9

Worked example – Paper 1

0 Introduction

This chapter contains an example project for CP2 Paper 1. It consists of the project specification and instructions, followed by a detailed solution and a sample marking schedule for this paper.

The solutions are presented as a running commentary of the thought process that a well-prepared student might go through when working through this project. Extracts from the student's work are interspersed.

The complete audit trail is shown in Section 3. The sample marking schedule is shown in Section 4.

The student's plan for the project is in Section 2.3.

1 Example project – Paper 1

Exam requirements

1. Modelling steps and data checks

Read the background document, which describes the scenarios that need to be modelled and documented for this project.

Construct a spreadsheet model that produces the following calculations and charts. You should ensure that your spreadsheet contains appropriate self-checks and that you have performed and documented robust reasonableness checks at each stage of your calculations.

(i) Carry out appropriate checks on the annuity factors provided. [3]

(ii) For each client, calculate the expected final salary at retirement under Scenario 1. [2]

(iii) Calculate the projected value of the current fund at retirement for each client under Scenario 1. [1]

(iv) Calculate the projected value of the future contributions at retirement for each client under Scenario 1. [3]

(v) Calculate the total fund available at retirement for each client under Scenario 1. [1]

(vi) Calculate the expected annual income in the first year of retirement if an annuity is purchased at retirement for each client under Scenario 1. [2]

(vii) Calculate the expected annual income in the first year of retirement if drawdown is used at retirement for each client under Scenario 1. [3]

(viii) Determine the percentage of each client's final salary at retirement (calculated in part (ii)) that would be provided by the annuity and drawdown retirement incomes under Scenario 1. [2]

(ix) Repeat the calculations under Scenarios 2 and 3. [5]

(x) Produce a table comparing the following factors under each scenario for all clients:

- age
- current fund value
- current salary
- income in retirement as a percentage of final salary under the annuity and drawdown approaches. [3]

(xi) Produce a graph showing a comparison of the retirement income percentages for the individuals in the table under each arrangement based on Scenario 2. [2]

[Sub-total 27]

Note: All scenarios outlined above should be modelled separately within your spreadsheet. The user should not need to change the parameters to see the results.

2. Modelling technique and practice

(i) Auto checks on modelling completed in question 1. [3]

(ii) Demonstration of good modelling technique and practice [7]

[Sub-total 10]

3. Audit trail

Produce an audit trail for your spreadsheet model that includes the following aspects:

- purpose of the model
- data and assumptions used
- methodology, *ie* a description of how each calculation stage in the model has been produced
- explanation of the checks performed.

You should ensure that your audit trail is suitable for both a senior actuary, who has been asked to approve your work, and a fellow student, who has been asked to peer review and correct your model, or to continue work on it, or to use it again for a similar purpose in the future.

Marks available for audit trail:

Audit approach

(i) Communication skills (*the audit trail provides enough detail to be read as a self-standing document*) [4]

(ii) Fellow student can review and check methods used in the model [7]

(iii) Senior actuary can scrutinise and understand what has been done [7]

(iv) Written in clear English [4]

(v) Written in logical order [3]

Audit content

(i) All steps clearly explained [8]

(ii) Reasonableness checks [5]

(iii) Clear signposting included throughout [4]

(iv) Statement of assumptions made [5]

(v) All model steps accurately covered [16]

[Sub-total 63]

[Total 100]

Background

You have been approached by *LongerLives*, a company that provides advice on retirement options to employees who are contributing to personal pension plans.

In the past they have advised most of their clients when they reach retirement age to take out an index-linked annuity. Under this arrangement, the employee's entire fund built up by retirement is used to buy a pension for the remainder of their life, which will increase each year in line with inflation.

They are now offering a 'drawdown' option where the fund remains invested after retirement and the pensioner withdraws an amount directly from this fund at the start of each year to provide an income.

An analysis has produced the following table showing the typical profile of their clients.
'Fund now' indicates the fund the employee has already built up by the age indicated.

Age	Fund now ($'000)	Salary ($'000)
20	0	20
30	10	25
40	25	30
50	50	35
60	100	40

You have been asked to assist with a series of calculations to compare the projected pensions (expressed as a percentage of the client's salary at retirement) under each arrangement (annuity and drawdown) for the individuals in the table.

Under both arrangements, you should assume that retirement takes place at age 65 and the pension payments increase each year in line with inflation.

Technical specification

You have been provided with the following table of annuity factors. These are used to calculate the cost of buying a pension of $1 per annum under the annuity arrangement.

	ANNUITY FACTORS (calculated at rate of interest $k + 1\%$)			
Age	2%	3%	4%	5%
55	22.4	20.5	18.7	16.9
60	20.6	19.0	17.3	15.6
65	18.9	17.4	17.3	14.3
70	17.2	15.8	14.4	13.0
75	15.5	14.2	13.0	11.7

The above annuity factors are calculated using a rate of interest of $k+1\%$ *pa*, where k represents the expected future rate of inflation. In above table, the percentages represent values of $k+1\%$.

