

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORT

September 2016

Subject CA2 – Model Documentation, Analysis and Reporting

Introduction

The Examiners' Report is written by the Principal Examiner with the aim of helping candidates, both those who are sitting the examination for the first time and using past papers as a revision aid and also those who have previously failed the subject.

Possible models with an audit trail or summary are posted on the website. It should be noted that these include more detail than would ordinarily be possible within the time allowed for the examination.

The specimen solutions are based on one possible approach to modelling the assignment set but the examiners gave credit for any alternative approach or interpretation which they considered to be reasonable.

Luke Hatter
Chair of the Board of Examiners
December 2016

A. General comments on the *aims of this subject and how it is marked*

1. The aim of this subject is to ensure that the successful candidate can model data, document the work (including maintaining an audit trail for a fellow student and senior actuary), analyse the methods used and outputs generated and communicate to a senior actuary the approach, results and conclusions.
2. The subject is split into two papers, the first covers the objectives:
 - analysis of data.
 - development of a model with clear documentation.

The second paper covers:

 - ability to analyse the methods used and the model's outputs.
 - ability to apply and interpret the results.
 - communication of the approach, results and conclusions to a senior actuary.
3. As the focus of the subject is on communication the majority of the marks are for the documentation and outputs generated rather than for technical modelling skills. For example, a technical mistake is only penalised once and students can still earn marks for accurate and clear communication of what was done.
4. Candidates who give well-reasoned points, not in the marking schedule, are awarded marks for doing so.

B. Comments on *student performance in this diet of the examination*

PAPER ONE

Modelling

In this section the candidates could gain 30 marks by using the data provided and carrying out the required modelling steps. To ensure the accuracy of the results, as with any data supplied, the candidates are expected to perform an analysis of the data. This analysis should include some checks would confirm that the data supplied is reasonable and free of obvious errors. Most candidates did not include reasonableness checks in their audit trail and lost marks.

Most candidates made a reasonable attempt at the first part of the model and correctly calculated the simulated value of investment. Most candidates also succeeded in producing simulated investment with the higher diffusions. But quite a few candidates could not rank the scenarios and did not produce the sample paths.

The key statistics from the model were often calculated correctly but some candidates did not calculate the key statistics from the formula.

Most candidates did not perform adequate reasonableness checks on the results and lost some of the available 8 marks. Candidates need to be aware of the importance of the relevant reasonable tests in ensuring that the results make sense and the model is robust in producing reasonable results.

Most candidates demonstrated reasonable modelling techniques and gained most of the available marks in this area.

Audit trail

Most candidates offered a well-structured audit trail with sections following the order in which the modelling stages were carried out. The audit trails mostly started with an overview of the model and the assumptions relating to the calculations in the model. Some audit trails lacked sufficient detail in the methodology section, although there were some very good audit trails describing the method and also the reason for carrying out the various steps.

To score well in the method part, candidates need to describe the modelling steps as well as signpost where in the worksheet the calculation has been carried out. Signposting may be provided by reference to the worksheet, tables or row and columns of the worksheet. Almost all candidates provided some description of the method and signposted the calculations by reference to the relevant worksheet. However the candidates who provided a detailed description of the methodology with sufficient technical detail and adequate signposting scored the highest marks in this section.

PAPER TWO

Modelling

In this section 15 marks were available for accurate completion of the additional modelling and production of the required charts. The majority of the candidates carried out the required modelling and produced the relevant charts fairly well. Some charts representing the split between capital repayment and interest offered did not show the total payment and did not gain the full marks. In modelling the additional scenario, some candidates did not determine the level of expense inflation when $NPV=0$ and lost marks.

Summary

The structure of the summary was generally completed to a high standard. The examination question effectively provided an outline for the summary and the points to be included. The vast majority of the candidates offered a summary that followed the same order of the items that they had been requested to include in the summary.

Most candidates did well in producing a list of assumptions. Most candidates produced the required charts but some did not state all the results relating to one or both products.

The description of the modelling approach in the summary needs to be of a different style and depth to that needed in the audit trail as the two documents serve different purposes. While selective use of parts of the audit trail (such as formulae) is acceptable, large scale

reproduction of the method from the audit trail in the summary is inappropriate. A minority of the candidates reproduced sections of the audit trail in the methodology part of the summary. Stronger candidates were able to provide a balanced level of method detail suitable for a senior actuary. Weaker candidates failed to give clear method steps with accurate formulae or descriptions.

