

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINATION BOOKLET – ONLINE VERSION

November 2015

CA2: Model Documentation, Analysis and Reporting

Paper 2

This document must be destroyed after the examination has been completed

Please note that the content of this booklet is confidential and students are not to discuss or reveal the contents under any circumstances.

Examination instructions

1. You must download the exam assignment at the start of the exam time stated. All times given are UK times. Please note that it will not be available to you at any other time. The morning sitting will take place at 09.00hrs to 12.15hrs and the afternoon sitting is 14.00hrs to 17.15hrs. The exam paper is three hours plus 15 minutes reading time. **It is your responsibility to ensure that all of your files are submitted within this time limit. Failure to do so will result in your assignment not being marked.** To submit your assignment please upload your documents as instructed or e-mail your files to online_exams@actuaries.org.uk. Only your first submission will be accepted and marked.
2. You may refer to any written or electronic reference material provided as part of the CA2 exam. You have been supplied with all data electronically at the start of the exam time. It is recommended that you use the first 15 minutes as reading and planning time.
3. The work you submit **MUST** be saved in Microsoft 2007 format, i.e. using docx (Word) or xlsx (Excel) file extensions. Do not embed documents in your spreadsheet.
4. You must build your model from scratch and not use an imported e-template.
5. You are required to work through the exam assignment without assistance from another person. The assessment regulations of the Institute and Faculty of Actuaries apply as set out in the Examination Regulations except that you may refer to reference material. By submitting your files you are confirming that all material is entirely your own work and you wish this to be taken into account for this assessment.
6. Save your work regularly. You do not have to print out your work but you may choose to do so from time to time if you prefer to check a printed copy. Saving your work is your responsibility so failure to do so will not be a significant mitigating circumstance.
7. You must not discuss or disclose the material. To do otherwise may lead to a disciplinary case.
8. You are reminded that by undertaking this exam you are bound by the Institute and Faculty of Actuaries' Examination Rules and Regulations.
9. At the end of the allotted time or when you have completed your exam, you need to submit your work.

Your filenames must include your ARN (e.g. Summary_90XXXXX.docx) and each file should also contain your ARN as a header or footer on at least one page. You will receive an acknowledgement by email from the Online Exams Team confirming receipt. The Online Exams Team will send you an email after the exam requesting you to delete all your files relating to the exam, together with your planning notes and any print-outs. If you experience difficulties in submitting your work, you must inform the Online Exams Team immediately at online_exams@actuaries.org.uk or T. +44 (0)1865 268 255.

Professional behaviour is mandatory and no material relating to the exam may be disclosed or discussed with others, nor used in a further attempt at the exam.

Failure to comply with this will be deemed to be a breach of examination regulations and may result in disciplinary action.

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Exam requirements

1. Read the background document, which describes the scenarios that need to be modelled and documented for this project. Technical assistance for the modelling work, should you require it, can be found in the additional guidance contained in this booklet.
2. Read the audit trail which has been written by your colleague Sam, another actuarial student, for the calculations that he performed. This will assist you in following and understanding the calculations performed in the Excel model provided.

You are not required to add to or amend the audit trail.

3. Expand the spreadsheet model to produce the required additional calculations for option C and the low cost scenario. You should ensure that the additional work you undertake on the spreadsheet contains appropriate self-checks.
 - (i) Rebase the equity index to 100 to allow a chart of the equity returns and the bond returns to be produced.
 - (ii) Expand the fund projection to include the option C portfolio.
 - (iii) Expand the internal rate of return calculation to include the option C result.
 - (iv) Repeat the projection and internal rate of return calculations under the low cost fund scenario.

You should assume that your colleague's calculations have been checked and are correct.

[7]

4. Illustrate the following using five suitable charts:
 - A comparison of the equity fund and bond fund indices, with the equity fund index rebalanced to start from 100 to make it comparable with the bond fund index.
 - The total projected portfolio values under each of the three original options.
 - The projected portfolio internal rate of return under each of the three original options.
 - The total projected portfolio values under each of the three options and under both the original and low cost scenarios.
 - The projected portfolio internal rate of return under each of the three options and under both the original and low cost scenarios.

[8]

[Sub-total 15]

5. Prepare a summary document of around five to seven pages, capturing the main features and results of the work done by you and your colleague. You can assume that the summary is being prepared for your boss, a senior actuary, who will present the work to the client.