Drawdown calculations are carried out on the assumption that everybody lives to exactly age 90 and the income drawn down increases by inflation each year.

It is assumed that all employees will contribute 15% of their salary between now and retirement.

The calculations are to be carried out on three different bases, as show in the table below. In each case, the values of these variables are assumed to remain constant in the future.

	SCENARIO		
Variable	Scenario 1	Scenario 2	Scenario 3
Investment return (i)	4%	6%	8%
Salary increases (j)	3%	4%	5%
Inflation (k)	1%	2%	3%

Formulae

The formulae used to calculate the pension are:

- Investment growth to retirement age = $(1+i)^{R-x}$
- Projected valuation of future contributions at age x

$$= p \times S_0 \times \left\{(1+i)^{R-x} + (1+j)(1+i)^{R-x-1} + \cdots + (1+j)^{R-x-1}(1+i)\right\}$$

$$= p \times S_0 \times (1+i)\left[\frac{(1+i)^{R-x} - (1+j)^{R-x}}{i-j}\right]$$

- Annuity factor for drawdown benefits = $(1+i)\left[\frac{1-\{(1+i)/(1+k)\}^{R-M}}{i-k}\right]$

where:

x = Current age

R = Retirement age

i = Investment returns

j = Salary increases

p = Contribution rate to drawdown fund each year (% of salary)

S_0 = Current salary

M = Maximum age (for drawdown)

k = Inflation

2 Student's commentary

As you read this section you may want to have the spreadsheet solution the student is discussing open in front of you. This can be downloaded from the ActEd website at ActEd.co.uk (Subjects, Core Practices, CP2).

2.1 Getting started

Right, then. I've downloaded and printed out the instructions for the project.

I'll start by reading through the instructions carefully to make sure I understand what I have to do.

It's about personal pensions. I don't work in pensions, but I don't expect it will require any specialist knowledge of pensions and I can see that they've given a page of formulae to help with the calculations.

They're asking me to compare two types of pension arrangement – annuities and drawdown. I remember reading something about that in Subject CP1. I think they changed the rules on annuities a few years ago but I can't remember the details.

They've also given three scenarios in the table. So that will be similar to the other CP2 projects I've looked at.

2.2 Planning the project

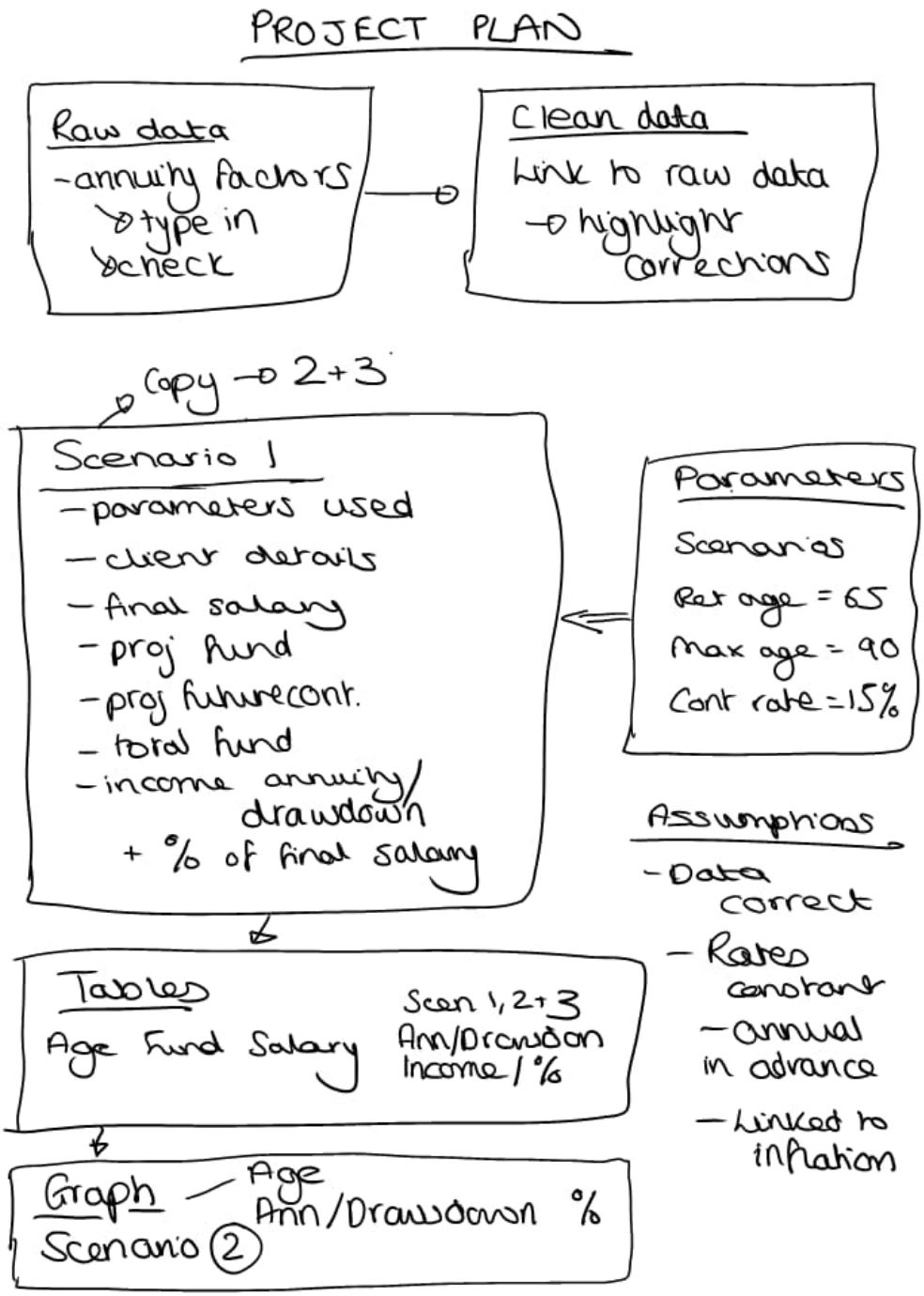
OK, that gives me a good idea of what's going to be involved. I'll spend the next quarter of an hour doing a handwritten plan to map out how I'm going to set up the worksheets in my spreadsheet. I'll also include some checks I can apply and make a note of any issues I need to mention in my audit trail.