Having produced the results, candidates are expected to comment on the results and explore interactions within individual scenarios and the comparison between the results of the scenarios. Often inadequate commentary on the results is due to shortage of time. Candidates are advised to allow sufficient time to analyse the results and comment on the observed pattern. Such commentary indicates the extent to which the purpose of the model and the results it has produced, have been understood.

Often candidates did not include overall conclusions or repeated their comments on the results. Weaker candidates lacked commentary on the results and candidates who passed tended to offer some explanation of the results and provided some overall conclusions.

In the next steps section of the summary, candidates are required to include their recommendation on the next steps to take on the basis of their model and how it works, the results and the analysis of the results. The next steps, therefore, need to be relevant and specific to the particular model. Most candidates were able to produce a list of next steps, but generic next steps from previous exams could not be readily used and some new points were made which often did not gain marks. However, where new points were included that were relevant but not in the specimen answers, these were accepted and gained the full 3 marks. Some candidates did not provide a sufficiently broad range of next steps or alternatively did not provide an adequate explanation to gain all the available marks.

C. Pass Mark

The Pass Mark for this exam was 60.

PAPER 1 (Simulation of Investment Product)

Marking Guide

Q2

(i)

Checks performed

Check that $B(0) = 0$	[1]
Count on number of data elements	[1]
Check on mean of $B(t + 1) - B(t)$	[1]
Check on sd of $B(t + 1) - B(t)$	[1]
Check on max and min	[1]
Check on distribution of $B(t + 1) - B(t)$ compared to $N(0,1)$	[2]

[Maximum 5]

(ii) to (ix)

Calculations performed

Investment Simulation

Correct calculation of amount invested at $t = 0$	[1]
Correct calculation of simulated value of investment at each time period	[4]
Calculation of min, max and mean of modelled values at $t = 20$	[2]
Calculation of corresponding annualised returns	[2]
Calculation of sd of modelled value at $t = 20$	[2]
Calculation of mean of $S(20)$ from given formula	[2]
Calculation of sd of $S(20)$ from given formula	[2]
Correct calculation of the rank of each scenario	[2]
Chart sample paths for scenarios ranked 25, 50 and 75	[2]

Investment Simulation – Higher Diffusion

Simulate investment with higher diffusions	[1]
Calculation of requested statistics and annualised returns	[1]
Calculation of mean and sd of $S(20)$ from given formulae	[1]
Calculate the rank of each scenario	[1]
Chart sample paths for scenarios ranked 25, 50 and 75	[1]
Chart comparing average, max and min for different diffusion scenarios	[2]

[Maximum 26]

Other marks

Good spreadsheet practice

Use of cell references rather than copy & paste	[1]
Use of parameters rather than hard-coding in formula	[1]
Flagging rows/columns that don't copy down	[1]
Use of simple techniques	[2]
Clear and accurate labelling within the spreadsheet	[2]

[Maximum 7]

Other (non data) checks

Mean of modelled values at maturity and mean using provided formula are very close	[1]
Mean of modelled annualised returns and that using formula are close	[1]
Standard deviation of modelled maturity values and that from formula are close	[1]
Reasonable that annualised return on maximum scenario is greater than av return	[1]
Reasonable that annualised return on minimum scenario is less than av return	[1]
Reasonable that minimum projected value is positive (as can't be negative)	[1]
Reasonable that in the worst performing scenario the annualised return is negative	[1]
Reasonable that average maturity values in higher diff coefficient case are similar	[1]

Reasonable that sd of maturity value in higher diff case is higher than base (more volatility)	[1]
Reasonable that max value in the higher diff case is greater than base case (more volatility)	[1]
Reasonable that min value in the higher diff case is less than base case (more volatility)	[1]
Expected that the rank of each scenario remains unchanged in the higher diffusion case	[1]
Setting diffusion coefficient back to the original value produces base case results	[1]
Reasonable that sample paths 25, 50 & 75 are more spread out in the higher diff case	[1]
Reasonable that sample paths 50 is broadly the same in higher diff case	[1]

[Maximum 7]

[Total 45]

