Applications

Introduction

Financial modelling is about designing, developing, and implementing financial models. Accountants, for instance, have worked with manual financial models for years. Later came the powerful computer financial modelling packages that required a certain degree of programming skill. But now because of the power, convenience and ease of use of spreadsheet packages, most models from the simplest to the most complex are now spreadsheet-based. Programs like Microsoft Excel and Lotus 1-2-3 possess such impressive functionality that it is now possible to build very powerful modelling applications.

Historical note

Financial modelling has been around for decades although it may not have been known by that name throughout that time. Executives and managers have analysed financial data prepared by accountants, made projections based on their analysis and then made decisions based on their projections. Much of this activity was carried out using pen and paper and no more sophisticated a tool than a calculator. It was when computers began to be used commercially that financial modelling truly came into its own. For the first time it became possible to analyse detailed financial flows from a variety of perspectives and in a timely manner.

Early modelling systems were usually the preserve of operational researchers and engineers who generally tended to be computer literate. However, financial modelling packages emerged in the 1970s that permitted professionals with limited computing skills to develop robust if limited applications. These systems were effectively programming languages and were capable of facilitating the development of substantial financial modelling applications. However, that still demanded a higher level of computer literacy than most accountants and managers could muster.

The start of the 1980s heralded the age of the desktop PC and the arrival of spreadsheet programs. Spreadsheets made it possible for virtually anyone to, in a manner of speaking, get in on the act. Spreadsheet applications proliferated and practically every company and organisation, large or small, now use them. Early spreadsheet programs were no more than electronic versions of accountants' analysis sheets. In time their sophistication grew as new features were added. Today, spreadsheet programs are loaded with features that enable highly sophisticated applications to be built. The availability of tools such as macros and VBA have made it possible to build financial modelling applications that are as complex as most commercial computer applications available today.

Definitions

A *model* is a simulation of a real-life object, mechanism, process, function, or scenario. Examples of models include Cindy Crawford, car manufacturers' mockups of new cars, aircraft prototypes, computer models of business processes, laboratory experiments, and so on. A model is used in place of the “real thing” to determine how the real thing will look or behave in real-life situations.

A *financial model* is a manual or computer-based model that simulates a real-life business (usually) situation and expresses the outcome in financial terms. Financial modelling requires both financial as well as modelling skills. Examples of financial models include budgetary planning, capital investment appraisal, merger planning, acquisition planning, promotional planning, long-range planning, cash management, resource allocation, performance measurement, option pricing, and so on.

Types of models

Models can be classified by application and by modelling technique. Classified by application, models include macroeconomic models, industry models, corporate financial models, and other more specialised models. Classified by modelling technique, models include deterministic models, econometric models, stochastic models, decision tree models, and optimisation models.

Designing and constructing a model

The following paragraphs cover the issues that have to be addressed when designing and constructing a modelling application.

Designing the model

As for all models, the design phase is a critical one. Ask any systems analyst who has launched into building a system without adequate forethought and found amending and maintaining the system a messy affair. It pays to have a clear idea of the overall structure of the model and the purpose of the various parts and how they fit together.

Objectives of the model

Be clear about the purpose of the model and what it is intended to achieve. A model is generally intended to provide information. It saves future time and cost if one thinks through carefully the kind of information the model is going to have to yield and the kind of facilities it is going to have to afford. For example, apart from calculating profit, cash flow, and financial position, the model may have to provide a forecasting capability, a "what if?" capability, a risk evaluation capability, and so on. Clear and comprehensive objectives are critical to the success of the modelling application. It is often tempting to launch into a development without thinking the model through carefully. However, investment of time and effort in clarifying model objectives usually provides a worthwhile return in terms of time saved in making changes later or even rewriting the whole model.

There are two aspects to the objectives of a model. First, there is the overall aim of the model, e.g. calculate the return on investment, calculate profit, etc. Second, there are the design objectives one of which must be to ensure that the overall aim of the model is achieved.

Overall structure of the model

This is determining the way the model is to be structured, i.e. the number of separate sections that are to be in the model, the purpose and scope of each section, and how they are to be linked. Individual modules can take one of several forms, e.g. input worksheets, cell logic worksheets, output worksheets, and macro worksheets. Each one is defined briefly below.

- Input sheets enable data to be entered directly or through links from another sheet. Inputs to the model include so-called key drivers which are elements of input that critically affect the outcomes from the model. It is clearly important to identify these in full and any other variables for which data is to be entered to the model. Properly designed data input sheets provide user-friendly aids to facilitate data entry. Such aids include instructions as to the exact format for the data that is to be entered.

- Cell logic sheets are the sheets where the calculations of the model are carried out. Cell logic is the engine of the model in that it performs all the necessary calculations to arrive at the required results. Different types of calculations can be carried out in different parts of the sheet with each type having clear headings or labels. Notes can be added to the sheets to explain the logic.

- Output sheets are sheets that enable the results of the calculations to be displayed using reports and/or charts. Presentation of results includes tables, reports, graphs, etc. Report design is an especially important aspect of any computer application because it determines how easily and quickly users can absorb and assimilate the information provided by the model. Computers can generate large volumes of information very quickly, but relevance more than volume of information should be the key consideration when designing reports. Individual report lines can be linked back to appropriate cells in the cell logic sheets and numbers can be rounded as needed.

- Macro sheets hold the macros for the module. Macro sheets have to be designed with care to ensure convenience when updating and maintaining. In earlier versions of Excel macro code was stored on worksheets in the same way as model data, formulas, etc. Macros are now VBA-based and VBA code is stored separately from worksheets and is accessed using the Visual Basic Editor.

Sensitivity analysis
This is a most important aspect of financial modelling, enabling users to test the robustness of their assumptions and how movements in the value of key drivers and other variables impact outcomes. Sensitivity tables can be set up that show at one and the same time the impact on an output variable of several different values of up to two input variables. For example, in a valuation model, a table can be set up to show the valuation for different values of future sales growth. Alternatively, a table can be set up that shows the valuation for different combinations of values of two input variables, e.g. sales growth rate and operating profit margin.

Navigational and related issues
This is concerned with the practical aspects of enabling users of the model to find their way around the model. A simple menu system that enables a user to switch easily between worksheets can greatly assist the user to navigate the model especially when there are a large number of worksheets. Furthermore a menu system can be aesthetically appealing and can help with promoting use of the model especially by inexperienced users.

Embellishments

This is concerned with enhancing the appearance, readability, and usability of the model. Mention was made in the previous paragraph of the importance of aesthetic appeal. Sensible use of colours, lines, boxes etc. can greatly enhance the usability of the model.

Testing the model

This is clearly one of the most important aspects of model building. Information from working models is often used for making decisions that involve thousands if not millions of pounds. Incorrect information can therefore lead to enormous losses. Even in an application that is relatively limited errors can creep in and unless they are identified can render the information unusable. Thorough testing of models is always an imperative which one should not take lightly. One cannot always be certain that a model is 100% correct but it is nevertheless important that sufficient time and resources are devoted to the testing process. Spreadsheet programs possess tools that assist the model-builder to test models, e.g. pattern match and audit trace.

Implementation and operating instructions

When the integrity and reliability of the application has been established through the testing phase, the application can be implemented. Operating instructions have to available if the application is to be used in a meaningful way by someone other than the developer of the model.

Maintenance issues

Modelling applications have to be maintained. Unfortunately, computer systems are notorious for inadequate or out-of-date documentation and computer models are no exception. The more complex the model becomes the more important it is to document the model. Adequate documentation helps the model builder as well as others to maintain the system. Frequently, the person who has developed the application moves on and others have to work out how the application operates. For this and other reasons adequately documenting an application is as important as designing and building it. A good way to think about the kind of documentation to create is to imagine that having developed a substantial application, you have to leave it aside for several months. You then have to return to it to amend it significantly and to get it working properly. What kind of documentation would you welcome to enable you to familiarise yourself with what you did before.

Uncertainty and Risk

In most modelling work, making estimates and forecasts is part and parcel of the modelling process. Indeed for many models the known part of the data is by far the smaller part of the data used in the model. The rest consists of estimates, guesstimates, rule-of-thumb, and forecasts. It is well known that the output from operating a model is only as accurate as the least accurate data that is input to the model. For this reason, it is critical to obtain a more balanced view from the model by evaluating the output from the model using different sets of assumptions and values.

There are a number of techniques used to take account of the effects of risk and uncertainty in models. They are as follows:

- sensitivity analysis;
- scenario analysis;
- dynamic what-if analysis;
- Monte Carlo simulation; and
- decision trees.

These techniques are will be discussed fully during the course.

Further design tips and suggestions

1. Employ a modular structure. For example, in the case of a simple financial model it may suffice to have a module which calculates profit, another the balance sheet, and yet another the cash flows. All three would of course be linked. For a more complex model, e.g. one to determine company cash flows, one might have several modules including a sales module, manufacturing module, an overhead module, a module for investment in assets, a funding module and so on. A modular approach facilitates model building and makes it easier and more convenient to maintain and update the model.