[See Project Plan on the next page]

Next comes the data. Hmm. The instructions give quite a few tables of information, but I wouldn't really call those data. We don't have a list of employees with their dates of birth, or anything like that. Maybe the data is the small table with the client profile on the first page. I'm not sure.

Ah! (i) also asks us to check the annuity factors so that must be the 'data'. They probably came from an insurance company or a table off the internet. So, I'll make the annuity factors my data and apply some checks to the numbers.

2.3 Project plan



Then there are the parameters. I can treat the information in the other tables as parameters. There's the client profile table and the percentages in the table of scenarios. There are also the three numbers – the retirement age (65), the drawdown that goes up to age 90 and the 15% contribution rate. These should be parameters because they will feed into the calculations and they might need to be changed later.

There are three scenarios and the calculations look quite complicated. So, I'll set up 3 separate worksheets for these.

After that I'll add a ResuIts worksheet that brings together the key numbers they've asked for in the table in part (iii). I'll write down all the column headings for that, so that I know what exactly I'm aiming for.

And then my final table will be for the graph. As usual, I'll pick out the data I need for the graph and include it on the same sheet as the graph itself.

Well, 15 minutes has gone already. It says that there are only 27 + 10 = 37 marks for the spreadsheet, but 63 marks for the audit trail. So, I need to make sure I allocate enough time to the audit trail and don't spend too long doing the spreadsheet.

2.4 Setting up the audit trail

In fact, I'll set up my audit trail now. I prefer to do my audit trails in Word, rather than trying to squeeze things into columns in Excel. So, let's create a new Word document ... and let's give the new file a name ... File > Save *... I'll give it the name I've been told to use with my ARN in ... and I'll make a note of which folder I've put it in, so that I can find it again later.*

I'll start by typing an introduction describing the background to the project. I'm going to update the rest of the audit trail as I go along, after I've done each section of my spreadsheet.

[If you want to refer to the student's finished Audit Trail as you're reading through, you can find it in Section 3.]

2.5 Setting up the spreadsheet (student's commentary)

We haven't been given any data in a spreadsheet to work with, so I'll just set up a new spreadsheet.

Note

In the printed book the colours used by the student show as shades of grey, but the student has used actual colours in their spreadsheet. If you want to see the actual spreadsheet, you can download it from the ActEd website. This can be downloaded from the ActEd website at ActEd.co.uk (Subjects, Core Practices, CP2).

Data

I'll start with the data. So, if I double-click on the tab name 'Sheet1', I can then change the name to 'RawData'.

Since I've only be given a hard copy of the data (the annuity factors), I'll have to type these in myself. I'll type in a table of annuity factors exactly as they appear in the instructions. I'll use very simple formatting, just changing the 'bits round the edge' to bold to distinguish them from the values in the middle of the table. Excel doesn't show the 0 when you type 19.0, which makes the numbers look inconsistent. So, I'll also set all the numbers to show 1 decimal.

Hmm … I must have made a mistake. I've typed the number 17.3 twice. Actually, it looks like there's a mistake in the table we've been given. One of those 17.3's is wrong. Actually, that's good because I can include some automated checks on the numbers, which should earn me some marks.