Q3 **Audit Approach**

Fellow student can review & check the methods used in model

For a newcomer, the audit trail is easy to follow i.e. 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]
There is sufficient technical detail	[1]
The workbook is well labelled and is easy to navigate through	[2]
Where there are, or could be errors, the audit trail would enable the student to identify and correct errors	[1]
Danger areas in the spreadsheet are appropriately flagged (e.g. goal seek)	[1]

[Maximum 8]

Senior actuary can scrutinise & understand what has been done

A reasonable overview of the model is included	[1]
There are clear statements of the assumptions made, and justification of the values chosen	[2]
There is sufficient technical detail and does not include excessive use of Excel formulae to describe steps	[1]
Data sources are clearly described	[1]
Data checks are clearly stated and explained	[1]
Reasonableness checks are clearly stated and their results explained	[2]

[Maximum 8]

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]

[Maximum 4]

Logical order

- AT is set out in the following order: Objectives, Data, Assumptions, Steps, Results. Reasonableness steps are linked to the appropriate methodology steps. There is a logical flow within each section of the AT
Data is introduced before referring to it -1
Assumptions are stated before using them -1
The methodology is not described in a logical order i.e. nothing is introduced which would require that the reader has read ahead -1

[Maximum 3]

Audit Content

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 (e.g. goalseeks or non-standard model areas) [1]
The marker does not need to look directly at the model to understand what has been performed [1]

[Maximum 7]

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]
There is adequate signposting in the audit trail to describe the general direction of the model [1]
Model labelling is consistent with the audit trail (data, parameters, scenarios, outputs, charts) [1]

[Maximum 5]

Assumptions

- Up to 5 marks for including assumptions (1 for each distinct, reasonable “added value” one listed)

[Maximum 5]

Steps CORRECTLY described

e.g.:

Overview	[1]
Data used, including source	[1]
Calculation of time series increments	[1]
Verification of data	[1]
Allowance of initial charges on the amount invested	[1]
Simulation of investment for each time period and scenario	[1]
Calculation of rank of each scenario	[1]
Calculation of max, min and mean maturity values	[1]
Calculation of annualised returns (clear that Gross initial investment in denominator)	[1]
Calculation of standard deviation of maturity value	[1]
Calculation of mean and standard deviation using formulae	[1]
Simulation of investment with higher diffusion coefficient	[1]
Calculation of rank of each scenario under higher diffusion coefficient	[1]
Calculation of summary statistics under higher diffusion coefficient	[1]
Construction of charts	[1]

[Maximum 15]

[Total 55]

PAPER 2 (Analysis and Summary)

Marking Guide

Q3 Charts (from Existing Model)

Construction of chart showing monthly mortgage repayments	[2]
Construction of chart showing outstanding loan over time	[2]
Construction of chart showing split of premium (capital and interest) for Product 1	[2]
Construction of chart showing split of premium (capital and interest) for Product 2	[2]

[Maximum 8]

Q4 Techniques – Additional Scenario

Explicit inflation parameter	[1]
Allowance for expense inflation in cf model	[2]
Solving for target NPV = 0	[1]
Check on goal seek/trial and error	[1]

[Maximum 5]

Q5 Charts (for Additional Scenario)

Construction of chart showing NPV over time with and without expense inflation [2]
[Maximum 2]

Q6 Summary Methodology

(inc Purpose, Data, Approach, Assumptions)

Statement of purpose [1]
Data and parameters used [1]
Source of data and parameters [1]
Assumptions – up to 5 marks for a good list of “added value” assumptions [5]
Award 0.5 mark for any assumption restated from Audit, 1 mark for new valid ones
Calculation of mortgage payment for Product 1 [2]
Calculation of introductory payment for Product 2 [1]
Calculation of payment after introductory period on Product 2 [2]
Production of loan schedule [2]
Detail of cash flow components [2]
Calculation of final sale price [1]
Highlighting difference at $t = 1$ and $t = 240$ [1]
Determining net cash flow at each time period [1]
Calculation of net present value [1]
Allowance for inflation in additional scenario [1]

Determining maximum level of inflation [1]

[Maximum 20]

Summary Drafting

(Clear & concise drafting to give a senior actuary a good understanding)