2. Design flexibility into the model, i.e. flexibility to make changes to one module without affecting the others, flexibility to expand the capability or capacity of the model without rewriting the whole thing, and so on. This is easier said than done, however, as many a systems developer has found out over the years. Nevertheless it is an objective that it is well worth taking the time to try and achieve.

3. Setting up the cell logic efficiently enables errors to be identified and corrected more easily. Getting it right first time will help. Avoid building data into formulas. This is often referred to as “hard-coding”. For example, including the sales growth rate in the formula for calculating sales means that if you wish to use a different sales growth rate, the formula has to be amended. If on the other hand, the sales growth rate is part of the input to the model then the rate can easily be changed by simply entering a new rate.

4. It can help to flowchart your design in order to more clearly see where there are flaws in data flows, cell logic etc. A flowchart is a device for mapping the modules of the model, how they interrelate and the way in which data flows between the modules.

5. Sensible use of colours enhances the usability of a model. Data input cells can be coloured a different colour from cells containing formulas. Headings can be yet another colour. A key to the colour scheme also helps. However, it is easy to get carried away with colours so that the application begins to appear garish. Other ways to enhance the appearance of information in a model is to use appropriate number formats, different fonts, and lines and boxes,

6. Displaying the values of some of the key results on the input sheet assists the user to immediately view the effect of changes to input data without having to switch another sheet, e.g. cell logic or output.

7. Circular references can and do arise, sometimes intentionally and sometimes unintentionally. Clearly, when they arise unintentionally the modeller has

made an error which must be fixed. Intentional circular references are not a hardship because modern spreadsheet programs are equipped to handle or “resolve” them. Circular references can be a nuisance especially when a message appears suddenly and confuses the user who is unfamiliar with what they are. Where possible they should be avoided but there will be times when they are unavoidable.

Building a one-year profit planning model

Let us assume that we wish to build a one-year profit-planning model. A profit planning model is, as the name suggests, a model to plan the profit for the year. Management needs to be able to enter assumptions about the key factors that drive profit and to see the results of their assumptions. The following discussion shows how such a model can be created. The aim of this illustration is to demonstrate some of the complexities that accompany the building of even a relatively simple model such as this.

The starting point is the profit and loss account and balance sheet for the year just ended.

Historic data

The financial statements for the year just ended are shown below.

Hakuna Matata Limited	**(£)**
Profit & Loss Account for the year to …	**31.08.02**
Sales	100,000
Less: Cost of goods sold	60,000
Gross profit	40,000
Less: Overhead costs	17,500
EBITDA	22,500
Less: Depreciation	1,950
Operating profit (EBIT)	20,550
Less: Interest expense/(income)	425
Profit before tax	20,125
Less: Tax	5,031
Profit after tax	15,094
Less: Dividends	7,547
Retained profit	7,547

Hakuna Matata Limited	
Balance Sheet as at …	**31.08.02**
Assets	
Current assets	
Stock (Inventory)	12,000
Debtors (Receivables)	15,000
Bank balances and cash	3,793
Total current assets	30,793
Fixed assets	
Gross book value	25,000
Less: Accumulated Depreciation	7,500
Net book value	17,500
Total Assets	48,293

Liabilities and Shareholders' Equity	
Current liabilities	
Creditors (Payables)	6,000
Accrued expenses	500
Taxes owed	3,019
Dividends owed	3,774
Total current liabilities	13,293
Long term liabilities	
Long-term loans	10,000
Total long-term liabilities	10,000
Shareholders equity	
Share capital	10,000
Retained earnings	15,000
Total shareholders equity	25,000
Total Liabilities and Shareholders' Equity	48,293

The historic data above can be held in a separate worksheet, say *Historic*. Note the following:

- Terminology that is used is more or less standard practice in the UK.
- Figures in the profit & loss account (P&L) that are deducted are shown as positive numbers, e.g. the figure for *Cost of goods sold* is shown as 60,000. The formula for *Gross profit* is built to deduct the COGS figure from Sales. This practice although widely used can be confusing. A better approach is to show figures to be deducted as negative numbers and then to add them in the formulas.
- The P&L broadly follows the UK format while the balance sheet follows no particular format but is intended to be as simple to follow as possible.
- While the data in the statements purports to have been copied from somewhere else, formulas are nevertheless included where appropriate. This helps to check that the figures have been copied correctly.

Key Drivers

Key drivers can be held in a separate worksheet called *Key drivers*, say.
The P&L drivers are shown below.

Profit & Loss Account	
Sales growth rate	5%
COGS/Sales	60%
Overhead costs	17,500
Depreciation rate	20%
Interest rate	8%
Effective tax rate	25%
Dividend payout ratio	50%

Note the following:

- Overhead costs are entered explicitly. This is because overhead costs are more or less independent of sales or any other item. An alternative approach would be to use an escalator percentage based on, say, inflation.
- For simplicity a single depreciation rate is entered to apply to all assets. Depreciation is charged on the opening balance of fixed assets.
- For simplicity a single interest rate is entered to calculate both interest paid and interest received. Interest is calculated by netting average bank and cash balances with average loans and applying the common interest rate.
- To simplify the tax calculation, an “effective” tax rate is used which can be applied to the profit before tax.

The balance sheet drivers are shown below.

Balance Sheet	
Stock/COGS ratio	20%
Debtors/Sales ratio	15%
Fixed assets/sales ratio	25%
Creditors/COGS ratio	10%
Accruals/Sales ratio	0.50%
Taxes owed percentage	60%
Dividends owed percentage	50%
Loans raised/(repaid)	0
Equity raised/(redeemed)	0

Note the following:

- The working investment ratios (stock, debtors, creditors, accruals) are expressed as percentages. Management frequently prefer to think in terms of days stock, days debtors, etc.
- The fixed assets to sales ratio is somewhat unrealistic because fixed assets do not normally rise proportionately in line with sales.
- The taxes owed percentage and the dividends owed percentage are included in order to facilitate the calculation of the amounts outstanding at the end of the year. The percentages are applied to the corresponding figures on the P&L.
- The loans raised/(repaid) and the equity raised/(redeemed) figures are useful for management to decide whether there will be sufficient funding available to support the year’s operations.

Profit plan

The profit plan can be held in a worksheet with the same name, say. The profit plan is shown below.

Hakuna Matata Limited	(£)
Profit & Loss Account for the year to …	**31.08.03**
Sales	105,000
Less: Cost of goods sold	63,000
Gross profit	42,000
Less: Overhead costs	17,500
EBITDA	24,500
Less: Depreciation	3,500
Operating profit (EBIT)	21,000
Less: Interest expense/(income)	124
Profit before tax	20,876
Less: Tax	5,219
Profit after tax	15,657
Less: Dividends	7,829
Retained profit	7,828

Hakuna Matata Limited	
Balance Sheet as at …	**31.08.03**
Assets	
Current assets	
Stock (Inventory)	12,600
Debtors (Receivables)	15,750
Bank balances and cash	13,099
Total current assets	41,449
Fixed assets	
Gross book value	26,250
Less: Accumulated Depreciation	11,000
Net book value	15,250
Total Assets	56,699
Liabilities and Shareholders' Equity	
Current liabilities	
Creditors (Payables)	6,300
Accrued expenses	525
Taxes owed	3,131
Dividends owed	3,915
Total current liabilities	13,871
Long term liabilities	
Long-term loans	10,000
Total long-term liabilities	10,000
Shareholders equity	
Share capital	10,000
Retained earnings	22,828
Total shareholders equity	32,828
Total Liabilities and Shareholders' Equity	56,699

Note the following:

- The vast majority of cells hold formulas. Even the headings can be generated using formulas that obtain the headings from the Historic sheet. This means that if any heading changes are required then they only have to be made in one place.
- The P&L figures are calculated by simply applying the key drivers to the historic data and then totalling as needed. Care has to be taken to ensure that taxes and dividends when the company makes a loss are properly handled.
- The balance sheet numbers are calculated by applying the key drivers to appropriate figures on the historic data and the current year's figures with some exceptions (see immediately below)
- The *Bank balances and cash* figure is used as a "plug" figure to force the balance sheet to balance. This is reasonable because if all the other figures on the balance sheet have been determined independently, then it must be the cash that takes up the "slack". Of course, the bank balance could go overdrawn in which case the overdrawn amount would have to appear within current liabilities. In our simple case here, bank balances and cash figure would simply go negative if the bank account goes overdrawn. To do this properly, two plug numbers would be needed and the Max function used to determine where the resulting figure would go. The Max function sets the value of a cell equal to the greater of a calculated figure or zero.
- For simplicity, depreciation for the year is calculated as a percentage of the opening net book value of fixed assets. This means that no depreciation is charged on assets acquired during the year, an unrealistic assumption. The more correct treatment is to use the calculation shown below. The treatment used here also means that the depreciation method used is the reducing balance method, which is not appropriate for many if not most classes of fixed assets.
    - Take the opening net book value
    - Add assets acquired during the year
    - Deduct WDV of assets disposed during the year
    - Apply the depreciation rate to the resulting figure to obtain the depreciation for the year
- Interest has been calculated by applying the single interest rate to the average balances of bank and cash and the average balance of loans outstanding. However, as the closing bank and cash balance depends on the amount of interest we have what is referred to as a circular reference. Circular references can be handled (resolved) by more recent versions of Excel.
- Because of the use of the plug figure and the way it is calculated, the balance sheet is automatically self-balancing.
- A cash flow statement can be generated which helps to ensure that the P&L and balance sheet calculations have been done correctly. Of course, it does nothing to assure us that the correct ratios have been used and

that the figures on the P&L and balance sheet have been derived correctly.