How can I check these numbers? These numbers represent the cost of a pension of $1 a year, so they must basically be values of a_x *– or probably* $\ddot{a}_x$ *– since it says that the drawdown pensions are paid at the start of the year. I know from the other actuarial subjects that these should go down as the person gets older and they should also go down as the interest rate increases. To check that they go down I'll type the formula* =IF(AND(B5>B6,B6>B7,B7>B8,B8>B9),"OK","Error!") *in cell B10. I can now copy this formula across to the other columns. Good! It's picked up the error in the 4% column.*

I can do something similar for the rows. In cell F5 I'll type the formula =IF(AND(B5>C5,C5>D5,D5>E5),"OK","Error!") *and then copy it down the column. These are all ok this time – no new errors.*

	A	B	C	D	E	F
1	**RAW DATA**					
2						
3			**ANNUITY FACTORS**			
4	**AGE**	**2%**	**3%**	**4%**	**5%**	CHECKS
5	**55**	22.4	20.5	18.7	16.9	OK
6	**60**	20.6	19.0	17.3	15.6	OK
7	**65**	18.9	17.4	17.3	14.3	OK
8	**70**	17.2	15.8	14.4	13.0	OK
9	**75**	15.5	14.2	13.0	11.7	OK
10	CHECKS	OK	OK	Error!	OK	

Screenshot 1 – RawData worksheet

It doesn't really make sense here to do the usual kinds of summary statistics. Calculating the average etc doesn't make much sense. So I'll leave it at that.

I'll now set up a new tab for the corrected data I'll use for the later calculations. I'll call it 'CleanData'. I can do this quickly by right-clicking on the RawData tab name and then selecting 'Move or Copy …' and ticking the 'Create a copy' box. I then need to link the entries by formula to the original data. So I click in cell B5 in the CleanData tab and then start typing = and then click over to the RawData tab, pick out cell B5 and press Enter. Excel enters the formula =RawData!B5. *I can then copy this formula to the whole table. Now, if anyone makes any corrections to the raw data later, these will follow through automatically.*

	A	B	C	D	E	F
1	CLEAN DATA					
2						
3			ANNUITY FACTORS			
4	AGE	2%	3%	4%	5%	CHECKS
5	55	22.4	20.5	18.7	16.9	OK
6	60	20.6	19.0	17.3	15.6	OK
7	65	18.9	17.4	15.85	14.3	OK
8	70	17.2	15.8	14.4	13.0	OK
9	75	15.5	14.2	13.0	11.7	OK
10	CHECKS	OK	OK	OK	OK	

Screenshot 2 – CleanData worksheet

I now need to amend the incorrect value. It's the 17.3 in the middle of the 4% column. It looks as though someone has copied this from the number above. But what value should I use? They haven't told us what mortality table these numbers are based on, so I can't just look it up. And anyway, these probably come from an insurance company and they will have adjusted the rates to allow for expenses and profits.

The numbers seem to progress fairly steadily in the table. So I can probably just average the ones either side for the moment and make a note in the audit trail that the correct number needs to be established. If I average above and below I get 15.85, the same as if I average either side. So I'll use that number. In fact, I can say that I've averaged the four surrounding numbers, which sounds a bit more scientific. I'll use dark shading for that cell to show that it's a correction and I'll change it to 2 decimal places so that I can see the exact value I've used. And I'll make a note in the audit trail to say that I've used manual intervention here.

Another very simple reasonableness check I could mention is to say that with a low rate of interest such as 2%, the discounting will have very little effect, so the annuity factors should be just a little smaller than the life expectancy at that age. So, 75-year-olds will live to 90-something, which seems right.

Which reminds me … I need to type up the description of the data preparation in the audit trail before I forget.

Right. I think I've written enough about the data preparation for anyone looking at my spreadsheet to see what I've done. I'd better press on …

Parameters

I'll set up a new tab for the parameters. I'll arrange the rates for the three scenarios in a table, as in the instructions. I can put the other parameters separately below. I'll add the letters used for these in the calculations (R and M) for reference.

	A	B	C	D
1	**PARAMETERS**			
2				
3			**SCENARIOS**	
4		**Scenario 1**	**Scenario 2**	**Scenario 3**
5	**Investment return (i)**	4%	6%	8%
6	**Salary increases (j)**	3%	4%	5%
7	**Inflation (k)**	1%	2%	3%
8				
9				
10	**OTHER PARAMETERS**			
11	Retirement age (*R*)	65		
12	Maximum age (*M*)	90		
13	Contribution rate	15%		

Screenshot 3 – Parameters worksheet

Scenario calculations

Now I need to work through each of the calculation steps in turn.

In part (ii), I need to calculate the final salary for each client in Scenario 1. It looks like all these calculations are for all clients and just Scenario 1. So, I'll set up a Scenario 1 worksheet. For ease, I'm going to link the parameters that I need on this worksheet so they are there when I need them.

OK, so I'll set up a table with the clients in the rows. Perhaps these should go in the parameters worksheet as they aren't going to change for the other scenarios … yes, I'll add them there and then link it through to the calculations.

Back to part (ii) then and the expected final salary for each client. I'll need to know how long each client has until retirement so I'll calculate this first. The retirement age is always the same and I've included that in my Parameters worksheet.

The current salary will then increase with salary increases each year until retirement. So, I need to multiply the current salary by (1+salary increases) to the power of the duration to retirement. That wasn't too bad!