Clear / concise drafting of the objective, and data summary/description [1]
Clear / concise drafting of the assumptions and methodology [1]
Clear / concise drafting of the results and conclusions [2]
The summary report is written in clear, crisp and flowing English. [2]
Accurate spelling [2]
The summary is well laid out, in a reasonable order, with good formatting to aid clarity [2]

[Maximum 10]

Results (inc Charts)

Inclusion of the five charts [2]
Statement of the mortgage payment under Product 1 [1]
Statement of the mortgage payment (introductory and after) under Product 2 [2]
Statement of NPV under Product 1 [1]

Statement of NPV under Product 2	[1]
Clear statement that both products will meet the required rate of return	[1]
Clear statement that Product 1 offers the best rate of return	[1]
Statement of maximum level of expense inflation before returns falls below required level	[1]

[Maximum 10]

Conclusions

(where Results are observed but not explained, only award 1 mark)

Observation that premium under Product 1 is level throughout the mortgage	[1]
Observation that premium under Product 2 increases after introductory period	[1]
Explanation of why premium in introductory period is lower than Product 1 premium	[2]
Explanation of why premium after introductory period is higher than Product 1 premium	[2]
Explanation of why outstanding loan reduces over time (i.e. mtg payment > interest accruing)	[2]
Observation that outstanding loan at end of mortgage is 0	[1]
Explanation of why there is an inflexion point on the outstanding loan curve for Product 2	[2]
Explanation of why outstanding loan falls quicker during introductory period for Product 2 compared to Product 1	[2]
Explanation of why there is a crossover on the outstanding loans after the introductory period.	[2]
Observation that sum of interest and capital repayment is fixed on Product 1	[1]
Explanation of why the amount of capital repaid with each payment increases over time	[2]
Observation that sum of interest and capital repayment changes at end of introductory period for Product 2	[1]
Explanation of why interest component is lower during the introductory period compared to period immediately after.	[2]
Explanation of why capital component is greater during the introductory period compared to period immediately after.	[2]
Recommendation to choose Product 1 due to higher NPV	[1]
Explanation of why maximum level of expense inflation was expected to be greater than 0	[2]
Explanation of why new present value with no expense inflation will be greater than the net present value with expense inflation.	[2]
Explanation of why NPVs with and without expense inflation are reasonable close (i.e. expense inflation a small component)	[2]
Explanation of why net present values converge towards the end of the projection	[2]
Any other valid conclusion	

[Maximum 20]

Next Steps

(where Results are observed but not explained, only award 1 mark)

Validate the parameters and information provided	[2]
Allow for any change in the purchase price between now and the expected date of investment	[2]
Confirm that the assumed level of rental income can be obtained for the specific property	[2]
Confirm the timing of the expense and rental income cash flows	[2]
Model the underlying interest rate stochastically in order to obtain a range of possible outcomes	[2]
Determine the actual rate of return for Product 1 and Product 2	[2]
Determine the level of expense inflation which can be experience under Product 2 before the rate of return drops below 8%	[2]
Vary the level of HouseCo's initial investment to see if a higher rate of return can be obtained	[2]
Sensitivity test the level of monthly income to see how sensitive the rate of return is to this assumption.	[2]
Allow for the possibility of voids in the cash flow model	[2]
Confirm that the annual rate of house price inflation is applicable for the property being purchased.	[2]
Obtain another source of data for house price inflation (e.g. a building society).	[2]
Model future house price inflation stochastically so that a range of future sale prices can be obtained.	[2]
Sensitivity test the level of house price inflation or the sale price that can be achieved on the property.	[2]
Amend the model so that it can allow for variable interest rates over time.	[2]
Amend the model so that it can allow for variable expense inflation rates over time.	[2]
Allow for the impact of taxation in the cash flow projection.	[2]
Allow for the impact of costs associated with the purchase and sale of a residential property.	[2]
Consider some extreme scenario tests – e.g. large crash in the property market, imposition of rental controls, etc.	[2]
Explore if there are alternative mortgage products available including fixed interest products.	[2]
Consider alternative sources of capital for the proposed investment.	[2]
Update the model in the future to reflect actual experience to date and/or a change in mortgage interest rates.	[2]
Model over a different time period / consider a different term mortgage	[2]
Obtain a peer review of the work performed.	[2]
Any other valid next steps	

[Maximum 25]

[Total 85]

END OF EXAMINERS' REPORT