Reports and output

A report or output worksheet can also be included, which extracts key figures that would be of interest to management and which could be printed off. In a profit planning exercise, some of the key figures that would be of immediate interest would include sales, gross profit, EBITDA, operating profit, profit after tax, and the bank and cash balance. Key figures would be extracted to the report worksheet. A button could be included and assigned to a macro that would print a report with the key figures. In the case of this illustration, the entire P&L and balance sheet has been extracted to the report worksheet. The P&L and balance sheet for the previous year have also been extracted to facilitate comparison.

Modelling for Break-even analysis

Break-even analysis, also known as Cost/Volume/Profit analysis, is about determining the level of sales volume or sales revenue at which a company or division breaks even, i.e. makes neither a profit nor a loss. Determining the break-even point is critical in profit planning and in decision making. The aim of this discussion is to show how the modelling of break-even analysis can help with profit planning and with decision making.

The problem is concerned with a company that wishes to take advantage of a new business opportunity. Analysis of the business opportunity has yielded data for the first year of operation. This is how the data might be held in the worksheet in the model.

Data Entry

Sales	
Expected sales volume (units)	25,000
Price per unit	£95
Variable costs per unit	
Materials	£15
Labour	£38
Variable overhead	£22
Total	£75
Fixed costs	
Selling and distribution costs	£260,000
Administrative costs	£210,000
Allocation of general overheads	£130,000
Total	£600,000

The problem here is to determine the break-even point and to determine whether the proposed business venture is worth undertaking. The break-even point can be expressed in terms of sales revenue or in terms of sales volume. The break-even point is calculated as follows:

$$\text{Sales revenue break} - \text{even} = \frac{\text{Fixed overheads}}{\text{Contribution margin}}$$

where

$$\text{Contribution margin} = \frac{\text{Contribution}}{\text{Sales}}$$

and

$$\text{Sales volume break} - \text{even} = \frac{\text{Fixed overheads}}{\text{Contribution per unit}}$$

Here is how the modelling of the calculation of the break-even point may be done in the model.

Calculation of break-even

Price per unit	£95
Total variable cost per unit	£75
Contribution per unit	£20
Total fixed costs	£600,000
Contribution margin	0.2105263
Break-even sales	
Incl. allocation of general o/hs	£2,850,000
Excl. allocation of general o/hs	£2,232,500
Break-even volume (units)	
Incl. allocation of general o/hs	30,000
Excl. allocation of general o/hs	23,500

The break-even point has been calculated with fixed costs including and excluding the allocation of general overheads. Clearly, with sales volume expected to be 25,000 units the venture is unlikely to break-even in the first year. However, if the allocation of general overheads is ignored then the venture appears able to break-even. However, allocations of general overheads cannot be ignored as they are part and parcel of business life. Nevertheless viewing the problem in this way prompts us to question whether the allocation is altogether fair. If they are too high then a reduction in the allocation would help to achieve break-even. But how much of a reduction would be needed? We can find out by using trial and error methods or the Goal Seek facility in Excel. Goal Seek is covered later in these notes.

If we wanted to know whether the business opportunity is worth exploiting then we would have to look elsewhere for the answer. The Profit and Loss Account shown below contains a clue to the answer.

Profit & Loss Account

	Incl. o/h allocation	**Excl. o/h allocation**
Sales revenue	£2,375,000	£2,375,000
Total variable costs	£1,875,000	£1,875,000
Contribution	£500,000	£500,000
Total fixed costs	£600,000	£470,000
Profit	-£100,000	£30,000

If the £130,000 general overhead allocation is an unavoidable cost for the company regardless of whether the venture is undertaken or not, then if the venture is not undertaken that allocation would have to be re-allocated elsewhere in the company. However, if we look at the P&L excluding the overhead allocation we notice that the venture makes a “profit” of £30,000. In other words by undertaking the venture the company earns a useful £30,000 “contribution” towards its fixed costs and profit. So what would you conclude from this?

Modelling for Capital Budgeting Decisions

This topic is concerned with evaluating the financial viability of undertaking investment projects such as acquisition of fixed assets or the purchase of securities. In this section we examine how to set up a simple model to analyse a proposal to acquire and operate a capital asset. The problem is to evaluate a proposal to acquire and operate an asset. Data related to the investment are as follows:

Purchase cost:	£500,000
Investment period:	5 years
Expected residual value:	£10,000
First year cash inflow:	£250,000
Cash inflow expected growth rates:	
- Year 2	40%
- Year 3	30%
- Year 4	10%
- Year 5	-10%
First year cash outflow:	£190,000
Cash outflow expected growth rates:	
- Year 2	10%
- Year 3	10%
- Year 4	10%
- Year 5	10%
Weighted average cost of capital:	12.5%

The model can be set up to include a number of worksheets. One worksheet can hold a menu that permits quick and easy switching to any one of the other worksheets and exiting the model. The menu worksheet is not shown in these notes. The other worksheets are described below.

Data Entry

This worksheet holds data entered by the user. Data is entered on what appears like a form that might typically be required to be filled in by the person or department proposing the investment. The data entry "form" is reproduced below. Note the following:

- Data entry points have been marked clearly by boxing and shading.
- On-screen instructions are provided saying where and how data is to be entered.
- The data entry form has a reasonably uncluttered appearance with lots of "white space".
- Colours may be used to further enhance the appearance and usability of the form.

Capital Budgeting Model

Data Entry

Asset				
Purchase cost (£)	**500,000**		**Data to be entered in shaded boxes only**	
Residual value (£)	**10,000**			
Cash inflow				
1st Year (£)	**250,000**			
	Year 2	**Year 3**	**Year 4**	**Year 5**
Growth rate (%)	**40.0**	**30.0**	**10.0**	**-10.0**
Cash outflow			Percentages must be entered as numbers, i.e. without a % sign	
1st Year (£)	**190,000**			
	Year 2	**Year 3**	**Year 4**	**Year 5**
Growth rate (%)	**10.0**	**10.0**	**10.0**	**10.0**
Weighted average			Percentages must be entered as numbers, i.e. without a % sign	
Cost of capital (%)	**12.5**			

Cell logic

This sheet holds the calculations to determine the financial viability of the investment proposal. The cell logic sheet is shown below. Note the following:

- On the assumption that the cell logic sheet is the one worksheet that users will not need to visit, the appearance of the sheet is not a vital consideration.
- Rounding can be used to avoid calculations appearing to be incorrect.
- A discount factor can be calculated as an intermediate step to calculating the present value of net cash flows in the various years. The PV function could be used instead but there are times when one or more intermediate steps can simplify the construction of formulas. Note the use of the year numbers in row 2 to calculate the discount factors.
- At least two methods are available to calculate the NPV, one of them being the NPV function. The two ways provide a useful crosscheck.

- The IRR function can be used to calculate the IRR and a further check made to see if the IRR does indeed yield a zero NPV.
- The cell logic sheet can be documented with the use of notes attached to specific cells, on-screen comments, and embedded Word documents.

Capital budgeting						
Year	**0**	**1**	**2**	**3**	**4**	**5**
Cost of asset	-500000					
Cash inflows		250000	350000	455000	500500	450450
Cash outflows		-190000	-209000	-229900	-252890	-278179
Residual value						10000
Net cash flow	-500000	60000	141000	225100	247610	182271
Discount factor	1.0000	0.8889	0.7901	0.7023	0.6243	0.5549
PV of net cash flow	-500000	53334	111404	158088	154583	101142
Cum. PV of NCF	-500000	-446666	-335262	-177174	-22591	78551
Net present value	78565					
Internal rate of return	17.7%					
Check:						
NPV at IRR	0					

Output and reports

This worksheet extracts relevant data and information from other worksheets and formats them into a report that can be printed by simply clicking on a button (not shown) attached to a suitable macro. The report is shown below. Note the following:

- The report holds very little information but just enough to tell a busy manager what he/she needs to know. Detailed data can always be attached as supporting documentation.
- The report has an uncluttered appearance, which lends visual appeal and enhances usability. Report design is an important issue in financial modelling.
- Note the IF statements in two of the cells, e.g. E17 and E21 which control whether a Yes or a No appears in those cells. E17 compares the project return with the company's cost of capital to determine if it exceeds the company's threshold rate of return. E21 performs a similar comparison but adds a risk premium to the threshold rate to determine if the return from the project exceeds the risk-adjusted threshold rate.