Next, in part (iii), I have to project the current fund value at retirement. This is only worth 1 mark so it should be straightforward. I have the investment return, so it will just be the current fund value multiplied by (1+investment return), again to the power of the duration to retirement. Oh yes, I was given this in the question! That isn't great for the youngest client, but it increases with age which is what I'd expect. Oh, I could add a check that this increases as expected.

Part (iv) is to calculate the projected value of the future contributions at retirement. This is worth more marks so I think this is going to be a bit harder. Oh … there was something about this in the formulae section … here it is, the second bullet point. OK, so I have the proportion of salary that is contributed (p) and I have the starting salary, and all the other elements too! It's quite a long formula so I think I'll break it up – I'll do the bit in the square brackets first, then multiply it by the other bits to get the final projected value. I'll call the first step 'Future contributions factor'.

So, the projected value of the future contributions is reducing, which seems reasonable as the older you get, the less time there is to save for retirement. I should add a check in that this is the pattern though.

On to part (v), I need to calculate the total fund available at retirement. So, that will be the current fund with investment growth and the future contributions, my answers to part (iii) plus my answer to part (iv).

Now, on to part (vi), the income if they purchase an annuity. The annuity factors were in the table of data I checked in part (i). This will be the same for all the clients in Scenario 1, so I can include this at the top of the worksheet. I'll look it up from the table based on the retirement age parameter. What is the interest rate I should use though? The question says it is the rate of inflation plus 1%, so I can work that out too. I'll use an HLOOKUP to find the right position in the table depending on the inflation rate as that is changing for the scenarios. I'll have to make sure I document in my audit trail that if the retirement age changes this formula will need updating.

I'm sure I could probably think of a way to link this formula to the retirement age parameter, but it would take me too long to do this and I need to get on with the rest of the calculations.

So, now I just need to divide the total fund at retirement that I calculated in part (v) by the annuity factor to give the income.

Next, in part (vii), I need to work out how much they will get if they use drawdown. Hmmm … I'm not sure what to use as an annuity factor this time. Hang on, wasn't there another formula in the question that I haven't used yet, I wonder if that will help? Yes, that's it! And just like in part (v) that will be the same for all the clients so I can just add that at the top of the worksheet too. Now, I can divide the total fund at retirement for each client by this factor to get their income.

I must be nearly there now?! Yes, just part (viii) before I copy my worksheet across, the percentage of their final salary that they would get as income. That's straightforward, the incomes from part (vi) and (vii) divided by the final salary I calculated back in part (ii).

Phew! So, now I need to copy this worksheet for Scenarios 2 and 3. It is just the parameters at the top of the page that will change so that is quite straightforward.

Time to update the audit trail.

Note

In the exam you may want to update your audit trail as you build your spreadsheet model. We would suggest documenting your work as you go, so document the data and checks once they are complete, then the parameters once they are included in the spreadsheet, and finally each of the modelling steps once you are reasonably happy with them. If, as here, you are asked to produce the same calculations in multiple scenarios, you may want to complete one scenario and fully document it before copying it across. Remember that there are more marks available for the audit trail than for the spreadsheet in Paper 1.

The Parameters tab is easy to document but for the scenario calculations I need to remember to explain all the formulae in words.

Assumptions

I need to make a list of the assumptions made in this model. I already made a note of some of these when I did my initial plan. I'll put these near the beginning of my audit trail.

Results table

The results table is easy to create. I just need to set up a separate Table tab and pick out the entries listed in the instructions.

	A	B	C	D	E	F	G	H	I
1	TABLE								
2									
3				SCENARIO 1		SCENARIO 2		SCENARIO 3	
4	Age	Fund now (£K)	Salary (£K)	Annuity	Drawdown	Annuity	Drawdown	Annuity	Drawdown
5	20	0	20	45%	47%	62%	66%	87%	92%
6	30	10	25	36%	38%	48%	51%	64%	68%
7	40	25	30	28%	30%	36%	38%	45%	48%
8	50	50	35	22%	23%	26%	28%	32%	33%
9	60	100	40	18%	19%	20%	22%	23%	25%

Screenshot 5 – Table worksheet

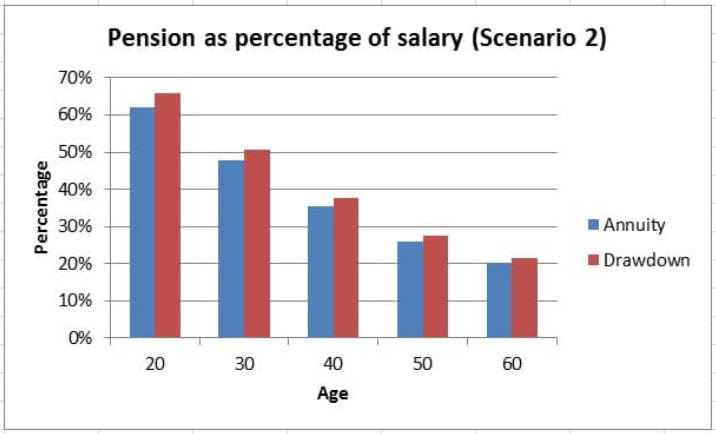
Graph

Finally, I need to set up a tab for the graph. I'll include a 'Data for graph' section with the numbers I need to use. It says to base the graph on Scenario 2, so I need to link to these values.

