=COUNTIF (Model_Simulation!\$O\$7:\$O\$1006, F103)

Bond values chart

Figure 15.29



Histogram of values

Figure 15.30

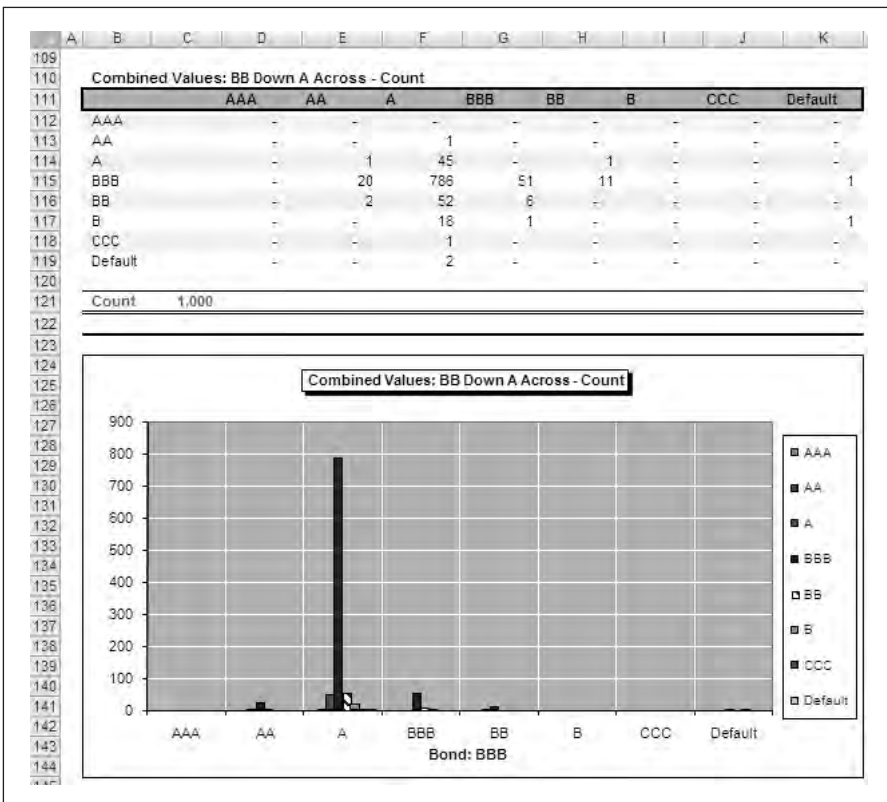
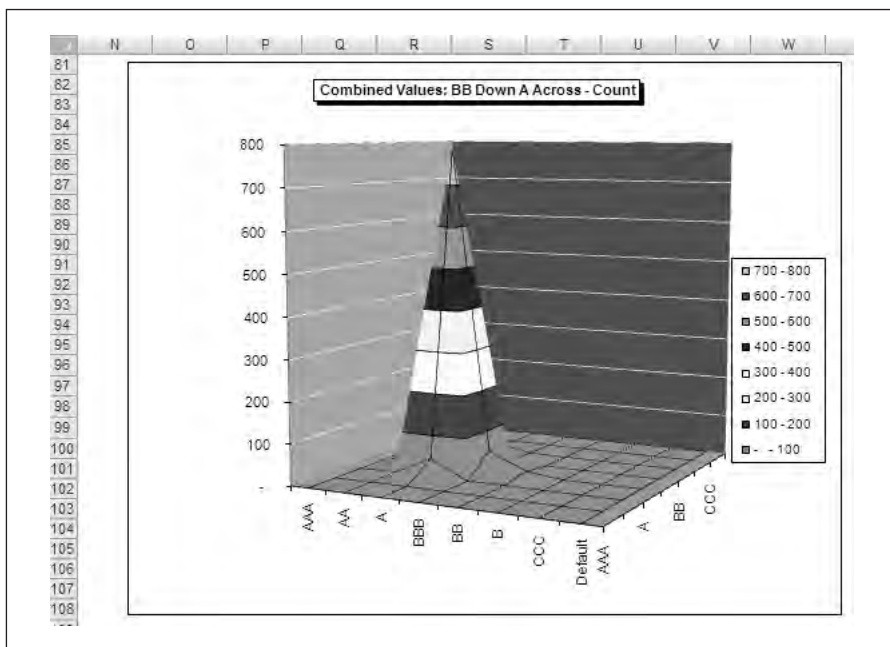


Figure 15.31 is an alternative view of the histogram values showing the peak at the intersection of BBB and A together with the tail of values to default.

Figure 15.31

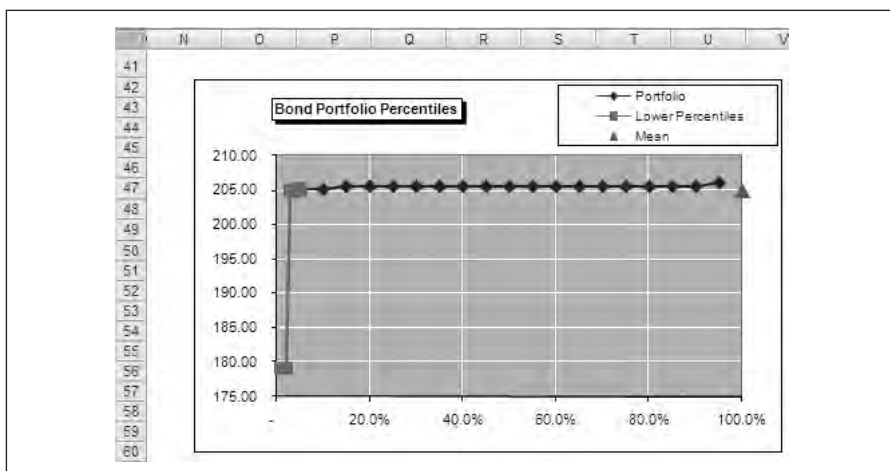
Portfolio result



Figures 15.32 and 15.33 plot the values and probabilities, to show first the values and second the cumulative probability as percentages.