Your summary should include the following:

- purpose of the project, data, method and assumptions used by you and your colleague
- results, including charts
- commentary on the results, key conclusions and suggested next steps

The summary should cover the full scope of the project, including the partial results, which were modelled in the spreadsheet provided.

You are not required to add to or amend the audit trail.

Marks available for the summary:

Methodology (including purpose, data, method and assumptions)	[20]
Results, including charts	[10]
Commentary on results and conclusions	[20]
Next steps	[25]
Drafting	[10]

[Sub-total 85]

[Total 100]

Background

You are an actuarial student working for a consultancy in the country of Actuaria.

One of the clients of the consultancy, Mr Brown, has approached your boss, a qualified actuary, and asked her to perform some modelling in order to help him plan for his retirement.

Mr Brown is planning on investing \$1,000 at the start of each year into some investment funds to build up a portfolio for his retirement. He is considering a mixed portfolio containing two different funds, one which is invested in equities and targets the Equity 500 index, and another fund that invests in 10 year Government bonds.

The funds have the following annual management charges:

- Equity fund: 1% per annum
- Bond fund: 0.5% per annum

He has identified the following three options for his portfolio:

Option A: Each year, invest \$600 in the equity fund and \$400 in the bond fund.

Option B: Each year, invest \$1,000 and rebalance the portfolio at the end of each year so the overall split of 60% equity and 40% bonds is maintained.

Option C: Each year, invest \$1,000 and rebalance the portfolio at the end of each year, where the split each year is determined by his age at that time, such that the equity percentage is 105% minus his age. Mr Brown is currently exactly 25 so the initial percentage is 80% in the equity fund.

He would like to have a better understanding of the fund values that are expected to be achieved when he is 65 years old under each of these options.

Your boss has already asked your colleague, Sam, to perform a modelling exercise to help Mr Brown assess the relative merits of each of the options above. She has suggested that they use the actual performance figures for the Equity 500 and Government 10 year bond indices over the years 1973 to 2013 for this purpose. Your boss has sourced the historic values of these indices from the Actuarial's National Statistics website to model the three options.

Sam was also asked to summarise the relative performance of the two indices, to illustrate to Mr Brown the different returns and the volatility observed. Finally, Sam was asked to calculate a single internal rate of return which gives the same projected fund value for each portfolio.

Sam has completed the projections for options A and B only, and produced an audit trail for the work completed. A copy of the audit trail is given below. Sam is currently at a client meeting and cannot be contacted. In Sam's absence, your boss has asked you to enhance the model to include option C and some further scenarios set out below.

Your boss is a supporter of low cost fund investing and wishes to discuss this topic too with Mr Brown. She has identified alternative low cost funds that Mr Brown could invest in which also track the same indices. The low cost annual management charges are:

- Equity fund: 0.3% per annum
- Bond fund: 0.15% per annum

You have been asked to repeat the projections of the three portfolios but assuming the funds have the low cost annual management charges. You are requested to produce two new charts comparing the three options under the original and low cost scenarios. You should chart the projected fund values and the internal rates of return achieved.

Additionally, your boss needs you to prepare a summary document covering both the original and low cost approaches.

You are not expected to include the additional modelling request in the audit trail, but your results should be included in the summary.

Additional guidance

Use of STDEV() function

Estimates standard deviation based on a sample. The standard deviation is a measure of how widely values are dispersed from the average value (the mean).

Usage: STDEV(range of numbers)

Use of IRR() function

Returns the internal rate of return for a series of cash flows. These cash flows do not have to be even but they must occur at regular intervals. The internal rate of return is the interest rate received for an investment consisting of payments (negative values) and income (positive values) that occur at regular periods.

Usage: IRR(values)

The values are a range of cells that contain numbers for which you want to calculate the internal rate of return. The values must contain at least one positive value and one negative value to calculate the internal rate of return. IRR uses the order of values to interpret the order of cash flows. Be sure to enter your payment and income values in the sequence you want.

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Audit trail

The following audit trail should be read alongside the provided model.

Objective

The purpose of the model is to compare retirement strategies for our client Mr Brown. He plans to save \$1,000 per annum for the next 40 years and is considering a range of investment options based on an equity fund and a bond fund as outlined below.

- **Option A:** Each year, invest \$600 in the equity fund and \$400 in the bond fund.
- **Option B:** Each year, invest \$1,000 and rebalance the portfolio at the end of each year so the overall split of 60% equity and 40% bonds is maintained.