A good type of chart to use for comparisons like this is a 'clustered column chart'. I think it will do it automatically if I just highlight my complete table of data (cells B4 to C9, including the headings) and then select Insert, click Column and pick the first chart type (2D clustered column). Yes, there we go. And red and blue are sensible colours to use.

To get the ages appearing on the x axis, I right-click on the graph, choose Select data, move to the right-hand panel, click Edit and then highlight the range of cell containing the ages (cells A5 to A9). Then press OK.

	A	B	C
1	GRAPH		
2			
3	DATA FOR GRAPH		
4	Age	Annuity	Drawdown
5	20	62%	66%
6	30	48%	51%
7	40	36%	38%
8	50	26%	28%
9	60	20%	22%



Screenshot 6 – Graph worksheet

I just need to add a title and to label the axes. To do these I need to highlight the graph, then select Add Chart Element from the Chart Layouts menu at the top. I can now use the Chart Titles and Axis Titles features.

I've been going for about 2½ hours now, so let's finish off the audit trail.

3 Audit trail

This audit trail relates to the spreadsheet Worked Example Project (Paper 1).xlsx.

Background

We have been asked by *LongerLives* to carry out a comparison of two pension arrangements for employees with personal pension plans – annuities and drawdown.

The accompanying spreadsheet calculates the projected pension amounts for the annuity and drawdown options under three different economic scenarios and a graph comparing the two arrangements for one of the scenarios.

Detailed descriptions of each worksheet are set out below.

The following colour conventions have been used:

- Pale shading indicates input cells that can be changed by the user
- Dark shading indicates corrected data
- Checks are shown in red text.

No macros or user-defined functions have been used.

Assumptions

The spreadsheet model makes a number of assumptions:

- The annuity factors provided are correct (after any adjustments have been made).
- The retirement age and the maximum age are assumed to be fixed.
- The rates of investment return, salary increases and inflation assumed in each scenario will remain constant in the future.
- The value assumed for the maximum age is appropriate.
- Pensions are paid annually in advance and are linked to inflation.
- Employees will be able to draw down their pensions in the future without any restrictions being introduced.

Data (annuity factors)

We have been provided with a table of annuity factors (provided by *LongerLives*) for a selection of retirement ages and interest rates.

These have been entered manually in the RawData worksheet. Checks have been included to ensure that these factors decrease with both the age and the interest rate, as would be expected. These revealed an error in the value for age 65 with 4% interest. This was amended to be the average of the values around the data point.

Other summary statistics, such as average, maximum and minimum values were not considered useful here.

The CleanData worksheet contains the annuity factors that will be used for the subsequent calculations. These are linked by formulae to the values in RawData. As the values appear to progress smoothly, the incorrect value has been manually overwritten as a temporary measure with the average of the four surrounding numbers. The correct value needs to be established and entered in the RawData tab. The formula from the cell above the incorrect value in CleanData can then be copied down.

As another reasonableness check, the annuity factors at the lowest interest rate appear to be consistent with life expectancies for the various ages.

Note that, if more data values need to be added to the table (*eg* more interest rates), the formulae on the CleanData tab will need to be copied across the worksheet and references elsewhere to this range of cells will need to be adjusted.

Parameters

Data on economic parameters and employee profiles was provided for use within the spreadsheet model.

The following parameters can be set here by the user:

- the investment return (i), salary increase rate (j) and inflation rate (k) for each scenario
- the retirement age (R), maximum age (M) for drawdown and contribution rate
- the employee profiles (age, fund now and salary) to be used in the calculations.

The employee profile data appears reasonable, the youngest age has the lowest fund and salary values. The fund values and salaries increase with age, as would be expected.

Scenario calculations

The worksheets Scenario1, Scenario2 and Scenario3 carry out the pension projections for each of the three scenarios.

The three economic variables at the top are linked to the corresponding parameter values. These are the only inputs that differ between the scenarios.

Annuity factors

The annuity factor is extracted from the annuity table in CleanData using an HLOOKUP function. The value is based on the inflation rate plus 1%.

Note that this formula currently assumes a fixed retirement age of 65, irrespective of the retirement age parameter. If the retirement age is changed, then this formula will also need to be changed.

The drawdown annuity factor is calculated using the following formula:

$$(1 + i)\left[\frac{1-\{(1+i)/(1+k)\}^{R-M}}{i-k}\right]$$

where:

R = Retirement age

i = Investment returns

M = Maximum age (for drawdown)

k = Inflation

CHECKS

For Scenario 2, the investment return and inflation parameters have increased compared to Scenario 1. We would expect the annuity factor to reduce as a result of this change – this is what is seen in the calculated values.

For Scenario 3, the investment return and inflation parameters have increased compared to Scenarios 1 and 2. So, we would expect this scenario to have the lowest annuity factors, this is what is seen.

