INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORT

September 2017

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.

The Examiners are charged by Council with examining the published syllabus. The Examiners have access to the Core Reading, which is designed to interpret the syllabus, and will generally base questions around it but are not required to examine the content of Core Reading specifically or exclusively.

For numerical questions the Examiners' preferred approach to the solution is reproduced in this report; other valid approaches are given appropriate credit. For essay-style questions, particularly the open-ended questions in the later subjects, the report may contain more points than the Examiners will expect from a solution that scores full marks.

The report is written based on the legislative and regulatory context pertaining to the date that the examination was set. Candidates should take into account the possibility that circumstances may have changed if using these reports for revision.

Luke Hatter
Chair of the Board of Examiners
December 2017

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. As the data for this examination was reasonably straightforward, a few checks to confirm that the data supplied is reasonable and free of obvious errors are sufficient.

Most candidates made a good attempt at the first part of the model and calculated the number of items sold, the revenue and the product costs correctly. However, in projecting the cashflows for the bakery over the course of the year, there were a number of errors. The most common ones, among candidates who had problems, were to do with timing of cashflows, and linking the interest and overdraft calculations to the bank account balance at the correct point in time. Interest should

have been applied to the bank balance after cashflows at the beginning of the month had been taken into account. A few candidates misunderstood the application of salary tax, allowing for a net rather than gross amount. Most candidates handled the calculation of the I-E tax figure correctly, although there were a number that excluded salary as a cashflow item. The timing of the accumulation (assuming cashflows half-way through the month) was also generally well handled, but a number of weaker candidates made errors here. A common mistake was to accumulate by (t-0.5) months instead of (12-t+0.5) months (where t is month 1 to 12).

Another common error was to use annual interest and accumulation rates without converting them to monthly rates. This resulted in notably incorrect figures, which a simple reasonableness check would have picked up.

Most candidates managed the later scenarios correctly, even if they had made errors in the base scenario. There were only a few cases where the wrong result was targeted. Some candidates who made an error in the I-E calculation ended up with a scenario that was either impossible to solve, or where any salary above a certain level would solve it. There were a number of students who didn't manage to complete the later stages of the modelling required, but these were the minority.

There were a few other minor errors which didn't have a material impact on the number of marks gained. Candidates are reminded, however, that it is important to make sure that the audit trail assumptions stated and description of methodology agree with their modelling approach.

The production of graphs was also reasonably good, with the majority of candidates managing to produce the correct type of graph with the right information.

The presence of clear auto checks in the model was weak in this sitting. Apart from checking that the percentages of items sold added up to 100%, very few checks were present. Candidates should be aware that to gain full marks for auto checks in the model they needed to have an automatic formula indicating "OK" or similar and ideally a description of what is being checked and why, rather than just a calculation.

Most candidates demonstrated reasonable modelling techniques and gained most of the available marks in this area. Some students seemed to have spent too much time making their spreadsheet look pretty, when all that was needed was for it to be clear and functional.

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, describing the data available and the assumptions relating to the calculations in the model. A number of students put a lot of effort into overly elaborate introductions, and then ran out of time to describe the workings of the model.

Some audit trails lacked sufficient detail in the methodology section, for example just stating what was carried out and not how. The calculation of bank charges and the changes made for scenarios 2 and 3 were often poorly documented. However, 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.

There was a maximum of eight marks available for discussing the reasonableness of the results obtained and the graphs constructed. Many candidates failed to gain any of these marks, and the vast majority earned less than half. Descriptions of the pattern of cashflows and the bank balance over the year, the changes between scenarios and explanations of why these are reasonable were provided by strong candidates. 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 did not include reasonableness checks in their audit trail and lost marks. This is a recurring point in Examiners' Reports for this subject: including reasonableness checks not only provides a check on your own work; it also proves to the examiners that you understand what you are doing, and can communicate this effectively.

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 most of the required modelling and produced the relevant charts well. A very common error was in the application of the Eat Healthily scenario, where the mortality improvements were cumulative, but were often applied as a single improvement to a power. That is, instead of (1 - 4%) * (1 – 3.7%) * (1 – 3.4%) in

year three, candidates used $(1 – 3.4\%)^3$. This meant that the results obtained did not allow for as much to be brought out in conclusions as would have been the case for correct calculations.

Charts were generally well produced, with only an occasional candidate choosing an unusual chart type. A few students tried to fit too much information onto the charts. The chart that was most often incorrect was for the annuity due factors, which were shown over each age up to 105, instead of at retirement.

Summary

The structure of the summary was generally completed to a high standard. 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 although it is important to add extra assumptions which were not included in the audit trail to gain full marks for this section.

The majority of candidates produced most of the required charts but some did not state all of the results, particularly the table life expectancies under all scenarios, for both ages and sexes.

Stronger candidates were able to provide a balanced method at a level of detail suitable for a senior actuary. Weaker candidates gave very brief methods with no accurate formulae or descriptions or alternatively provided too much detail with excel references and signposting which is not necessary, nor is it appropriate for the audience of the document. 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 in general. A minority of the candidates reproduced sections of the audit trail in the overview and methodology part of the summary.