Capital Budgeting Application

Financial Viability Report

Financial analysis of the proposal for the purchase of a machine to manufacture the new product line revealed the following:

Net present value	£78,565
Internal rate of return	17.7%

Does the return from the investment exceed the weighted average cost of capital ? (Yes/No)

Yes

Should the investment be undertaken considering the risks associated with the new product line? (Yes/No)

Yes

Sensitivity Analysis

This worksheet is intended as a "scratchpad" where different values of the input variables are tried in order to determine their impact on the output variable(s). The worksheet is shown below. A button (not shown) is incorporated that is attached to a macro that channels the user's figures through the model. The results can be viewed lower down on the worksheet e.g. rows 21 down. Nothing that is done on this worksheet cannot be done on the data entry sheet. However, the advantage of the scratchpad idea is that the worksheet can be left unprotected so that the user can carry out further analysis on the worksheet without fear of damaging any of the rest of the model. For example, different values of input variables can be tried and the results recorded, graphs prepared and information printed.

Sensitivity analysis

	Previous	Revised	
Asset			
Purchase cost (£)	500,000	500,000	
Residual value (£)	10,000	10,000	
Cash inflows			
1st Year	250,000	250,000	**Note:**
Growth rate			Numbers in Revised
- Year 2 (%)	25.0	25.0	column only may
- Year 3 (%)	30.0	30.0	be changed. All other
- Year 4 (%)	10.0	10.0	cells are protected.
- Year 5 (%)	0.0	0.0	Results can be view-
			ed in rows 27 down.
Cash outflows			
1st Year	190,000	190,000	
Growth rate			
- Year 2 (%)	10.0	10.0	
- Year 3 (%)	15.0	15.0	
- Year 4 (%)	20.0	20.0	
- Year 5 (%)	10.0	10.0	
Weighted average cost of capital (%)	12.5	12.5	
Results			
NPV	**-£71,974**		
IRR	**7.2%**		

Modelling for Company Valuation

This topic is concerned with developing a financial model to calculate a valuation for a company. In this section we examine how to set up a model to value a company for which we have several years of historic P&L and balance sheet data. The model comprises several worksheets each of which is described below.

Historic data

Historic data can be held in a worksheet called for example *Historic*. The data would comprise the Profit & Loss Accounts and Balance Sheets for several years for a small company. The financial statements, which are highly simplified, are shown on the next page. The statements are presented in more or less the format that is favoured in the UK.

Historic data is of course unchangeable and, once verified as correct, would not be changed. This worksheet and its contents would therefore be protected. Users would need to visit the worksheet occasionally to view the figures.

Financial Statements for year to 31st March

Profit & Loss Account	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Sales volume	85,000	85,498	85,882	87,625	88,582	89,580
Sales price	10.00	10.24	10.50	10.60	10.80	11.00
Sales	850,000	875,500	901,761	928,825	956,686	985,380
Variable Operating Expenses	578,000	596,216	617,710	630,670	654,370	680,857
Fixed Operating Expenses	104,900	105,550	106,000	107,400	108,200	109,000
Gross profit	167,100	173,734	178,051	190,755	194,116	195,523
Selling and Admin. Expenses	89,100	92,024	95,990	99,230	99,750	102,150
Depreciation	42,000	42,500	38,750	35,141	31,102	28,409
Operating Profit	36,000	39,210	43,311	56,384	63,264	64,964
Interest	6,000	6,000	6,000	6,000	6,000	6,000
PBT	30,000	33,210	37,311	50,384	57,264	58,964
Tax	9,000	9,963	11,193	15,115	17,179	17,689
PAT	21,000	23,247	26,118	35,269	40,085	41,275

Balance Sheet	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Gross Fixed Assets	420,000	433,370	450,883	473,700	480,780	490,720
Depreciation	150,000	192,500	231,250	266,391	297,493	325,902
Net Book Value	270,000	240,870	219,633	207,309	183,287	164,818
Stock	183,000	185,800	188,375	194,740	195,755	199,520
Debtors	130,000	140,080	153,300	162,550	172,205	175,485
Cash	32,500	72,907	106,287	141,435	197,396	250,170
Total current assets	345,500	398,787	447,962	498,725	565,356	625,175
Creditors	59,500	60,410	62,230	65,400	67,925	68,000
Overdraft	0	0	0	0	0	0
Total current liabilities	59,500	60,410	62,230	65,400	67,925	68,000
Net current assets	286,000	338,377	385,732	433,325	497,431	557,175
Total net assets	556,000	579,247	605,365	640,634	680,718	721,993
Long term liabilities	75,000	75,000	75,000	75,000	75,000	75,000
	481,000	504,247	530,365	565,634	605,718	646,993
Share capital	150,000	150,000	150,000	150,000	150,000	150,000
Share premium account	40,000	40,000	40,000	40,000	40,000	40,000
Profit and loss account	291,000	314,247	340,365	375,634	415,718	456,993
Total capital and reserves	481,000	504,247	530,365	565,634	605,718	646,993

Calculating Key Drivers

The next step in the valuation process is to calculate the key drivers for the model. This is done by analysing the historic data and then taking a view as to how the drivers would behave in the future. The calculation of the key drivers could be held in a separate worksheet called *KeyDrCalc,* say. The contents of the worksheet may be as shown below.

Calculating Key Drivers

Key drivers	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Sales volume growth rate		0.6%	0.4%	2.0%	1.1%	1.1%
Sales price escalator		2.4%	2.5%	1.0%	1.9%	1.9%
Var. op. expenses to sales	68.0%	68.1%	68.5%	67.9%	68.4%	69.1%
Fixed op. expenses to sales	12.3%	12.1%	11.8%	11.6%	11.3%	11.1%
S and A expenses to sales	10.5%	10.5%	10.6%	10.7%	10.4%	10.4%
Stock to cost of sales	26.8%	26.5%	26.0%	26.4%	25.7%	25.3%
Debtors to sales	15.3%	16.0%	17.0%	17.5%	18.0%	17.8%
Creditors to cost of sales	8.7%	8.6%	8.6%	8.9%	8.9%	8.6%
Fixed assets to sales	49.4%	49.5%	50.0%	51.0%	50.3%	49.8%
Depreciation to fixed assets		15.7%	16.1%	16.0%	15.0%	15.5%
Cash tax rate	25.0%	25.4%	25.8%	26.8%	27.2%	27.2%

It is not difficult to see how the drivers, which are ratios, are calculated. The sales volume growth rate is the rate of growth over the previous year as is the sales price escalator. The gross book value of fixed assets is used in the fixed assets to sales driver. The depreciation to fixed assets driver uses the depreciation for the year calculated as a ratio of the opening net book value of fixed assets. The cash tax rate uses a highly simplified method of dividing the tax charge for the year (proxy for tax actually paid) by the operating profit. The missing values in 1995 are because the drivers are dependent on figures for 1994, which are assumed here to be unavailable.

As this worksheet holds calculations based on historic data the contents of the worksheet should remain stable once the accuracy of the historic data has been confirmed. The next step is to analyse the values calculated for the key drivers and to arrive at forecasts for those key drivers for use in the valuation model. This function is reserved for the next worksheet.

Analysing and Forecasting Key Drivers

The analysis can be held in a separate worksheet called *KeyDrForecast,* say. The contents of the worksheet could be as shown below. Note the following:

- Because of the fact that the key drivers have remained fairly stable over the six years, a decision can be made to confine the analysis to simply calculating an arithmetic average of the values over the five or six years. This is of course somewhat simplistic because in practice not all drivers would show the degree of stability we see in this example. In that case we would need to analyse the values of the drivers more rigorously in order to identify patterns, trends, etc.

- There is an over-ride column, which provides the user with the option to use the average figures calculated by the model. It is the values in the over-ride column that drive the model.
- There can be a button (not shown) that is attached to a macro that enables the user to transfer the average values to the over-ride column. Having the transferred the values the user can employ business judgement to change any or all of the values.
- It is on this sheet that any sensitivity or data tables would have to be built. Unfortunately Excel does not permit data tables to be set up other than where the input data resides.
- Data validation should be built into the data entry boxes in the over-ride column to ensure that data entered is appropriate.