Checks have been included for both of these within the spreadsheet next to the annuity factors in the Scenario 2 and Scenario 3 worksheets.

Main calculations

The details of each client (Age, Fund now and Salary now) are linked to the parameters worksheet.

The following calculations are carried out for each client:

- n (years to retirement) – based on the parameters for the retirement age, works out how long that client has to retirement by subtracting the current age from the retirement age.
- Final Salary – the final salary at retirement, calculated based on the current salary with salary inflation (from the parameters at the top of the worksheet) for n years.
- Fund value at retirement – the expected value of the current fund at retirement, takes the current fund value and increases it with investment returns (from the parameters at the top of the worksheet) for n years.
- Future contributions factor – calculates part of the formula for the projection of future contributions, allows for investment returns for n years, less salary increases for n years, divided by the rate of investment return less the rate of salary growth.
- Value of future contributions at retirement – multiplies the future contributions factor by the contribution rate (from the parameters worksheet), the current salary and (1+ investment returns).
- Total retirement fund – sums the fund value at retirement and the value of future contributions at retirement.

- Annuity Income – calculates the expected annual income if an annuity is purchased. Uses the annuity factor calculated at the top of the worksheet, calculated as total retirement fund divided by annuity factor.
- Annuity % of final salary – calculates the percentage of the final salary that the annuity would provide, annuity income divided by final salary.
- Drawdown income – calculates the expected annual income if income drawdown is used. Uses the drawdown annuity factor calculated at the top of the worksheet, calculated as total retirement fund divided by the drawdown annuity factor.
- Drawdown % of final salary – calculates the percentage of the final salary that the drawdown income would provide, drawdown income divided by final salary.

CHECKS

- The check below the values of n ensures that the average age in the table and the average value of n sums to the retirement age R.
- The check below the Fund Value at Retirement column uses an AND function to ensure that the values of the fund increase down the column, *ie* with increasing age, as there has been longer for the fund to be invested and grow with investment returns. For Scenario 3, this check does not hold as the investment growth is high, and this outweighs the benefit of the higher starting fund value at older ages.
- The check below the Value of future contributions at retirement columns uses an AND function to ensure that the values of the fund decrease down the column, *ie* with increasing age, as at older ages there is less time for the future contributions to be made before reaching retirement age.
- For each scenario, given the difference in the annuity factors between the annuity and drawdown approaches, the difference in the income and percentage of salary appears reasonable. This has been checked in the final column of the data by comparing the income ratio of annuity to drawdown approach by the ratio of the annuity factors. This has been repeated for the percentage of final salary.

Table

The Table worksheet summarises the results in the form of a table.

The entries in the first three columns of the table are linked to the employee profiles in the Parameters worksheet. The other entries are linked directly to the two corresponding columns in the Scenario tabs (headed '% of final salary').

Graph

The Graph worksheet produces a graph comparing the pension percentage amounts for each client under the two arrangements. The input values for the graph are linked directly to the columns with the same names in the worksheets for Scenario 2.

A clustered column chart has been used here, as this makes it easy to compare the results for the different scenarios.

4 Sample marking schedule

Marking schedule – Question 1 (up to 27 marks)

(i) *Checks on annuity factors*

- Checking annuity factors reduce as interest rate increases [1]
- Checking annuity factors reduce as age increases [1]
- Identification of incorrect value (age 65, interest rate 4%) and reasonable correction [1]

[Total 3]

(ii) *Calculation of the expected final salary at retirement for each client under Scenario 1* [2]

(iii) *Calculation of the projected current fund value at retirement for each client under Scenario 1* [1]

(iv) *Calculation of the projected value of future contributions at retirement for each client under Scenario 1* [3]

(v) *Total fund value available at retirement for each client under Scenario 1* [1]

(vi) *Expected annual income if annuity purchased at retirement for each client under Scenario 1:*

- selection of annuity value [1]
- calculation of income [1]

[Total 2]

(vii) *Expected annual income if drawdown used at retirement for each client under Scenario 1:*

- calculation of annuity value [2]
- calculation of income [1]

[Total 3]

(viii) *Percentage of each client's final salary at retirement under annuity and drawdown approaches under Scenario 1:*

- annuity approach [1]
- drawdown approach [1]

[Total 2]

(ix) *Calculation of values for Scenarios 2 and 3:*

- Fund value at retirement for Scenario 2 [½]
- Value of future contributions at retirement for Scenario 2 [½]
- Total retirement fund value for Scenario 2 [½]

- Income under annuity and drawdown approaches for Scenario 2 [½]
- Percentage of salary under annuity and drawdown approaches for Scenario 2 [½]
- Fund value at retirement for Scenario 3 [½]
- Value of future contributions at retirement for Scenario 3 [½]
- Total retirement fund value for Scenario 3 [½]
- Income under annuity and drawdown approaches for Scenario 3 [½]
- Percentage of salary under annuity and drawdown approaches for Scenario 3 [½]

[Total 5]

(x) *Appropriate tabulation of the data required* [3]