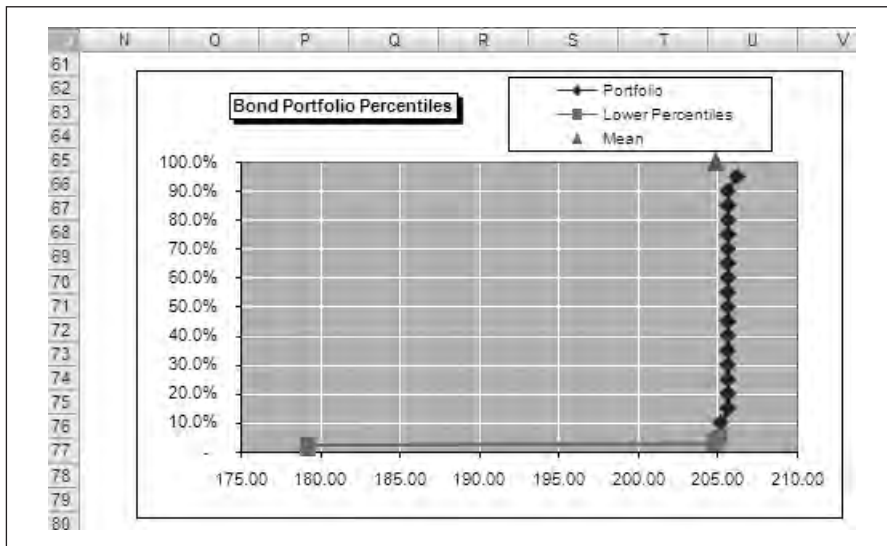
Figure 15.32

Cumulative values



Cumulative probability chart

Figure 15.33



SUMMARY

Credit value at risk is a methodology for encompassing both default and the upgrades and downgrades, and produces value at risk scores for portfolios. The method is flexible for a number of different credit exposures, and this chapter has illustrated the main principles using a simple portfolio model with one and then two bonds. The main elements are:

- exposures and their distributions;
- the possibility of upgrade, downgrade and default;
- the calculation of a monetary value at the five percentile for a possible portfolio value at the end of a timeframe.

Using this approach provides a framework for considering risk as a monetary value across portfolios and industries, and it gives decision makers more information for setting credit limits and managing risk capital.

Software installation and licence

The appendix contains:

- system requirements
- installation
- accessing the application files
- licence
- file list.

A CD containing the Excel files and templates accompanies this book. The CD contains example files only and complete versions are available for purchase at www.financial-models.com. The file names relate to their chapter numbers and you should refer to the file list. The file notation is MRM2 and then the chapter number. For completeness, the files for a particular chapter are quoted at the beginning of each chapter.

Follow the instructions below to install the files and create a program group using the simple SETUP command.

SYSTEM REQUIREMENTS

This section summarizes the requirements for using the application:

- IBM-compatible personal computer;
- hard disk with 20Mb of free space;
- Microsoft Mouse or other compatible pointing device;
- EGA, VGA or compatible display (VGA or higher is recommended);
- Microsoft Windows and Excel 2003 or later.

INSTALLATION

- Insert the CD into your CD-ROM drive.
- Select the Start button in the bottom left of your screen.
- Select Run.

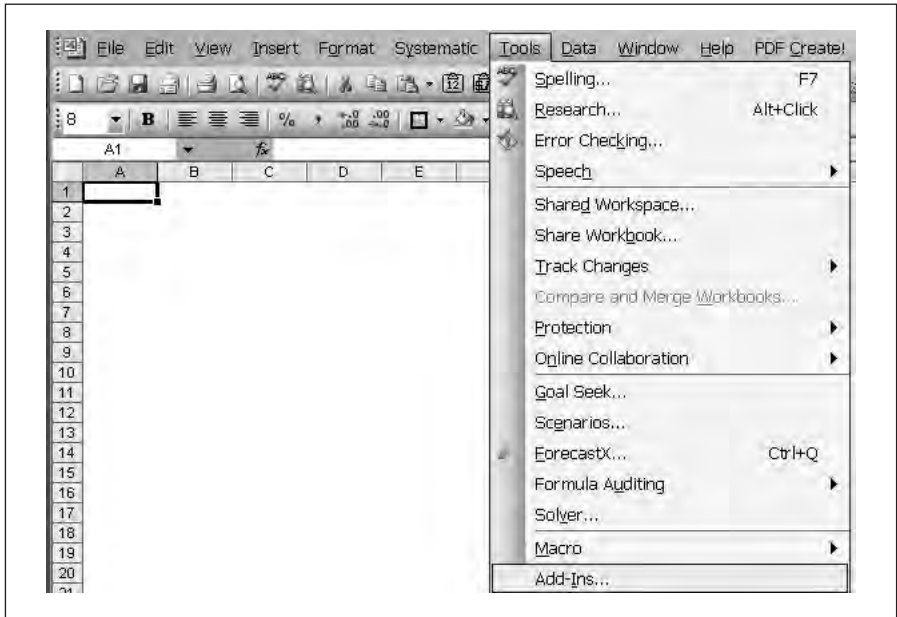
- Write in the space provided: D:\SetUp.exe where D is your CD-ROM drive. (If this is not correct for your machine then change the letter accordingly.)
- The application will now install itself. Follow the instructions on-screen to select a destination directory.
- If you are prompted, please restart Windows.
- If you encounter any errors due to insufficient privileges for installing software on your machine, the files are also available in an uncompressed form in the CD_Files directory.

When the installation has finished, open Excel and select Tools – Add-ins. You need to make sure that Analysis Toolpak and Solver are selected. This is because the files use some of the advanced functions such as EDATE and XNPV or Solver routines. Analysis Toolpak is often not installed using a typical installation. If this is the case, use your original Office disks to install the missing option.