Analysing & Forecasting Key Drivers

	Average	Over-ride	
Sales volume growth rate	1.1%	1.5%	
Sales price escalator	1.9%	1.9%	
Var. op. expenses to sales	68.3%	67.5%	
Fixed op. expenses to sales	11.7%	11.7%	Data in shaded
S and A expenses to sales	10.5%	10.5%	boxes only may
Stock to cost of sales	26.1%	25.0%	be altered
Debtors to sales	16.9%	16.9%	
Creditors to cost of sales	8.7%	8.7%	
Fixed assets to sales	50.0%	50.0%	
Depreciation to fixed assets	15.7%	15.7%	
Cash tax rate	26.2%	25.0%	

Calculating the weighted average cost of capital (WACC)
This process can be carried out in a separate worksheet called *WACC*, say. There are three stages to the calculation, namely (a) calculating the cost of debt, (b) calculating the cost of equity, and (c) calculating the WACC. The contents of the worksheet can be as shown below. Note the following:

- For calculating the cost of debt, it is assumed there will only be one type of debt in the capital structure. Given the characteristics of this type of debt, the objective is to model the calculation of the yield to redemption of the debt. The yield is the same as the cost of debt. The model calculates the present value of the future cash flows of the debt, namely interest payments and redemption payment. The model uses the PV function in Excel and a rate entered by the user. The rate is adjusted until the present value of future cash flows is the same as the market value of the debt. This condition is tested by the calculation in a different cell which has to provide a zero result value for the condition to have been met. The user can try different values or use Goal Seek to find the value. The resulting value is the cost of debt.

- For calculating the cost of equity, it is assumed here that the parameters required for the CAPM equation are known. The model then calculates the cost of equity using the CAPM formula. The model can of course be modified if it is required to calculate the beta, say, from basic market data.
- The calculation of the WACC requires the user to enter the tax rate and the proportion of debt in the future capital structure.

Calculating the weighted average cost of capital (WACC)

Cost of Debt		
Par value	£100.00	Numbers in the shaded boxes only may be changed.
Market value	£84.44	
Coupon	5.0%	
Redemption period	5	
Interest	£5.00	
Redemption amount	£100.00	
PV of future cash flows	-£84.44	
Net of B10 and B5	£0.00	If the terms of the loan change then adjust the cost of debt until this number returns to zero. Alternatively use Goal Seek to set this value to zero by changing the cost of debt figure.
Cost of debt	9.0%	
Cost of Equity		
Risk-free rate	5.0%	
Market risk premium	7.5%	
Company beta	1.33	
Cost of equity	15.0%	
WACC		
Tax rate	30.0%	
Proportion of debt	30.0%	
Proportion of equity	70.0%	
After-tax cost of debt	6.3%	
WACC	12.4%	

Cell Logic

This worksheet called *Cell Logic* is the engine of the model because it performs the many calculations that are needed to arrive at a value for the company. There are a number of stages in the calculation as follows:

Stage 1 – Importing key drivers and other data

It is always good practice to marshal all the key drivers and other data from the other worksheets that are required for the valuation calculations. It makes for simpler formulas and also increases convenience and cuts down on the time taken to build the formulas. The imported data is shown below.

Stage 1 - Importing key drivers and other data

Sales volume growth rate	1.5%
Sales price escalator	1.9%
Var. op. expenses to sales	67.5%
Fixed op. expenses to sales	11.7%
S and A expenses to sales	10.5%
Stock to cost of sales	25.0%
Debtors to sales	16.9%
Creditors to cost of sales	8.7%
Fixed assets to sales	50.0%
Depreciation to fixed assets	15.7%
Cash tax rate	25.0%
WACC	12.4%
Previous year	
- Sales volume	89,580
- Sales price	£11.00
- Var. operating expenses	£680,857
- Fixed operating expenses	£109,000

Stage 2 – Calculating sales

The next stage is to calculate the sales for each year. This is done in a number of steps including calculation of the growth in sales volume, each year's sales volume and sales price, and each year's sales and sales growth. Six future periods (years) are used giving forecast periods of 1, 2, 3, 4, 5 or 6 years.

Stage 2 - Calculating sales

Year	**1**	**2**	**3**	**4**	**5**	**6**
Previous year's sales	985,380	1,019,427	1,054,649	1,091,083	1,128,778	1,167,774
Growth in sales volume	1344.0	1364.0	1384.0	1405.0	1426.0	1448.0
This year's sales volume	90,924	92,288	93,672	95,077	96,503	97,951
This year's sales price	£11.21	£11.43	£11.65	£11.87	£12.10	£12.33
This year's sales	1,019,427	1,054,649	1,091,083	1,128,778	1,167,774	1,208,125
Sales growth	34,047	35,222	36,433	37,695	38,996	40,351

Stage 3 – Calculating after-tax cash inflows

The first step is to calculate depreciation for each year. The order of the calculation is as follows:

- Take the opening net book value of fixed assets
- Apply the deprecation rate to the opening NBV to obtain the depreciation for the year.
- Use the depreciation figure as an estimate of the replacement capital expenditure
- Calculate the expansion capital expenditure based on the sales growth for the year. Calculate the closing net book value of fixed assets which gives the opening NBV for the following year,

Note that any disposals have been conveniently ignored but disposals can sometimes be significant and would have to be taken into account.

Having calculated depreciation the relevant part of the P&L for each year can be calculated. This in turn provides the after-tax cash inflow for each year.

Stage 3 - Calculating after-tax cash inflows						
Year	**1**	**2**	**3**	**4**	**5**	**6**
Opening fixed assets	164,818	181,840	199,449	217,663	236,509	256,005
Depreciation	(25,821)	(28,487)	(31,246)	(34,099)	(37,052)	(40,106)
Replacement capex	25,821	28,487	31,246	34,099	37,052	40,106
Expansion capex	17,022	17,609	18,215	18,845	19,496	20,173
Closing fixed assets	181,840	199,449	217,663	236,509	256,005	276,178
Sales	1,019,427	1,054,649	1,091,083	1,128,778	1,167,774	1,208,125
Variable Operating Expenses	(688,113)	(711,888)	(736,481)	(761,925)	(788,247)	(815,484)
Fixed Operating Expenses	(119,080)	(123,195)	(127,450)	(131,854)	(136,409)	(141,122)
Gross profit	212,234	219,566	227,152	234,999	243,118	251,518
Selling and Admin. Expenses	(107,235)	(110,940)	(114,772)	(118,737)	(122,839)	(127,084)
Depreciation	(25,821)	(28,487)	(31,246)	(34,099)	(37,052)	(40,106)
Operating profit	79,178	80,140	81,133	82,162	83,227	84,328
Add Depreciation	25,821	28,487	31,246	34,099	37,052	40,106
EBITDA	104,999	108,627	112,379	116,262	120,278	124,434
Notional taxes	(19,795)	(20,035)	(20,283)	(20,541)	(20,807)	(21,082)
After-tax cash inflows	85,204	88,592	92,096	95,721	99,472	103,352

Stage 4 – Calculating incremental fixed asset and working investment needs

This is a fairly straightforward calculation. The relevant ratios together with the growth in sales are mainly used to calculate the capital expenditure and the incremental needs for working investment. The relevant part of the worksheet is given below.

Stage 4 - Calculating incremental fixed asset and working investment needs						
Year	**1**	**2**	**3**	**4**	**5**	**6**
Fixed asset needs						
Replacement capex	25,821	28,487	31,246	34,099	37,052	40,106
Expansion capex	17,022	17,609	18,215	18,845	19,496	20,173
Total capex	42,842	46,096	49,461	52,945	56,548	60,279
Working investment needs						
Growth						
- Sales	34,047	35,222	36,433	37,695	38,996	40,351
- Cost of sales	17,337	27,889	28,848	29,847	30,878	31,950
Stock movement	4,334	6,972	7,212	7,462	7,719	7,988
Debtors movement	5,766	5,964	6,170	6,383	6,604	6,833
Creditors movement	1,511	2,431	2,514	2,602	2,691	2,785
Working investment needs	8,589	10,505	10,868	11,243	11,632	12,036

Stage 5 – Calculating free cash flow

This is done by deducting the incremental fixed asset needs and the incremental working investment needs from the after-tax cash inflow. The relevant part of the worksheet is shown below.

Stage 5 - Calculating free cash flow						
Year	**1**	**2**	**3**	**4**	**5**	**6**
After-tax cash inflow	85,204	88,592	92,096	95,721	99,472	103,352
Fixed asset needs	(42,842)	(46,096)	(49,461)	(52,945)	(56,548)	(60,279)
Working investment needs	(8,589)	(10,505)	(10,868)	(11,243)	(11,632)	(12,036)
Free cash flow	33,773	31,991	31,767	31,533	31,292	31,037

Stage 6 – Discounting the free cash flows

The present value of the free cash flows is now calculated. The relevant part of the worksheet is shown below. Note the use of the intermediate step of calculating discount factors in order to simplify the formulas that are used in calculating present values. Note also the line that accumulates the present values of the free cash flows.

Stage 6 - Discounting the free cash flows						
Year	**1**	**2**	**3**	**4**	**5**	**6**
Free cash flow (FCF)	33,773	31,991	31,767	31,533	31,292	31,037
Discount factor	0.8899	0.7919	0.7047	0.6271	0.5581	0.4966
Present value of FCFs	30,055	25,334	22,387	19,776	17,464	15,414
Cumulative PV of FCFs	30,055	55,388	77,776	97,551	115,015	130,429

Stage 7 – Calculating residual value and the present value of the residual value

For the purpose of this model it has been assumed that there will be no further growth beyond the forecast period. Therefore all that is needed is to deduct replacement capex from the after-tax cash inflow to arrive at the free cash flow beyond the forecast period. This enables the residual value to be calculated and then discounted in the usual way. If further growth were expected beyond the forecast period, then expansion capex and incremental working investment needs would have to be taken into account in determining the free cash flow beyond the forecast period.