(xi) *Suitable chart showing retirement income as a percentage of final salary under Scenario 2:*

- bar chart [1]
- clear labelling of axes and title [1]

[Total 2]

Marking schedule – Question 2 (up to 10 marks)

(i) *Auto checks on the modelling completed in Question 1:*

- check years to retirement reduces as age increase [1]
- check fund value at retirement increases as age increases [1]
- check value of future contributions reduces as age increases [1]
- any other reasonable auto check [1]

[Maximum 3]

(vii) *Good spreadsheet practice:*

- no hard-coding (use of parameters and no copy and paste values) [1]
- flagging rows/columns that don't copy down [1]
- easy to follow (inputs, checks and outputs easy to find) [1]
- logical order (left to right, top to bottom, within and between sheets) [1]
- clear and accurate labelling within the spreadsheet – rows, columns, worksheets [1]
- use of simple techniques (but not oversimplified) – formulae not overly complex / steps split out and calculations built up [2]

[Total 7]

Marking schedule – Question 3 (up to 63 marks)

Audit approach

(i) *Communication skills:*

- HOW the steps have been executed is clear, rather than just WHAT has been done being stated [2]
- there is sufficient technical detail and does not include excessive use of Excel formulae to describe steps [1]
- sufficient detail is provided in the audit trail as a stand-alone document [1]

[Total 4]

(ii) *Fellow student can review and check the methods used in the model:*

- for a newcomer, the audit trail is easy to follow, *ie* the marker does not have to look at the model directly to understand what has been done [2]
- all the steps are correctly and clearly described [1]
- the workbook is well labelled and is easy to navigate through [1]
- where there are, or could be errors, the audit trail would enable the student to identify and correct errors [2]
- danger areas in the spreadsheet are appropriately flagged (*eg* Goal Seek) [1]

[Total 7]

(iii) *Senior actuary can scrutinise and understand what has been done:*

- a reasonable overview of the model is included [1]
- there are clear statements of the assumptions made, *ie* concise list of value added assumptions, not long list with many not adding value [1]
- data sources are clearly described [1]
- it is easy for a senior actuary to pick up the high-level detail of the modelling – can pick up the high level without having to read all the detail [2]
- the level of detail is appropriate for a senior actuary – explanations are clear and concise [1]
- reasonableness checks are clearly stated and their results explained [1]

[Total 7]

(iv) *Written in clear English:*

- the audit trail is written in clear, crisp and flowing English [2]
- accurate spelling [1]
- the audit trail is laid out well, with good formatting to aid clarity [1]

[Total 4]

(v) *Written in a logical order:*

- data is introduced before referring to it [1]
- assumptions are stated before using them [1]
- the methodology is described in a logical order, *ie* nothing is introduced which would require that the reader has read ahead [1]

[Total 3]

Audit content

(vi) *All steps clearly explained:*

- the level of detail in the audit trail is appropriate for a newcomer to understand what has been done [1]
- all the methodology steps are set out clearly [2]
- data provided and any necessary adjustments made are described and justified clearly [1]
- all reasonableness checks applied are adequately documented [1]
- areas where manual intervention or caution is required are well flagged (*eg* Goal Seeks or non-standard model areas) [1]
- the marker does not need to look directly at the model to understand what has been performed [2]

[Total 8]

(vii) *Reasonableness checks:*

- annuity factors being reasonable by age / interest rate [1]
- client profiles reasonable based on age and career stage [1]
- projected fund values at retirement appear reasonable given age and starting value for fund [1]
- comment about different fund value pattern for Scenario 3 and that it is driven by impact of high investment returns negating the value of higher fund values at older ages [1]
- values of future contributions appear reasonable given age and time to retirement [1]
- comment on expected relationships between annuity values for different scenarios [1]
- any other sensible reasonableness check [1]

[Maximum 5]

(viii) *Signposting / labelling CLEAR:*

- the audit trail allows the user to follow the model through [1]
- the audit trail allows the user to understand each calculation easily [1]
- there is adequate signposting in the audit trail to describe the purpose of each tab [1]
- model labelling is consistent with the audit trail (data, parameters, scenarios, outputs, charts) [1]

[Total 4]

(ix) *Statement of assumptions made:*

- 1 mark for each distinct, reasonable 'added value' assumption listed [Maximum 5]

(x) *All model steps accurately covered:*

- overview [1]
- data used, including source [1]
- data checks [1]
- date error and adjustment [1]
- calculation of final salary at retirement [1]
- calculation of fund value at retirement based on current fund value [1]
- calculation of fund value at retirement based on future contributions [2]
- calculation of total fund available at retirement [1]
- calculation of annuity factor for annuity approach [1]
- calculation of annuity factor for drawdown approach [2]
- calculation of expected income in retirement for annuity and drawdown approaches [1]
- calculation of income as percentage of final salary under annuity and drawdown approaches [1]
- production of table of results [1]
- production of chart of scenario 2 income as percentage of final salary [1]
- any other distinct and valid step [1]

[Maximum 16]