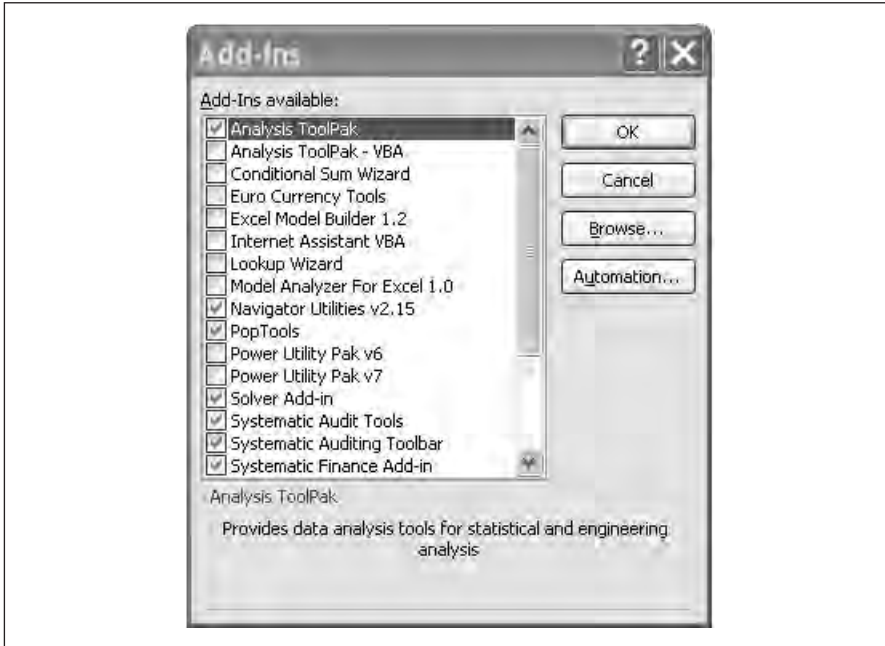
Office 2007 – Office Button, Excel Options, Add-ins, Excel Add-ins

Figure A1.1

Tools Add-ins



This Toolpak contains extra statistical and financial functions needed by the applications. Click it to select it and press OK. If you do not select it, you will encounter errors on certain files.

Analysis Toolpak**Figure A1.2****ACCESSING THE APPLICATION FILES**

- You will see that a program group has been created for you. The application will also now appear under Programs on the Start Menu.
- When installed, the program group should include all the files on the accompanying file list.
- To access any of the files, simply double-click the icons in the program group.
- You can also open a ReadMe file of installation instructions and a file list.
- Press OK to continue and the selected file will open.
- There is a master file list in the form of an Excel model and a list within the book.

LICENCE

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1	Overview	MRM2_01
2	Review of model design	MRM2_02
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7	Credit risk	MRM2_07
8	Equity valuation	MRM2_08
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13	Risk management	MRM2_13
14	Value at risk	MRM2_14
15	Credit risk and credit metrics	MRM2_15_01 MRM2_15_02

The above files comprise templates and files to allow you to practise building the finished spreadsheets rather than use or modify existing files. This is to allow you to learn by doing and thereby increase your own skill level. Complete versions are available for purchase at www.financial-models.com.

Microsoft Office 2007 (Office 12)

This appendix provides an introduction to Microsoft Office 2007 (Office 12) to show the differences in the menus and commands. Office 2007 marks a substantial departure from earlier versions of Office and attempts to make the menus, toolbars and options more accessible. This appendix provides an overview and some screenshots of the menu ribbon at the top of the screen. There is also a function reference on the disk (MRM2_Office_2007_Menu).

MICROSOFT OFFICE USER INTERFACE OVERVIEW

The whole Office interface has been redesigned to contain more features and new file formats. Microsoft explains that most Office users accessed only 8 to 10 per cent of the functions on the many toolbars and menus in previous versions of the applications, because most of the program's features were buried in layers of menus and sub-menus. In response, Microsoft has placed the functions on a single, changeable ribbon to make them more visible, and thus more likely to be used. The result is a user interface that should make it easier for people to get more out of Microsoft Office applications so they can deliver better results faster. Microsoft Office Word 2007, Office Excel 2007, Office PowerPoint 2007 and Office Access 2007 will feature a similar workspace to offer the same style across the Office family.

KEY FEATURES

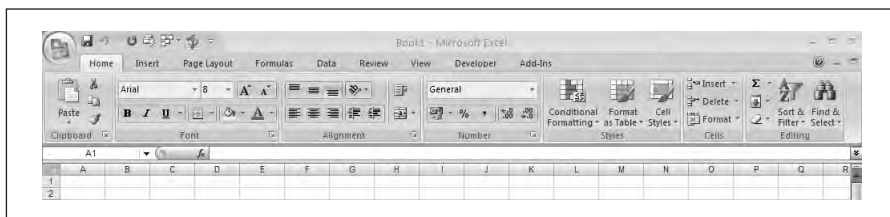
In previous releases of Microsoft Office applications, people used a system of menus, toolbars, task panes, and dialog boxes to get their work done. This system worked well when the applications had a limited number of commands. Now that the programs do so much more, the menus and toolbars system does not work as well. Too many program features are said to be too hard for many users to find. For this reason, the overriding design goal for the new user interface is to make it easier for people to find and use the full range of features these applications provide. The result should be better performing applications in Word, PowerPoint, Access and Excel.

THE RIBBON

The previous menus and toolbars have been replaced by the Ribbon, which presents commands organized into a set of tabs. The tabs on the Ribbon display the commands that are most relevant for each of the task areas in Office Word 2007, Office PowerPoint 2007, Office Excel 2007, or Office Access 2007.

Figure A2.1

Home screen



CONTEXTUAL TABS

Certain sets of commands are only relevant when objects of a particular type are being edited. For example, the commands for editing a chart are not relevant until a chart appears in a spreadsheet and the user is focusing on modifying it. In earlier versions of Office, these commands could be difficult to find. In Office Excel 2007, clicking on a chart causes a contextual tab to appear with commands used for chart editing. Contextual tabs only appear when they are needed and make it much easier to find and use the commands needed for the operation at hand.

GALLERIES

Galleries provide users with a set of clear results to choose from when working on their document, spreadsheet, presentation, or Access database. By presenting a simple set of potential results, rather than a complex dialog box with numerous options, Galleries simplify the process of producing professional looking work. The traditional dialog boxes are still available for those wishing a greater degree of control over the result of the operation.