Stage 7 - Calculating residual value and PV of RV						
Year	**1**	**2**	**3**	**4**	**5**	**6**
After-tax cash inflow	85,204	88,592	92,096	95,721	99,472	103,352
Replacement capex	(25,821)	(28,487)	(31,246)	(34,099)	(37,052)	(40,106)
FCF beyond forecast period	59,384	60,105	60,850	61,622	62,420	63,246
Residual value	479,966	485,792	491,817	498,055	504,506	511,185
Discount factor	0.8899	0.7919	0.7047	0.6271	0.5581	0.4966
PV of residual value	427,120	384,707	346,596	312,347	281,557	253,874

Stage 8 – Calculating shareholder value

This is the final stage of the calculation of shareholder value. The relevant part of the worksheet is shown below. Shareholder value is calculated as follows:

- The cumulative present value of the free cash flows and the present value of the residual value are added together to obtain enterprise value.
- Any existing debt in the capital structure is deducted because that would have to be discharged if the company was, say, sold.
- Any cash is then added back in order to arrive at shareholder value.

Note that because of the way that the model is set up, we automatically have the figure for shareholder value using forecast periods of 1, 2, 3, 4, 5, or 6 years. This is useful for gauging how sensitive the valuation is to changes in the length of the forecast period.

Stage 8 - Calculating shareholder value

Year	**1**	**2**	**3**	**4**	**5**	**6**
Cumulative PV of FCFs	30,055	55,388	77,776	97,551	115,015	130,429
PV of residual value	427,120	384,707	346,596	312,347	281,557	253,874
Enterprise value	457,175	440,096	424,372	409,898	396,572	384,303
Debt	(75,000)	(75,000)	(75,000)	(75,000)	(75,000)	(75,000)
Cash	250,170	250,170	250,170	250,170	250,170	250,170
Shareholder value	632,345	615,266	599,542	585,068	571,742	559,473

Sensitivity analysis

One more worksheet can be included in the model, namely one called *Sensitivity*. As has been explained elsewhere in these notes, this worksheet serves as a "scratchpad" where the user can try out various values for key drivers and record his/her results, prepare graphs, etc. without affecting the other worksheets. The contents of the worksheet are shown below.

Sensitivity analysis

Sales volume growth rate	1.5%
Sales price escalator	1.9%
Var. op. expenses to sales	67.5%
Fixed op. expenses to sales	11.7%
S and A expenses to sales	10.5%
Stock to cost of sales	25.0%
Debtors to sales	16.9%
Creditors to cost of sales	8.7%
Fixed assets to sales	50.0%
Depreciation to fixed assets	15.7%
Cash tax rate	25.0%

Data in shaded boxes only may be altered. Click the transfer button to transfer values from this sheet to the *KeyDrForecast* worksheet. Results may be viewed in row 16 below.
Note:
Changing key drivers relating to cost of debt and cost of equity must be done in the WACC sheet.

View results here

Years in forecast period	**1**	**2**	**3**	**4**	**5**	**6**
Shareholder value	632,345	615,266	599,542	585,068	571,742	559,473

Note the following:

- The user can enter new values for the key drivers in the shaded boxes. By clicking a button (not shown), which is attached to a macro, the new values are automatically copied to the appropriate cells in the *KeyDrForecast* worksheet, which drive the valuation.

- The effect of entering new values for key drivers can be viewed immediately without having to switch any other worksheet.

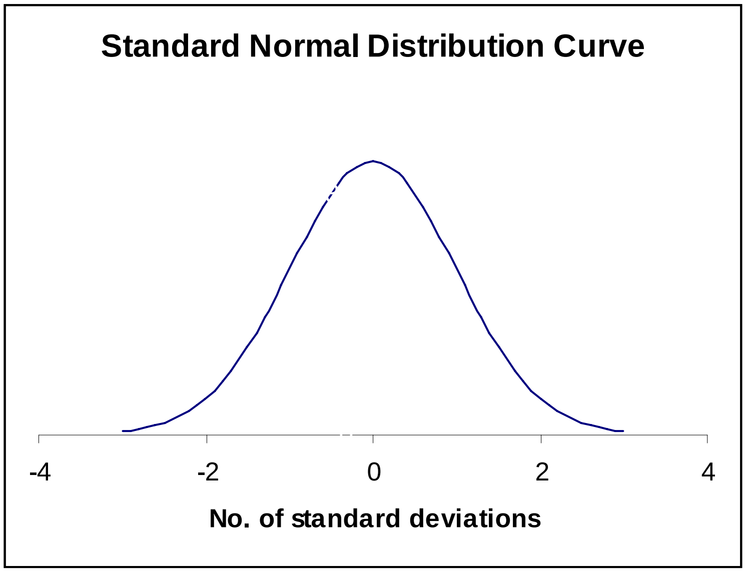
Monte Carlo Simulation

Models created by most people are deterministic in that they use single point estimates for the forecast values of the different variables of the model. The assumption in most cases is that these forecasts are “most likely” values for the different variables. The values of output variables are similarly single point values.

Using a technique known as Monte Carlo simulation one can increase the sophistication of the model by introducing probability distributions in respect of key variables. A probability distribution defines the different values that an input variable can take and the probability of each value. Probability distributions are also referred to as risk profiles. The distribution can take any of a number of different shapes, e.g. rectangular, triangular, normal, and so on. Having assigned a probability distribution to each key variable, one can then run a simulation. A simulation is a process whereby a computer selects values for the key variables in line with the assigned probability distributions. These values are run through the model and the result recorded. The process is repeated several times, typically several hundred times. The outcome of the process is that several values for the output variables are generated sufficient to yield a probability distribution of the various output variables. This then enables one to answer questions about the value of an output variable such as “What is the most likely value and what is its probability?”, “What is the probability of the value exceeding a certain level or falling below a certain value?”, and so on.

Normal distribution

As stated above, variance and standard deviation are measures of variability or volatility. This property enables us to use the measures for providing a quantitative indication of risk. Many phenomena in nature exhibit a tendency that is best summarised by the normal distribution or “bell curve”. The heights of men or the IQs of people are examples of such a tendency. There are also phenomena in business that exhibit similar tendencies. The returns from securities are one example. The chart below shows the typical bell-shaped curve that characterises a normal distribution.



Here are some characteristics of the normal distribution.

- The distribution is symmetrical about its central value or mean, in this case zero because it is a "standardised" normal distribution. It is possible, however, for a normal distribution to be skewed, i.e. distorted in one direction or the other.

- The normal distribution represents how the values of a given variable are distributed about the mean. For example, if the distribution relates to the IQs of people, then most peoples' IQs would be clustered around the mean or average, say 100. As increasingly brighter people and increasingly duller people are relatively rare, then the curve falls away as we get further and further from the mean IQ. Likewise, if the distribution relates to the possible returns from a security, then the most frequently occurring values would be clustered around the mean or expected value. The further we get from the expected value, the less frequent such values would be.

- The area under the curve provides a measure of probability. So, for example, the area to the left of the mean comprises 50% of the total area under the curve. This means that there is a 50% probability that the value of the variable to which the distribution relates will fall to the left of the mean. By the same token there is a 50% probability that the value will fall to the right of the mean. This is hardly surprising because the normal distribution is, after all, symmetrical about the mean.

- Table 1 in the appendix enables the area under various parts of the normal distribution curve to be determined. This in turn provides a measure of the probability of the value of a variable falling between two values. From the table, you can tell that approximately 68% of the area under the curve lies between one standard deviation to the left of the mean and one standard deviation to the right of the mean. Likewise, approximately, 95% lies between two standard deviations either side of the mean, and approximately 99% lies between three standard deviations either side of the mean.

Using Goal Seek

This is a very useful facility in spreadsheet programs which enables the following kind of analysis to be performed. Let us imagine a profit planning model in which sales and costs are used to determine profit. Put simply, goal seek would enable the desired value of an output variable (target cell) to be specified and the program would then search for the value of an input variable (change cell) which would yield the desired value of the output variable. Hence, in our profit planning model we could ask the question “what value of sales would yield the desired level of profit?” This is clearly an illustration using a fairly simple model but the idea can be extended to quite complicated models as well.

Let us revisit the example in the section on break-even analysis. The example concerned a company evaluating a business opportunity and wishing to know whether the venture would break even in the first year of operation. In that example we used certain relationships to calculate the break-even point. We could just as easily used Goal Seek to determine the break-even point. Here is the data for that example.