We have projected the total fund that Mr Brown may expect after 40 years under each of the options using historic data as a basis for future returns. We have calculated the overall internal rate of return of the projected portfolios.

Data and assumptions

The client, Mr Brown, has identified two funds that he would like to invest in and they have the following annual management charges:

- Equity fund: 1% per annum
- Bond fund: 0.5% per annum

Also the index values for the years 1973 to 2013 for the Equity 500 index and the Government 10 year bond index have been sourced from the Actuarial National Statistics website. The index data was checked for reasonableness by eye for any outliers but was assumed to be correct. Also the fund annual management charges look reasonable.

The following assumptions were made:

- The past investment returns are a good indication of future performance and volatility.
- The funds will track the indices perfectly other than for the annual management charge.
- Investment expenses and charges are ignored other than the annual management charges.
- Any tax implications are ignored.

Performance sheet

This sheet presents the market data given. It also calculates both annual performance net of annual management charges (AMCs) and calculates basic performance figures.

- The annual percentage change in the index value is calculated by dividing the current value by the previous value and subtracting 1. The AMC is then deducted from the percentage change. The annual performance percentage over 40 years is calculated as the fortieth root of the index value in 2013 divided by the value in 1973 (i.e. this ratio is raised to the power of one divided by 40). This percentage minus 1 and minus the AMC gives the overall annual performance over the 40 year period.

Reasonableness check: This overall annual percentage figure was compared to the average of all of the annual figures for 1974–2013 and the differences considered. The results were reasonably similar with more variation in the equity fund due to the higher annual variability.

The standard deviation of the annual performance percentages and their minimum and maximum values have also been calculated, using the Excel functions STDEV, MIN and MAX.

Reasonableness check: The equity index shows more variability and a higher/lower maximum and minimum. Due to the nature of equity markets versus bond markets this is to be expected.

Projection sheet

This sheet calculates the fund projections for Option A and B in line with the client's request.

The annual performance percentages for each year are linked through from the previous sheet into the first three columns.

For Option A the projection is set up in the second block of calculations. The number of years (0 to 40) go down the rows of the calculation table.

- In year 0, Mr Brown invests \$1,000, split 60% equity and 40% bonds, at the start of the year. There is a total column alongside.
- For years 1 to 40, the calculation takes the value of the bond or equity fund at the start of the previous year, increases it by the respective investment return for the previous year derived from the performance table. This gives the value at the end of the year. The additional annual investment of \$1,000 is then added, split by the relevant percentage (\$600 equity, \$400 bond), as outlined above.
- For year 40, this represents when Mr Brown is exactly 65 years old. The calculation in this row only includes the investment return for the previous year. Mr Brown does not make the \$1,000 investment when he retires.
- The approach in years 0 and 40 differ from the rest of the projection calculation and this is highlighted in yellow in the model.

For Option B the projection is set out to the right of Option A on the “Projection” sheet. The calculation is similar to Option A, but for Option B there are three additional columns included to rebalance the portfolio at the end of each year.

- The percentage that is to be rebalanced into the equity fund is given in the “% in equity fund” column (60% for Option B).
- The rebalanced equity amount is calculated as 60% of the total fund before rebalancing.
- The rebalanced bond amount is calculated as the total fund before rebalancing *minus* the rebalanced equity amount.

Results sheet

This sheet calculates the internal rate of return (IRR) for Option A and Option B and summarises the results of the calculations.

In the first three columns, the IRR is calculated for each option. These use the IRR Excel function at the top of the calculation table. The rest of the table sets out the cashflows under each option and the final fund value received. For Option A, the annual \$1,000 investment is shown as *minus* \$1,000 in each year for 40 years as the payments are made by the client into the fund. In year 40 the final projected fund value is paid out hence the large *positive* amount in the last row. The IRR for Option B is calculated in a similar way to Option A.

In the summary table alongside the cashflow calculations, the final fund values from the previous projections sheet are set out. A chart of these portfolio values is shown. A chart of the internal rate of return for each option is also shown.

Reasonableness checks: The average return on equities and bonds from the “Performance” sheet was approximately 6% / 7% and the internal rate of return results are in line with this at approximately 7%. Also it is reasonable that the internal rate of return result for Option B is higher than Option A as the final fund is higher.

END OF PAPER