In future sittings a clear warning will be made not to reproduce large sections from the Examination Question (including the audit trail) and that no credit will be awarded for doing so.

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, comment on the observed pattern and then try and explain what this pattern shows or why it has occurred. Explanation of why is the key to performing well in this section – merely observing the change in results earns minimum marks, but showing understanding of the reason for the change is what is required. 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. Candidates who passed tended to offer some explanation of the results and provided some overall conclusions.

Due to the large number of candidates who made an error in the application of the Eat Healthily calculation, the number of comments which could be made comparing the two scenarios were reduced, but credit was given to any reasonable conclusion drawn from the incorrect results.

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 and include specific descriptions linking them to the particular model and an explanation of what they would achieve. Most candidates were able to produce a list of next steps, but only the strongest gained the full marks available for each step by providing adequate explanation. Generic or irrelevant lists of next steps, sometimes reproduced from previous exams, did not gain many marks as they are adding very little, if any, relevant information.

C. Pass Mark

The Pass Mark for this exam was 60.

PAPER 1 (Grace's Bakery)

Marking Guide

Q2 (i)-(x)

Calculations performed

(i) Correct calculation of number of items sold each month - 0.5 mark for each food item	[2]
(ii) Correct calculation of the revenue received each month	[1]
(ii) Correct calculation of the costs incurred each month	[1]
(iii) Projection of the bank balance each month - correctly allow for all operating cashflows (salary, revenue, costs, rent)	[2]
(iii) Projection of the bank balance each month - correctly allow for timing of cashflows - rent and costs at BOM; revenue and salary at EOM	[2]
(iii) Projection of the bank balance each month - correctly allow for bank interest - 1 mark for check at BOM; 1 mark for checking if overdraft fees payable	[2]
(iv) Correctly produce the 'Income less Expenditure' numbers	[2]
(iv) Correctly calculate the factors to roll forward the 'I-E' numbers to the end of the year - 1 mark for using correct discount rate; 1 mark for using a reasonable period	[2]
(iv) Correctly value the 'I-E' numbers at the end of the year	[1]
(v) Correctly determine Grace's tax bill for the year	[2]
(v) Correctly calculate total bank interest and overdraft fees for the year	[2]
(vi) For scenario two - correctly set up and adjust new salary to be drawn - 1 mark for setting up new salary parameter; 1 mark for changing formula in model to refer to it	[1]
(vi) For scenario two - correctly set up goal seek/adjust salary so bank balance = tax bill	[1]
(vii) For scenario three - correctly set up and adjust new salary and goalseek so total accumulated I-E = $0	[2]
(viii) Correct chart for projection of bank balance under each of the three scenarios	[3]
(ix) Correct chart for Grace's tax bill under each of the three scenarios	[2]
(x) Correct chart for net bank charges & fees each of the three scenarios	[2]
	[Maximum 30]

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 Checks

Auto checks

…flag to check if need to re-run goal seek (1 for each scenario) [2]

...other valid self-checks (e.g. percentages add up to 100%, number of units sold adds up to 1,000) [2]

Reasonableness checks

…number of pies sold uniformly decreases in first six months, then uniformly increases in next six months (or reference to number of sandwiches sold during the year) [1]

…symmetry in the revenue during the year (starts high, then falls to mid-year, then increases to year end) [1]

…comment on the progression of the bank account balance (falls, then rises for two months, then falls again, etc) [2]

…for scenario two, setting salary to $1,000 produces same result as scenario one [1]

…for scenario three, setting salary to $1,000 produces same result as scenario one [1]

…for scenario two, new salary is lower than $1,000, and as expected, bank balance account progression is higher than for scenario one [1]

…for scenario three, new salary is higher than $1,000, and as expected, bank balance account progression is lower than for scenario one [1]

…for scenario two, the total net bank fees are lower as the salary and therefore total expenditure is lower, reducing the need to use the overdraft [1]

…for scenario three, the total net bank fees are higher as the salary and therefore total expenditure is higher, increasing the need to use the overdraft [1]

Any other distinct, valid reasonableness check [1]

[Maximum 8]

[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]
It is easy for a senior actuary to pick up the high level detail of the modelling [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
Data is introduced before referring to it [1]
Assumptions are stated before using them [1]
The methodology is 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) [5]
[Maximum 5]

Steps CORRECTLY described
Overview [1]
Data used and source [1]

Calculation of the percentage of units sold for the four foods each month	[2]
Calculation of the revenue earned each month	[1]
Calculation of the expenditure each month (production cost, rent, salary)	[2]
Calculation of the timings for all cashflow	[1]
Calculation of bank account balance each month	[1]
Calculation of bank interest for the month	[1]
Calculation of the 'Income - Expenditure' value at the end of the year	[1]
Calculation of Grace's tax bill for the year	[1]
For scenario two - adjustments made to model	[1]
For scenario two - how revised salary determined (e.g. goal seek, trial and error)	[1]
For scenario three - adjustments made to model	[1]
For scenario three - how revised salary determined (e.g. goal seek, trial and error)	[1]
Construction of charts	[1]
Any other distinct, valid step…	[1]
	[Maximum 15]
	[Total 55]