LIVE PREVIEW

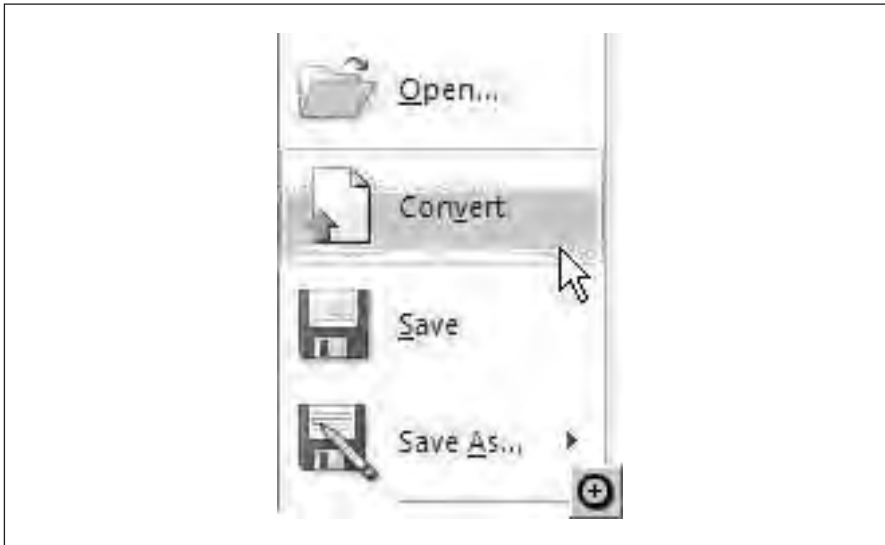
Live Preview is a new addition that shows the results of applying an editing or formatting change as the user moves the pointer over the results pre-

sented in a Gallery. This new capability simplifies the process of laying out, editing and formatting so users can create excellent results with less time and effort.

MIGRATION

Conversion

Figure A2.2



Office 2007 uses different file formats to Office 2003 primarily owing to the switch to XML file formats as the defaults in Word, Excel, and PowerPoint. Office 2007 applications can open and work on files created in previous releases back to Office 97, and you will be able to create files in all existing Office formats. However, to take full advantage of the smaller file sizes and other benefits of Office 2007, you are forced to use the new XML formats: .docx in Word, .xlsx in Excel, and .pptx in PowerPoint. In fact, saving files in older Office formats is not possible in the 'Save as' dialog box; instead, you must choose Convert from the new Office button, and Convert appears on the resulting drop-down menu only when a non-XML file is open.

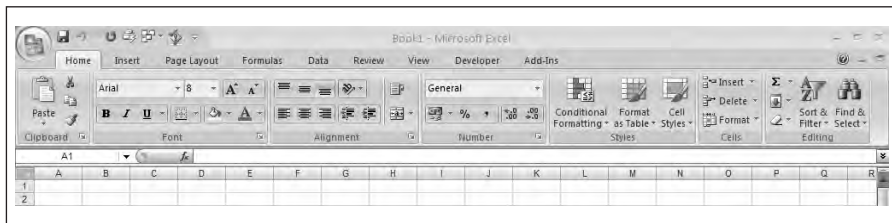
1 OFFICE MENUS – HOME

The screen below shows the difference in the menu commands starting with Home. To open, modify or print a document you click the Office icon in the top left. Home provides all cell formatting currently on the Formatting

toolbar and under Edit. The elements on the right such as conditional formatting, tables and styles are currently found under Format.

Figure A2.3

Home screen

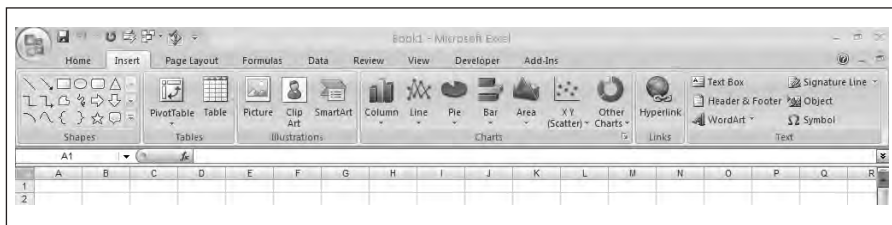


2 INSERT

This screen combines further toolbars and options: Shapes are currently on the Drawing toolbar, Pivot tables are under Data and Charts can be found on the Insert menu. These commands all insert objects on the spreadsheet so the new Office ribbon brings them together here. Where you see a triangle on the Ribbon item, further menus open out with options. When you click these buttons, they open to reveal further options. For example, inserting a column chart opens up all the variants of column charts or you can open a dialog box with all charts similar to the 2003 menus.

Figure A2.4

Insert

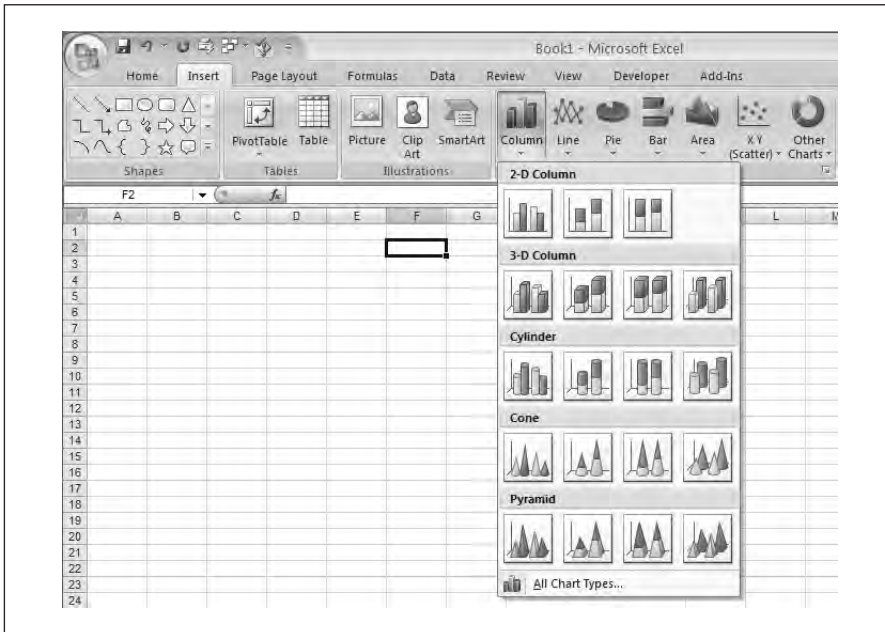


3 PAGE LAYOUT

The menu brings together all the layout commands from the different Excel 2003 menus. All the commands relate to the layout of individual sheets. Print comments are currently on the File menu while Custom Views are as on View. Commands such as Bring to Front are on the drawing menu.