Data Entry

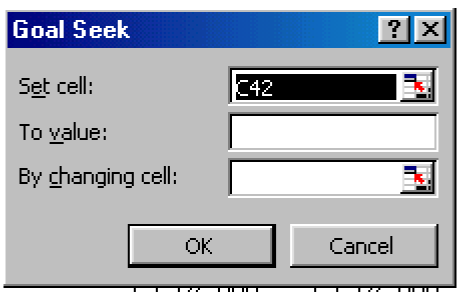
Sales	
Expected sales volume (units)	25,000
Price per unit	£95
Variable costs per unit	
Materials	£15
Labour	£38
Variable overhead	£22
Total	£75
Fixed costs	
Selling and distribution costs	£260,000
Administrative costs	£210,000
Allocation of general overheads	£130,000
Total	£600,000

Here is the first year’s Profit and Loss Account for the venture.

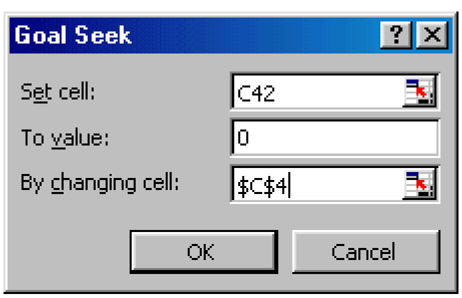
Profit & Loss Account

	Incl. o/h allocation	Excl. o/h allocation
Sales revenue	£2,375,000	£2,375,000
Total variable costs	£1,875,000	£1,875,000
Contribution	£500,000	£500,000
Total fixed costs	£600,000	£470,000
Profit	-£100,000	£30,000

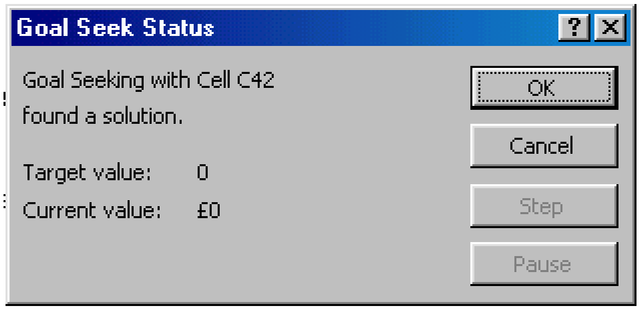
We know that the break-even point is the level of sales volume or sales revenue at which the venture makes neither a profit nor a loss. We can now use Goal Seek as follows:
In the model, move the cell pointer to the profit cell (C42).
Click the Tools menu and select Goal Seek…. You will see the following dialog box.



Notice that cell C42, our target cell, has already been entered to the *Set cell:* box. We now enter zero in the *To value:* box and the cell reference for cell C4 in the *By changing cell:* box. The dialog box should appear as follows:



Click OK and a status box is displayed as shown below.



Click OK and the results can be viewed.

The following extract from the model shows that the sales volume at break-even is 30,000.

Sales	
Expected sales volume (units)	30,000
Price per unit	£95

The following extract from the model shows the Profit & Loss Account:

Profit & Loss Account

	Incl. o/h allocation	**Excl. o/h allocation**
Sales revenue	£2,850,000	£2,850,000
Total variable costs	£2,250,000	£2,250,000
Contribution	£600,000	£600,000
Total fixed costs	£600,000	£470,000
Profit	£0	£130,000

We can confirm the result in an earlier section that the sales revenue at break-even is
£2,850,000.

Optimisation & Linear Programming

This is a most powerful technique that has been used in business ever since it was developed in the early part of the last century. It is an optimisation technique that enables an optimum solution to be found to a problem Let us look at an example of the kind of problem that lends itself to solution by this kind of technique.

Illustration

A manufacturer produces two products, Alpha and Omega. Alpha provides a contribution of $3 per unit and Omega $4 per unit. The manufacturer wishes to establish a weekly production plan, which maximises contribution earned from making and selling the two products. Production data are as follows:

	Per unit		
	Machine (Hours)	Labor (Hours)	Material (Pounds)
Alpha	4	4	1
Omega	2	6	1
Total available per week	100	180	40

Because of a trade agreement, sales of Alpha are limited to a weekly maximum of 20 units and to honor an agreement with an old established customer at least 10 units of Omega must be sold per week.

Solution

What, in simple terms, are the main features of this problem? First, there are two products that can be made, Alpha and Omega. Each product requires varying amounts of input resource per unit and there are upper limits to the amounts of input resource available. Each unit of product sold yields a contribution, Alpha yielding slightly less per unit than Omega. It would be tempting therefore to think that because Omega yields more contribution than Alpha it would be best to produce as much of Omega as one can sell. While that may hold true in this instance but it does not hold true as a general rule.

The essence of this problem therefore is that we have to find the combination of the amount of Alpha and the amount of Omega to be produced that will yield a maximum amount of contribution without violating the constraints on input resources. One could use a trial and error approach varying the amounts of Alpha and Omega until one finds a combination that yields the greatest contribution. But even the simplest of problems would take an inordinately large amount of time to solve. Furthermore there would be no foolproof way of determining whether an optimum solution had indeed been found. This is a typical problem that lends itself to the technique of linear programming for determining an optimum solution. We also use the Solver facility in Excel to perform the calculations needed to solve the problem.

We begin by formulating the problem in a way that facilitates its loading to Solver. This is done as follows:

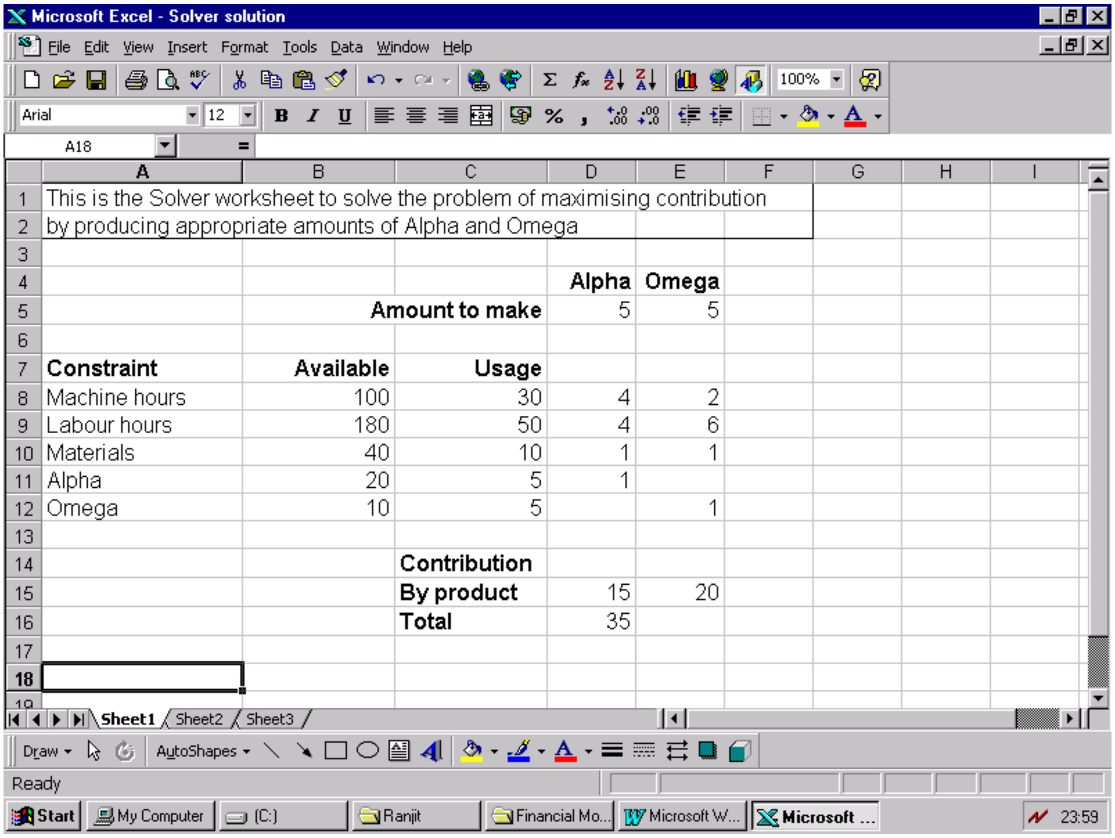
Let us assume that we produce x units of Alpha and y units of Omega. We can now restate our problem as follows:

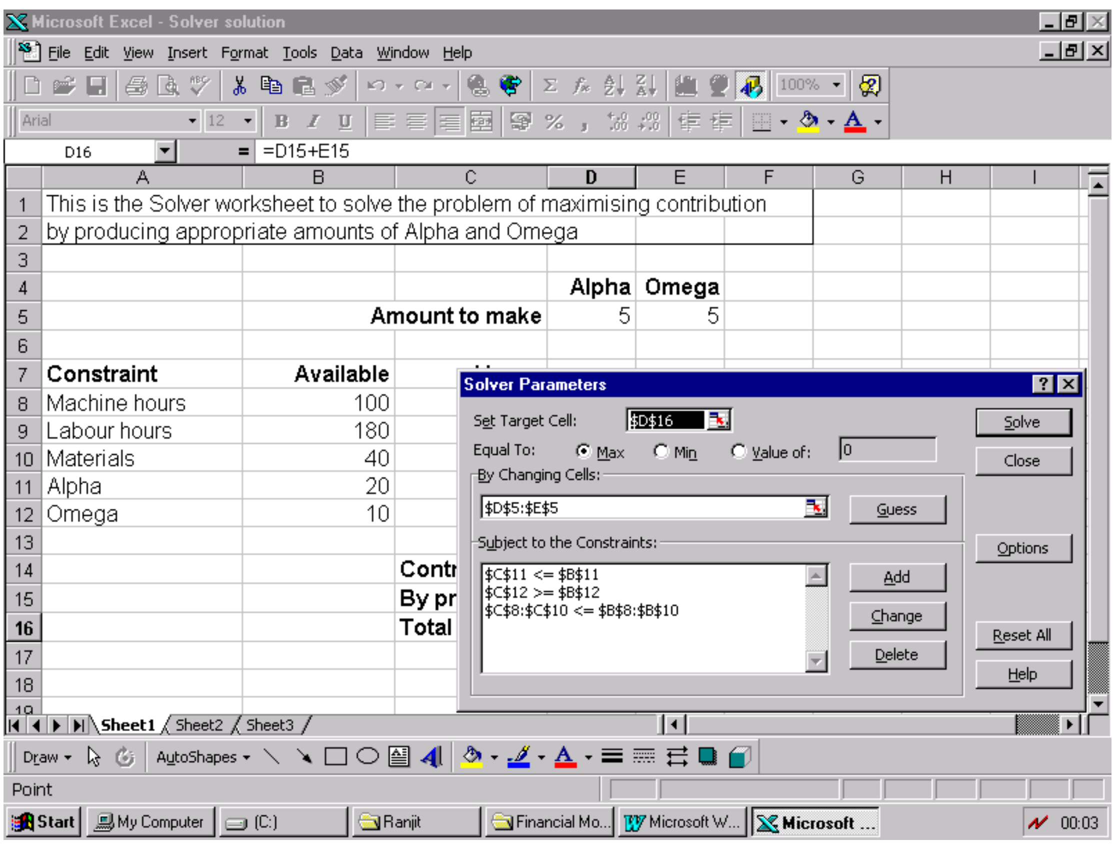
	Alpha		Omega		
Maximise	3x	+	4y		
Subject to					
Machine hours constraint	4x	+	2y	<=	100
Labour hours constraint	4x	+	6y	<=	180
Materials constraint	1x	+	1y	<=	40
Maximum Alpha constraint	1x			<=	20
Minimum Omega constraint			1y	>=	10

This can be further restated as follows:

	X		y		
Maximise	3	+	4		
Subject to					
Machine hours constraint	4	+	2	<=	100
Labour hours constraint	4	+	6	<=	180
Materials constraint	1	+	1	<=	40
Maximum Alpha constraint	1			<=	20
Minimum Omega constraint			1	>=	10

This now renders the problem in to a format that can be almost directly input into Excel. You can see the Excel screens on the pages that follow. The first screen shows the worksheet with the data on it. The second screen shows the same screen with the Solver dialog box superimposed. The third screen shows the result of applying Solver to the problem.


Microsoft Excel - Solver solution
File Edit View Insert Format Tools Data Window Help
A18
This is the Solver worksheet to solve the problem of maximising contribution
by producing appropriate amounts of Alpha and Omega
Alpha Omega
Amount to make 5 5
Constraint Available Usage
Machine hours 100 30 4 2
Labour hours 180 50 4 6
Materials 40 10 1 1
Alpha 20 5 1
Omega 10 5 1
Contribution
By product 15 20
Total 35
Sheet1 Sheet2 Sheet3
Ready
Start My Computer (C:) Ranjit Financial Mo... Microsoft W... Microsoft ...
23:59


Microsoft Excel - Solver solution
File Edit View Insert Format Tools Data Window Help
D16 =D15+E15
This is the Solver worksheet to solve the problem of maximising contribution
by producing appropriate amounts of Alpha and Omega
Alpha Omega
Amount to make 5 5
Constraint Available
Machine hours 100
Labour hours 180
Materials 40
Alpha 20
Omega 10
Contr
By pr
Total
Solver Parameters
Set Target Cell: $D$16
Equal To: Max Min Value of: 0
By Changing Cells:
$D$5:$E$5
Subject to the Constraints:
$C$11 <= $B$11
$C$12 >= $B$12
$C$8:$C$10 <= $B$8:$B$10
Solve
Close
Guess
Options
Add
Change
Delete
Reset All
Help
Sheet1 Sheet2 Sheet3
Point
Start My Computer (C:) Ranjit Financial Mo... Microsoft W... Microsoft ...
00:03

Microsoft Excel 8.0e Answer Report
Worksheet: [Solver solution.xls]Sheet1
Report Created: 29/10/2000 00:08:50

Target Cell (Max)

Cell	Name	Original Value	Final Value
$D$16	Total Alpha	35	125

Adjustable Cells

Cell	Name	Original Value	Final Value
$D$5	Amount to make Alpha	5	15
$E$5	Amount to make Omega	5	20

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$C$8	Machine hours Usage	100	$C$8<=$B$8	Binding	0
$C$9	Labour hours Usage	180	$C$9<=$B$9	Binding	0
$C$10	Materials Usage	35	$C$10<=$B$10	Not Binding	5
$C$11	Alpha Usage	15	$C$11<=$B$11	Not Binding	5
$C$12	Omega Usage	20	$C$12>=$B$12	Not Binding	10

Elements of Forecasting

Financial modelling involves having to make forecasts of sales or costs or cash flows and so on. This section deals briefly describes some of the more commonly used methods of forecasting. If you wish to pursue the subject in any detail then you are advised to consult one of the many excellent texts on statistics on the market.

There are a number of forecasting techniques. We will concern ourselves with the following only:

- Simple linear trend
- Simple exponential growth trend
- Multiple regression
- Non-linear trend forecasting
- Data smoothing methods

Simple Linear Trend

In this method, we assume that there is a straight-line relationship between the independent or x-variable and the dependent or y-variable. For example, we could surmise that there is a straight-line relationship between total cost of production and number of units produced. The relationship would be expressed as shown below.

$$C = Vn + F$$

where

C = total cost

V = slope of the line

n = number of units produced

F = the intercept on the vertical axis

If past production data was analysed in this way it could perhaps be shown that there is a straight-line relationship between costs and production. You may recognise that in the relationship above, V represents variable cost per unit and F represents fixed costs.

There are functions in Excel such as Trend, which perform linear regression analysis on historical data and then produce a forecast using the underlying trend.

Simple Exponential Growth Trend

Sometimes the trend may not be a straight line one. For example, when a new product comes on the market, sales may initially be slow but then if the product proves popular sales can grow rapidly. This kind of growth is referred to as exponential growth and an example of the kind of relationship that one would use for forecasting sales growth might be as follows:

$$S = a \times EXP(bt)$$

where

S = the forecast, e.g. for sales

a and $b$are appropriate constants

t is the independent variable, e.g. time

One can either use the FILL option in the EDIT menu or the Trendline command available within the chart options.

Multiple Regression
This is a method used when the dependent variable is affected by more than one independent variable. For example, the demand for mortgages could be dependent on personal income, interest rates, and the year. This kind of problem requires the use of a technique known as multiple linear regression. The mathematical relationship one would use is as follows:

$$D = a0 + (a1 \times \text{income}) + (a2 \times \text{interest rates}) + (a3 \times \text{the year})$$

where

D is the demand; and

$a0, a1, a2,$ and $a3$ are parameters of the model

The TREND function in Excel permits this kind of forecast to be prepared.

Non-linear trend forecasts
There is any number of instances where in practical situations the assumption of a linear relationship between dependent and independent variable does not hold. We have already met one instance in which the sales growth followed an exponential trend. In such an instance sales do not continue to grow exponentially and at some stage there will be a fall-off as the product reaches maturity. This is a good example of a non-linear trend. Another example is when production costs per unit fall as volume increases but beyond a certain point the cost starts to increase as new capacity has to be brought on-stream.

You can use the Trendline command in the charts option, which offers a number of other forecasting methods, e.g. logarithmic, polynomial, power, and moving average.

Data smoothing methods
This is a technique in which forecasts are recalculated in the light of new data. Two methods that are commonly used are exponential smoothing and moving

average. Both methods employ a form of averaging of historic data in order to arrive at forecasts. One difference between the methods is that while exponential smoothing gives more weight to the most recent data the moving average method gives equal weight to all the data in the calculation. Examples of the use of data smoothing methods include period sales, movement of the stock market index, and so on.

Area under the normal curve

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	0.9
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1154	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3168	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990