PAPER 2 (Health Improvement Campaigns)

Marking Guide

Q3 Techniques - Additional Scenario

Calculation of cumulative probability of survival for age 75 for Get Active	[1]
Calculation of expectation of life for age 75 for Get Active	[1]
Correct update to mortality improvement factors for Eat Healthily	[2]
Calculate adjusted mortality rate for age 65	[1]
Calculate Eat Healthily scenario results for age 65	[1]
Calculate Eat Healthily scenario results for age 75	[1]
	[Maximum 7]

Q4 Charts

Construction of chart showing the expectations of life for both ages and both sexes in the base scenario.	[2]
Construction of chart showing female mortality under three scenarios.	[2]
Construction of chart showing female expectations of life for both ages under three scenarios.	[2]
Construction of chart showing annuity-due factors for both sexes under three scenarios.	[2]
	[Maximum 8]

Q6 Summary methodology

Purpose, Data, Approach, Assumptions

Statement of purpose	[1]
Data used	[1]
Source of data	[1]
Data validation / review	[1]
Assumptions - up to 5 marks for a good list of "added value" assumptions Award a total of 1 mark for restating assumption from the Audit, 1 mark for new valid ones	[5]

Calculations

Calculation of cumulative probabilities of survival under base scenario for age 65.	[2]
Calculation of expectations of life under base scenario at age 65.	[1]
Extension of base scenario to 75 years of age.	[1]
Calculation of the annuity-due factors.	[2]
Application of the mortality improvement to the base mortality rates.	[1]
Recalculation of the cumulative probabilities of survival under the Get Active scenario.	[1]
Recalculation of the expectations of life under the Get Active scenario.	[1]
Update to annuity-due factors for Get Active scenario.	[1]
Calculate the mortality improvement factors for the Eat Healthily scenario.	[2]
Calculate the adjusted mortality improvement factors the for Eat Healthily scenario.	[1]
	[Maximum 20]

Senior actuary can understand what has been done

The level of detail included is appropriate for a senior actuary	[2]
All methodology steps are set out clearly	[2]
The senior actuary would be able to understand the approach taken without having to refer to other documentation	[1]
	[Maximum 5]

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

Inclusion of chart of the base expectations of life, by age and sex.	[2]
Inclusion of chart of the female mortality rates under the three scenarios.	[2]
Inclusion of chart showing female expectation of life, by age, under three scenarios.	[2]
Inclusion of table showing expectations of life, by sex and age, under three scenarios (or a clear statement of these figures).	[2]
Inclusion of chart showing annuity-due factors at age 65, by sex under each scenario.	[2]
	[Maximum 10]

Conclusions

(where Results are observed but not explained, only award 1/2 mark)	
Observation of reduction on expectations of life for older ages	[1]
Explanation of why the difference in expectation of life is less than ten years.	[2]
Explanation of why male expectation of life is lower than for females	[2]
Explanation of why the qx's are lower under the mortality improvement scenarios.	[1]
Explanation of why the qx's are lower under the Get Active compared to Eat Healthily scenarios.	[2]
Explanation of why the impact on the mortality rates increases over time.	[2]
Explanation of why the expectation of life is higher under the health campaign scenarios.	[2]
Explanation of why the impact is better for Get Active for 65 year olds but better for Eat Healthily for 75 year olds.	[2]
Explanation of the increase in the annuity-due factors under the mortality improvement scenarios.	[2]
Explanation of why the increase in annuity-due factors is relatively smaller than in the expectations of life.	[2]
Conclusion that Get Active will have the bigger impact on life expectancy for younger ages and Eat Healthily for older ages.	[1]
Conclusion that the actual outcome will depend on experience.	[1]
	[Maximum 20]

Next Steps

Steps need to be scenario specific and fully expanded to receive full marks	
Validate the mortality rate data provided	[1]
…against another source	[1]
…and is up to date	[1]
If necessary adjust the mortality data to bring up to the current date	[2]
Validate the appropriateness of the two health campaigns' mortality improvement	[1]
…by consulting experts at the Actuarial Association	[1]
Check that a 5% interest rate is appropriate for use as the long term rate.	[2]

Challenge assumption that age 105 is the limiting age and extend the model beyond age 105.	[2]
Adjust the model to allow for mortality improvement rates that vary over time	[1]
…or by sex	[1]
…or by age.	[1]
Allow for other mortality improvements changes e.g. due to reduced smoking.	[2]
Enhance the model to test the implications on morbidity as well as mortality.	[2]
Consider the impact of combining both campaigns.	[2]
Solve for improvement factors to target different ages of expectation of life.	[2]
Perform sensitivity tests such as:	
- Different base mortality rates	[1]
- Different mortality improvement factors.	[1]
- Different interest rates.	[1]
Model the improvement factors stochastically so that a probability distribution of results can be produced.	[2]
Test the model against experience going forward and update the mortality improvement assumptions accordingly.	[2]
Obtain a peer review of the work performed.	[1]
Any other valid conclusions or next steps.	[3]
	[Maximum 20]
	[Total 85]

END OF EXAMINERS' REPORT