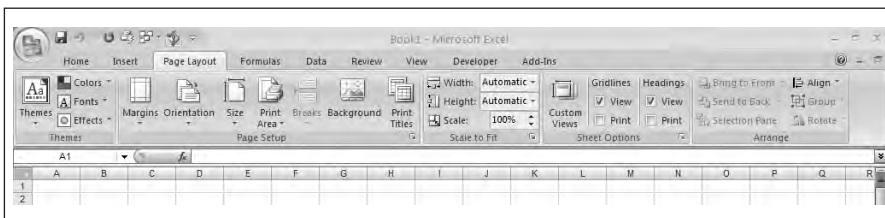
Sub-menu

Figure A2.5



Page layout

Figure A2.6

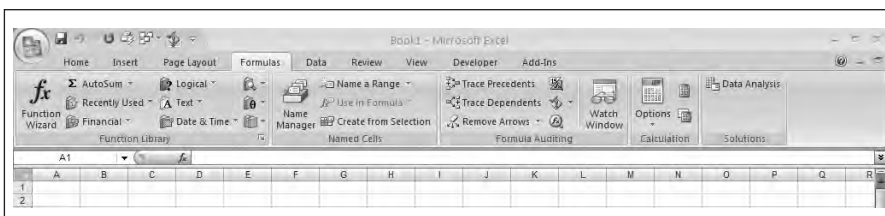


4 FORMULAS

Inserting formulas in Excel 2003 can be complex when you need to find one of the 300 different functions. This menu helps with functions arranged in categories and elements of the auditing toolbar together. Commands such as Evaluate Formula and Watch Window allow you to trace commands and understand the process of calculation and result. Currently the audit commands are hard to find; this layout tries to make them more accessible.

Formulas

Figure A2.7

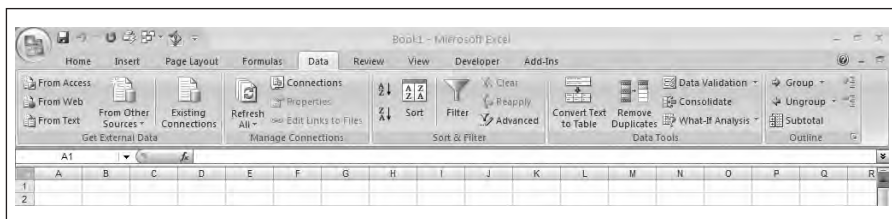


5 DATA

The Data menu contains some of the 2003 commands menu such as Connections and Data Validation. Sorting and Filtering is also on Data. ‘What if’ analysis such as Data Tables, Scenarios and Goal Seek is a Tools option on Excel 2003. These are key commands for risk and variance analysis in Excel. The commands for linking data and workbooks are also here since Excel works well with Access databases and other external sources.

Figure A2.8

Data

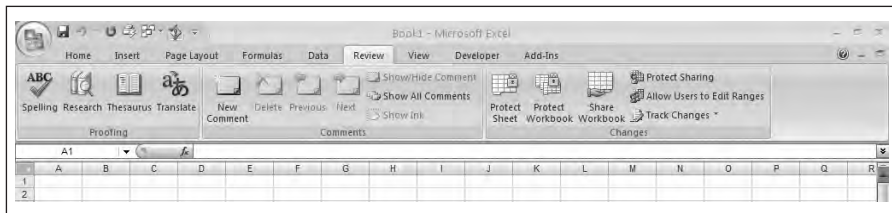


6 REVIEW

Reviewing includes Tools options such as spelling and protection together with Comments from the Insert menu. The idea is to use this set of commands when the initial workbook has been written. Good practice includes annotating and commenting cells, together with protecting formula cells against unauthorized changes.

Figure A2.9

Review

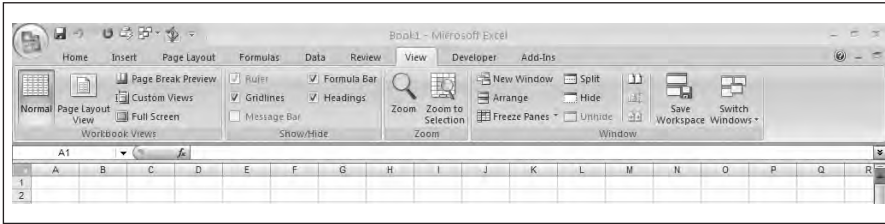


7 VIEW

There are a number of tools for changing the appearance of Excel such as gridlines, formula bar, etc, which can be found in Tools Options or View on earlier versions. Again, these are all the commands that stipulate the viewing of Excel, many of which are currently found under Window.

View

Figure A2.10

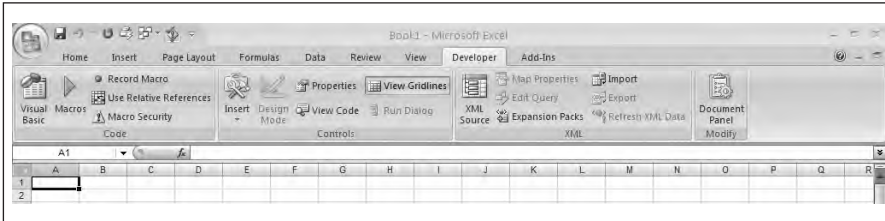


8 DEVELOPER

The Developer options are not available unless you click the box using the Options tab below. This allows you to record macros and make use of extended possibilities in Visual Basic. Macros are currently on the Tools menu or the Visual Basic toolbar and this option brings all the commands together.

Developer

Figure A2.11



Excel options

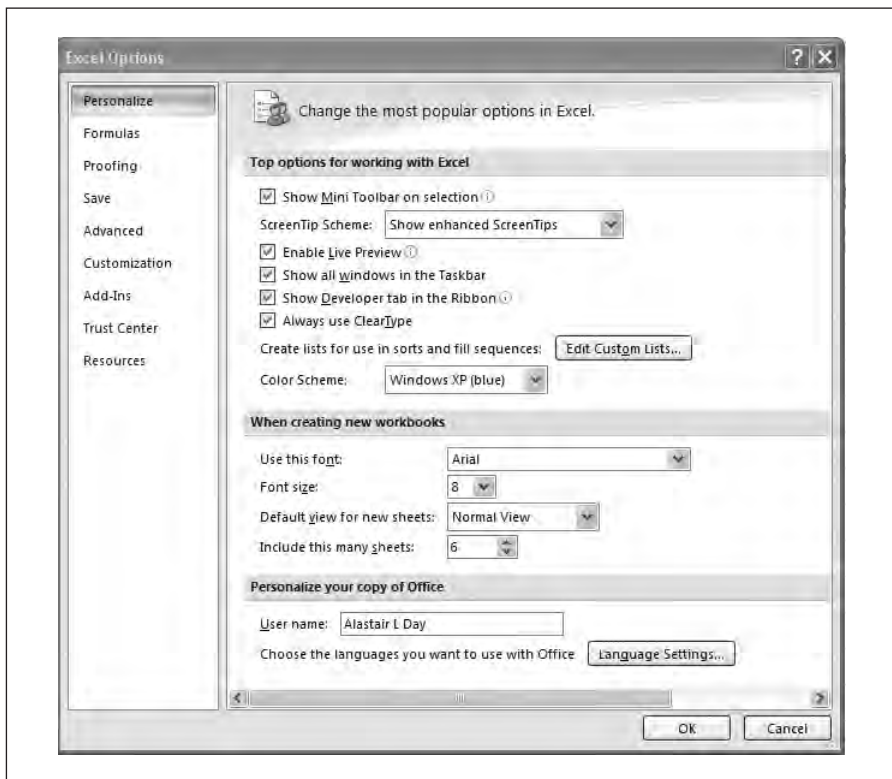
Figure A2.12



You need to tick the box below and the extra option appears on the Ribbon.

Figure A2.13

Show Developer toolbar

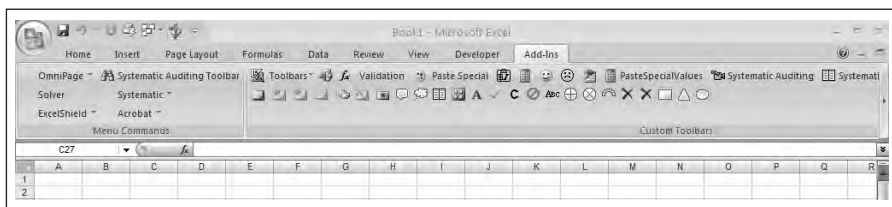


9 ADD-INS

On Excel 2003, you select add-ins with Tools and Add-ins. In Office 12 this is a separate option and you choose the add-ins with the options below. Tool bars open out when you select the add-ins such as Solver.

Figure A2.14

Add-ins

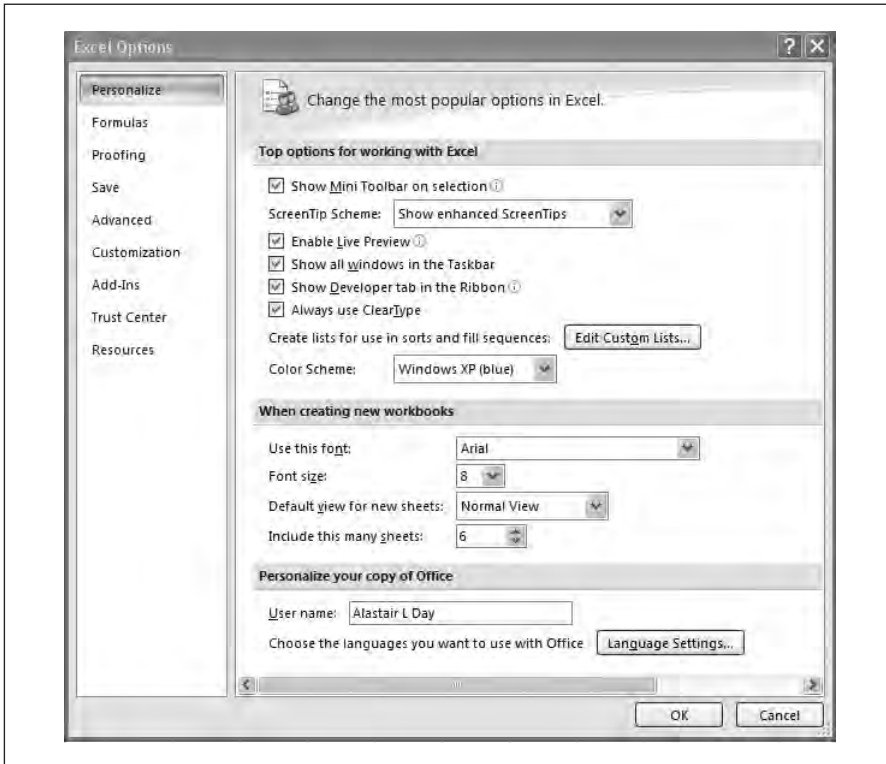


10 OPTIONS – PERSONALIZE

There are a number of options currently under Tools Options in the various tabs. The dialog screens are larger than current option screens in order to make the information clearer. This section is the equivalent to set up, for example, the default number of sheets in an Excel workbook. Tick the Developer tab for it to be visible on the Ribbon.

Personalize

Figure A2.15

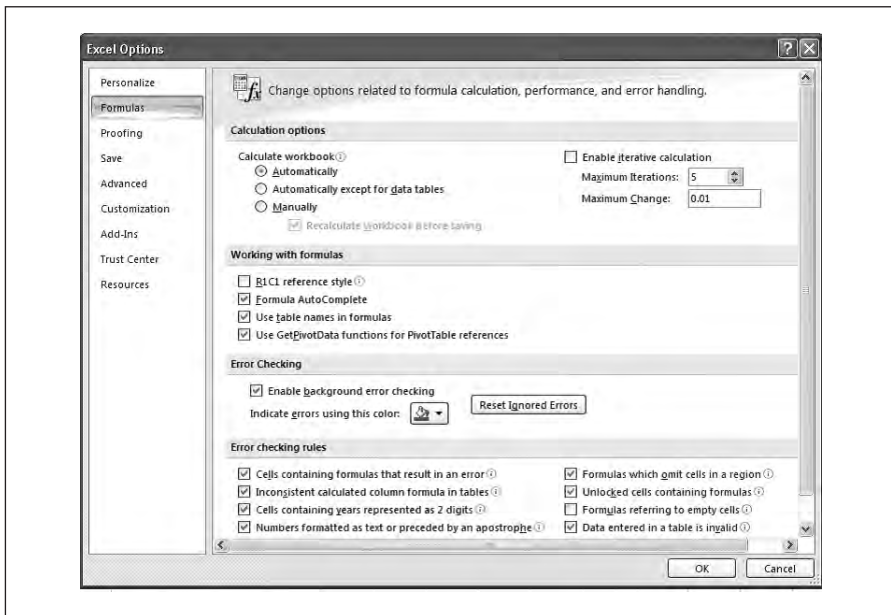


11 OPTIONS – FORMULAS

These options determine the automation of calculation and the error checking options currently in Tools Options Calculation and Error Checking.

Formulas

Figure A2.16

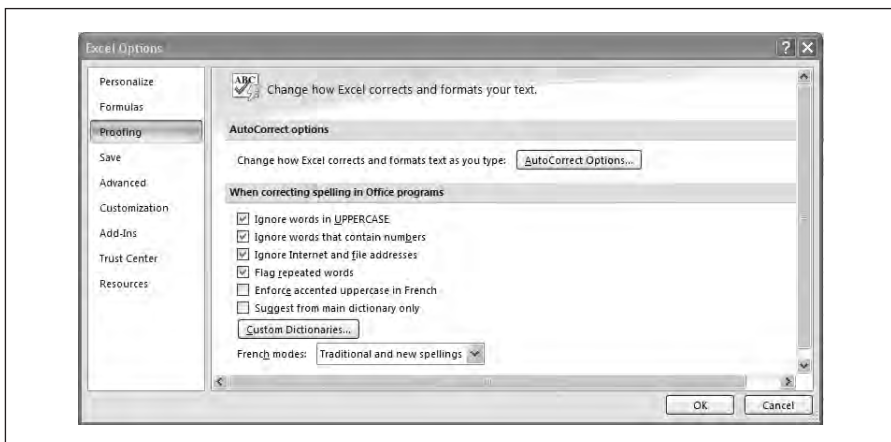


12 OPTIONS – PROOFING

This option is common with other parts of Office 12 and chooses how proofing is carried out and how Excel seeks to correct potential errors. The AutoCorrect and dictionary options are also here.

Proofing

Figure A2.17

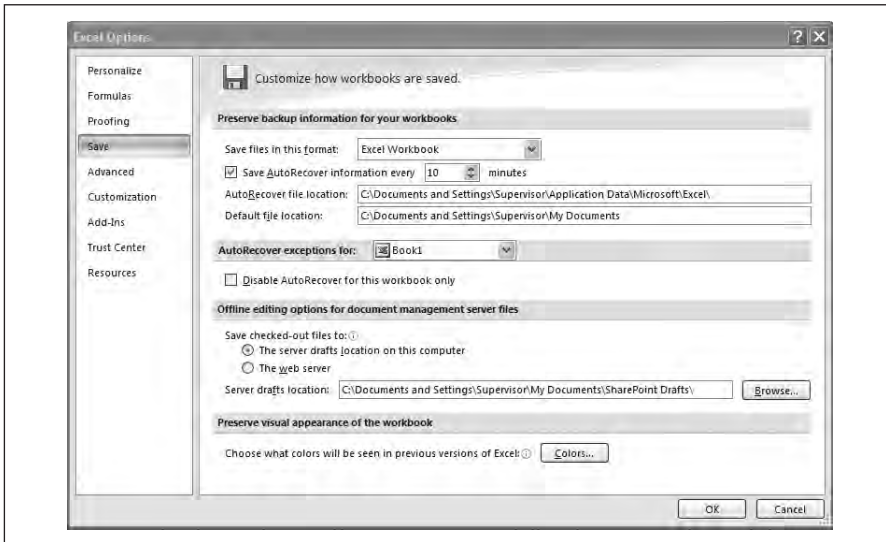


13 OPTIONS – SAVE

Here you set up file locations, the auto-save interval and the visual appearance.

Save

Figure A2.18

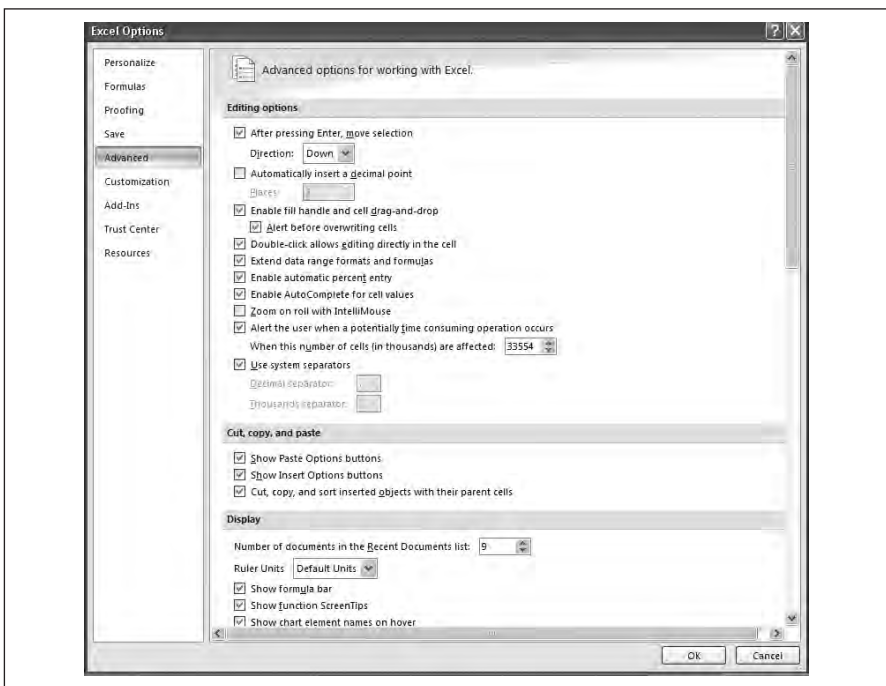


14 OPTIONS – ADVANCED

This section deals with advanced options for editing and other actions currently found in Tools Options. This includes the controls for editing options such as AutoComplete together with editing and display options.

Advanced

Figure A2.19

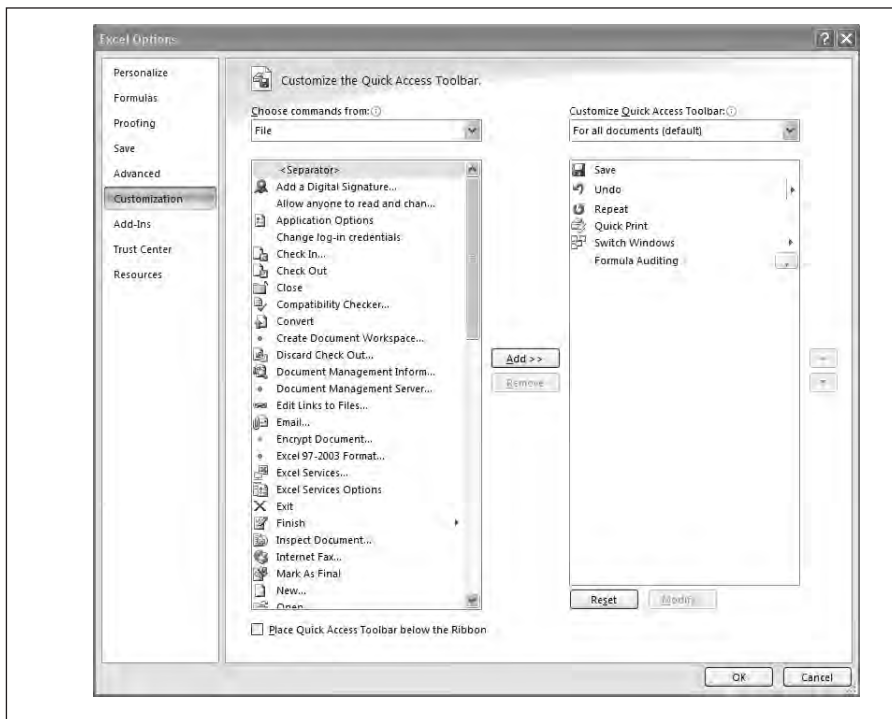


15 OPTIONS – CUSTOMIZATION

You can customize toolbars with quick commands and this menu options allows you to select commands for the quick toolbar. The quick toolbar is visible at the top left of the Ribbon.

Figure A2.20

Customization



16 OPTIONS – TRUST CENTRE

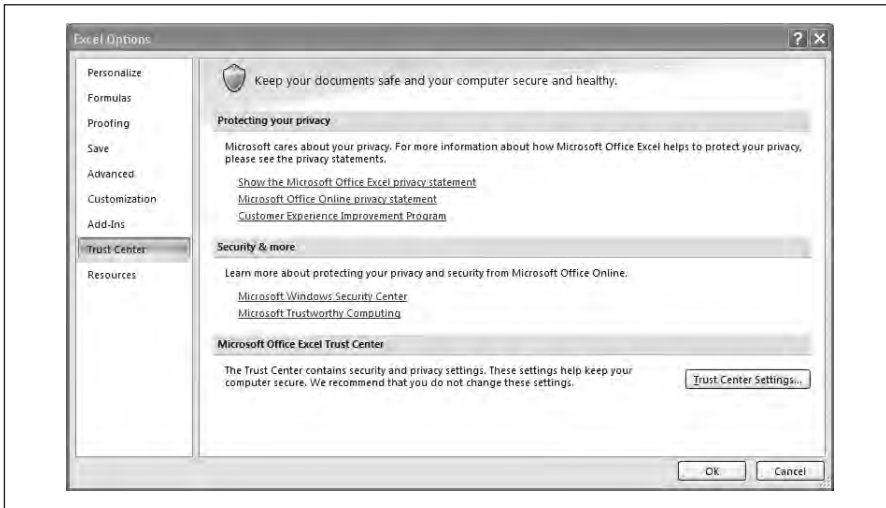
This section on security provides tools for securing documents and privacy. In Excel 2003 these tools are scattered in the different option boxes.

17 OPTIONS – RESOURCES

This section organizes all the assistance available in Office 12 for fixing problems, getting updates and downloading updates as they become available. The Office suite contains more advanced tools for finding and fixing installation problems.

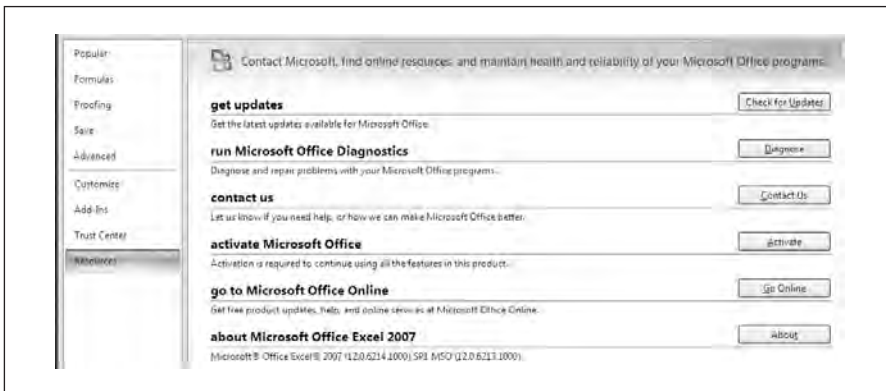
Trust Centre

Figure A2.21



Resources

Figure A2.22



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